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Trust in the Machine: The Impact of Virtual Agent Anthropomorphism on User Trust and Compliance in Circular Ecosystems.

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ABSTRACT:

The growing global collection of hazardous electronic waste, especially disposed consumer lithium-ion batteries, has developed a serious environmental crisis. A major shift toward a closed-loop circular economy from a traditional linear "take-make-dispose" economy is necessary in this situation. The usage of digital systems is rapidly growing to coordinate waste collection and to manage the safety rules required for harmful materials under the new concept of Circular Economy 4.0. This study investigates the influence of digital interface design in motivating consumer participation in recycling programs for hazardous materials. Especially, the study examines whether the anthropomorphic (human-like) virtual avatar design assists users in following complex, safety-critical guidelines in absence of human experts to help them.

The research builds on a theoretical model that incorporates the Elaboration Likelihood Model (ELM), Perceived Risk Theory, and the "Computers are Social Actors" (CASA) model. This model tests the interaction of different types of virtual agents (human-like vs machine-like) with a user's perceived efficiency and perceived greenwashing. The ultimate objective of the structural model is to predict a user's actual behavioural intention to comply with safety rules. A quantitative experiment was performed using Partial Least Squares Structural Equation Modelling (PLS-SEM) to analyse collected data to evaluate the structural model. To ensure the accuracy and robustness of the final results across the population, demographic factors were also added as control variable.

The analysis of the experimental data showed that the avatar's visual design had no direct influence on a user's behavioural intention to follow guidelines for recycling hazardous materials. The change of visual also failed to activate any of the hypothesized cognitive mediators. This lack of influence is explained as an "Avatar-Blindness" paradox. It happens when an anthropomorphic (human-like) digital avatar fails to produce expected social cues in safety-critical environment. Instead, the findings of the study show that users compliance behaviour is particularly guided by central route of cognitive processing. This route is defined by an in-depth evaluation of the system's functional usefulness and a critical check of the corporate integrity of green claims. The study concludes that users ignore aesthetic cues and focus on functional usefulness and transparent information when they encounter significant material risks. The success of digital systems in circular economy does not depend on visual aesthetic. Instead, the success depends on developing tools that actually fit the task, work effectively, and maintain ethical transparency.

KEYWORDS: Circular economy, Digitalization, Virtual agents, Artificial intelligence, Human-computer interaction, E-waste, User compliance, Information systems.

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Abbreviations

AI	Artificial Intelligence
AVE	Average Variance Extracted
CASA	Computers Are Social Actors
CR	Composite Reliability
DCE	Digital Circular Economy
DPP	Digital Product Passports
ELM	Elaboration Likelihood Model
GDPR	General Data Protection Regulation
HATEM	Human-Automation Trust Expectation Model
HCI	Human-Computer Interaction
HTMT	Heterotrait-Monotrait Ratio
IoT	Internet of Things
ISA	Information Security Awareness
IS	Information System
LIBs	Lithium-ion batteries
PEB	pro-environmental behaviour
PLS-SEM	Partial Least Squares Structural Equation Modelling
PII	Personally Identifiable Information
TFF	Task-Technology Fit
VA	Virtual Agents
VIF	Variance Inflation Factor

1. Introduction

This study explores the efficiency of anthropomorphic virtual agents in the context of a high-risk recycling service, more specifically aiming at dangerous e-waste (lithium-ion battery) recycling. As digital platforms increasingly mediate the transition towards a circular economy, the absence of interpersonal guidance creates psychological, and information processing may cause challenges for the users to adhere with the complex protocols of safety standards. Though the use of AI driven Virtual Agents (VA) is a scalable alternative in mimicking human characteristics, the design of VA may have critical influence over the user's trust, risk evaluation, and compliance with the recommendations.

This introductory chapter discusses the theoretical foundation and scope of the research. Section 1.1 focuses on the background of the study, discussing the digital transformation of the circular economy, the environmental risks related to disposal of lithium-ion batteries, and the development of conversational user interfaces. Section 1.2 investigates the core research problem by investigating conflict between the CASA (computers are social actors) paradigm and the practical necessity of safety-critical tasks. The primary objective of the study and the research questions that guide the experimental investigation are formulated in Section 1.3. The impact of the study will be discussed in Section 1.4 by evaluating how the findings from the investigation contribute to Human-Computer Interaction (HCI) and Information System (IS) literature while also addressing the practical applications for the digital sustainability platforms, and a brief structural overview of the subsequent chapters of this thesis will be presented in final Section 1.5.

1.1 Background of the Study

The increasing global production of consumer electronics has led to a critical e-waste (lithium-ion) accumulation crisis which presents a considerable challenge to sustainable

environment and public health. Core to this challenge is the lithium-ion batteries (LIBs) at their end-of-life management as LIBs have different types of dangerous chemical compounds which carry substantial physical and environmental risk in case of mishandling or improper disposition such as toxin leakage and thermal discharge. It is essential to address such risks by recovering those hazardous materials and closing the resource loops to make a successful transition from linear model (take-make-dispose) towards a circular economy. But success of such transition from linear waste model to closed-loop resource recovery increasingly depends on adapting into use principles of Circular Economy 4.0—a model that connects the sustainability goals with industry 4.0 innovations. The digital transformation approach leverages advanced technologies in managing complex reverse logistics and maintaining safety standards over the product lifecycle (Chen et al., 2024).

Digital platforms are serving as the core foundation in managing decentralized waste flows. Yet, the effectiveness of such platforms is quite limited due to a lack of consistent consumer awareness and information. Effective recycling of e-waste like lithium-ion batteries is generally challenged by the consumers' insufficient technical expertise regarding the explicit safety measures that are required for mitigating e-waste recycling related environmental and physical risks. Although product safety and sustainability data storage is aided by developing modern tools like Digital Product Passports (DPPs), they mostly operate as static archives that require manual analysis and interpretation by the end-user (Popowicz et al., 2025). Therefore, this limitation stresses the necessity for AI-powered intelligent and interactive interfaces, such as Virtual Agents, to assist and give real-time advice on recycling of hazardous items.

The Virtual Agents effectiveness in this domain rooted from the concept of "Computers Are Social Actors (CASA)", which suggests that "individuals' interactions with computers are fundamentally social" (Nass et al., 1994). The CASA paradigm advises that when people interact with the digital systems, they naturally apply social rules and expectations to it despite

knowing that they are engaging with non-human entities. Such human behaviour is explained by the "Medial Equation" which claims that "people treat computers, television, and new media like real people and places" (Reeves & Nass, 1996, p.5). By applying these natural human characteristics, Virtual Agents can deliver convincing and specified guidance by reducing mental effort and perceived risk in recycling dangerous materials. It is critical to understand the underlying socio-psychological dynamic forces of user-agents engagement in implementing sustainable circular waste management model as digital platforms now serve as the "primary infrastructure for coordinating the return of end-of-life batteries" (He et al., 2024, p. 344).

1.2 The Research Problem

General assumption by most of the developers is that assigning high anthropomorphism qualities to AI interfaces will make it more human which results in more trust by user on the digital platforms (Qiu & Benbasat, 2009; Kulms & Kopp, 2019). Such assumption is mostly based on social or affective settings, developing a major research gap related to the effectiveness of digital platforms in high-risk functional areas, for example management of hazardous waste recycling. As in such settings, users' main objective is the safe and effective recycling of dangerous materials such as lithium-ion batteries rather than developing social relationship with Virtual Agents.

Trust Transfer Theory justifies the cognitive link users builds when developing these basic viewpoints of a new system. According to Stewart (2003), trust transfer is a psychological process where "trust is transferred across hypertext links based on the perceived interaction and similarity of the linked organizations" (p. 6). Lin et al. (2011) further explained that trust originating from the visual quality of a interfaces is commonly conflated to actual quality of

the service. Although a human-like agent might help users to develop an early connection, its realistic looks may trigger unintentional doubt about the systems actual capabilities.

Recent studies indicates that highly realistic digital interfaces might have the adverse impact within the sustainability and environmental contexts. Rinaldi et al. (2026) explain "perceived greenwashing" as the user's ability to identify deceptive environmental claims in promotional activities, perceiving that unclear or over-stated "green" branding usually intensified suspicion rather than building trust. For example, a highly photo-realistic humanized virtual agent might be viewed as a superficial marketing tool rather than a functional requirement in e-waste recycling. Such design preferences can signal the environment conscious users the absence of genuine responsibility to sustainability.

The core theoretical conflict exists between social-based trust and the theory of Task-Technology Fit (TTF). According to Goodhue and Thompson (1995), TTF explains the "degree to which a technology assists an individual in performing his or her portfolio of tasks" (p. 216). In the context of management of dangerous waste, the perceived efficiency and operational safety is the critical necessity for any digital platform. A functional machine-like (robot) agent might present a better align for such functional task as it signals accuracy and safety. On the opposite, a human-like interface might turn out to be distracting from critical safety procedures. This study explores if a human-like (high anthropomorphic) avatar design is truly efficient in high-risk, functional tasks where safety is critical for users.

Figure 1.1. Conceptual model of the operational challenges and guidance gaps in digital e-waste recycling.

1.3 Research Objectives and Questions

The main objective of this study is to investigate the direct influence of Virtual Agent (VA) anthropomorphism on users' compliance intent, including the indirect influence through psychological assessments of risk and functionality, in dangerous e-waste recycling context. Specifically, the research explores whether a highly anthropomorphic avatar (human-like) or a minimally anthropomorphic agent (machine-like) more effectively influences users to comply to safety-intensive disposal practices.

In context of information systems, compliance is commonly expressed as behavioural conformation of an individual in following technical or organizational rules. Bulgurcu et al.

(2010) explain compliance intent as an individual's independent probability of choosing to follow a specific policy guided by his/her own logic and perception. In broader scope with sustainability context, Taufique et al. (2017) explain compliance as a user's willingness to follow green standards or ecological requirements, perceiving such behaviour are deeply dependent on the level of trust and credibility of the information source.

This thesis compares the anthropomorphic (human-like) and functional machine (machine-like) agents to examine how their visual appearance influence the users' compliance. More precisely, this research explores if the visual cues cause the feeling of functional efficiency or of scepticism concerning greenwashing. To investigate the research objective, the paper addresses the following questions:

RQ1: How does the visual appearance of Virtual Agent influence a user's compliance intention with hazardous waste recycling instructions?

RQ2: To what extent do perceive efficiency and perceived greenwashing explain the relationship between design of a Virtual Agent's appearance and user compliance?

1.4 Significance and Contributions of the Study

1.4.1 Theoretical Contribution

This study aims to contribute to Human-Computer Interaction (HCI) domain by establishing a critical boundary for the Computers Are Social Actors (CASA) framework, which suggests that human interact with computers socially through the automatic and intuition-based application of social rules and expectations (Nass & Moon, 2000). Though much of previous research highlight the positive impact of anthropomorphism on trust, the findings of this study show that such social interaction fails in the context of high-risk, functional

sustainability settings. This study presents the "Avatar-Blindness" concept to explain how the users completely ignore the visual appearance of Virtual Agent while focusing on high-risk instructions like recycling of hazardous e-waste. As such, the data shows that Task-Technology Fit - the extent to which the digital tools assist a user to finish their work (Goodhue &Thompson, 1995) - drive the compliance rather the anthropomorphic agent appearance. This research shows that functional accuracy is more critical than the social signals in serious task settings when a user's doubt and greenwashing perception —the doubt regarding firm's green claims in comparison to its actual environmental performance (Rinaldi et al. 2024)— can offset the intended influence of anthropomorphic visual design.

1.4.2 Practical Implications

The findings of this study offer practical plans for digital service designers and initiatives such as the VIRPI project. The data indicates that spending in investment intensive complex process of developing high anthropomorphic quality avatars does not generate measurable benefits in influencing users to comply for hazardous e-waste recycling. As an alternative, designers should focus on building efficient UI/UX interfaces which prioritize easy to follow guidelines and safety practices. Digital platform developers should focus to minimize perceived greenwashing and improving perceived efficiency to promote genuine user trust via functional dependability instead of visual impression. For safety-critical environmental application, this study recommends in shifting resources to data transparency and real-time guidance form visual design. Finally, the visual interface should act as an efficient tool in helping users operating through the complex environmental safety instruction without confusion.

1.5 Structure of the Thesis

This final part of introduction chapter presents the structure of this thesis throughout the following four chapters. Chapter 2 reviews the relevant current literature regarding the Computers Are Social Actors (CASA) framework, anthropomorphism, and digital sustainability which forms the foundation of this research's conceptual framework and hypotheses. Chapter 3 discusses the research methodology - the quantitative experiment design and the utilization of Partial Least Squares Structural Equation Modelling (PLS-SEM) to test the hypotheses. Chapter 4 presents the results covering measurement assessment, structural model, and mediation effects analysis. In the chapter 5, an interpretation of the results is presented in light of previous research, discussing the practical implications for digital design, and ends with an assertion of the study’s contribution, limitations, and future research suggestions.

2. Literature Review

This chapter focuses on developing conceptual framework for the study by combining the existing literature within Information System (IS), Human-Computer Interaction (HCI), and sustainability sciences. The main objective is to perform a systematic review the psychological and technological processes shaping user communication with digital agent interfaces, finally developing a conceptual framework to describe how design of virtual agent interface stimulates safety compliance.

The review is logically developed to connect the broader industrial perspective with micro-level psychological theories. Section 2.1 describes the circular economy digitalization and absence of clear guidance in hazardous e-waste recycling management. Section 2.2 presents the independent variable by evaluating Computers Are Social Actors (CASA) framework and the limits of anthropomorphism in high-risk situations. Section 2.3 explains the user's initial impression of credibility process using the Trust Transfer Theory (TTF). The review further continues to analyse proposed two mediating variables: Section 2.4 discovers Perceived Greenwashing as a mediating factor that negatively influence the users trust, as Section 2.5 focuses on Task-Technology Fit (TTF) as a positive mediating factor for efficiency. Section 2.6 explains the dependent variable by linking environmental behaviour with information system safety compliance. Finally, Section 2.7 unites these core ideas into the projected parallel mediation context in forming research hypotheses.

2.1 The Circular Economy Digitalization and Dangerous E-Waste

2.1.1 Circular Transition and Lithium-ion Battery Hazards

The shift towards circular economy models form traditional linear "take-make-dispose" manufacturing process means an essential change in resource movement, focusing on

closed-loop recovery, design for recycling, and prolonged product lifecycle (Biswal et al., 2024; Neumann et al., 2022). In circular economy framework, materials at their end of lifecycle are not considered as waste but are added back into manufacturing process as raw materials via efficient collection, sorting, and recycling. Though such transition is widely supported in sustainability theory, it is difficult to put this in practice when dealing with hazardous e-waste particularly lithium-ion batteries (LIBs). LIBs have a particular risk profile as it contains harmful toxic chemical composition of electrolytes, reactive lithium salts, cobalt, and nickel, carrying significant risk for environment and human health during disposal (Harper et al., 2022; Biswal et al., 2024). The recycling process of LIBs itself is complex and risky which includes shredding, smelting, carrying risk of leaking chemical into water and soil, emission of dangerous airborne particles, and workers' contact with acidic materials (Neumann et al., 2022; Singh et al., 2024). Additionally, lack of standard rules in battery disassembly process and difference in battery designs followed by manufacturers make it difficult in developing universal safety guidelines, leaving both the industrial and informal recycling workers expose to injury and environmental pollution (Sundar et al., 2023). Studies shows that efficient guidelines, technical capability, and strong recycling process structure is often missing, especially in developing countries where informal e-waste recycling is common (Sundar et al., 2023). Therefore, it is difficult to recover important materials from lithium-ion batteries as existing methods carry high safety risk, challenging the social sustainability of circular model.

2.1.2 The Concept of the Digital Circular Economy (DCE)

The concept of "Digital Circular Economy" (DCE) introduced by the scholars where technologies like Internet of Things (IoT), artificial intelligence analytics, traceability using blockchain technology are used in circular economy activities to support resource tracking, coordination, and transparency (Blackburn et al., 2022; Neri et al., 2023a, 2023b). According to Blackburn et al. (2022), digital platforms are explained as organizational structures that align

incentives, organize different groups working together, and enable resources exchanges through circular ecosystem. The concept was expanded by Neri et al. (2023a, 2023b) discussing the way of supporting closed-loop supply chain through digital platforms, claiming that digitalization of circular business model allows real-time data sharing about material stocks, product conditions, and waste-to-resource prospects. The idea was further elaborated by Han et al. (2023) and Wu et al. (2024) by explaining the possibility of optimizing resource allocation, advance prediction of possible maintenance, and waste sorting automation by linking "Industry 4.0" technologies, such as big data analytics and cloud computing, with circular economy value chain. Though technology focused circularity model is a convincing vision, their practical implication into real-world industrial applications is still in the pilot stage. The existing literature provides limited evidence for consumer-focused implementation of industry-scale system that successfully transform DCE theories into measurable consumer behaviour or environmental outcomes. Particularly, the process of digital interfaces influencing user participation in dangerous e-waste collection, and whether digital tools can replace human experts in high-risk safety circumstances are yet to fully explored. The DCE model provides a theoretical path for combining digital and circular reasonings, but the practical challenges of linking such systems with daily consumer behaviour-especially when hazardous e-wastes are the concern-has not been fully addressed.

2.1.3 The Operational Paradoxes in Digital Reverse Logistics

Digital platforms are successful in improving reverse logistics by coordinating networks, automating route optimization, and making waste collection efficient (Blackburn et al., 2022; Simaei & Rahimifard, 2024). Simaei and Rahimifard (2024) describe an AI-powered decision support system (DSS) empowered by visual recognition technology and multi-factor evaluation process in recommending best methods to recycle e-waste, automating sorting and routing tasks that used to need expert manual intervention. Mallick et al. (2023) also show a decision support tool for reverse logistics which can aid design and process of collection

networks by merging participants roles, channel and governance structures. Such improvements have reduced the logistical challenges and allow platforms to collect large amounts of water from different places. But the situation gets critical and challenging when users are needed to handle dangerous waste-such as damaged LIBs-using only digital platform. In such cases, users must follow complex and strict safety instructions through digital platforms without getting help from a trained person. Chandra et al. (2022) found that insufficient information distribution and users' awareness is the core of digital e-waste management failure in India, as users do not have proper know how about risk measurement and perform safe handling processes. Yadav et al. (2022) argue that individual confidence and capacity in performing recycling processes correctly influences the participation in e-waste management, and such confidence drops when recycling instructions are given via transactional digital interfaces. This absence of awareness is not just a problem; it results in critical safety gap. The impact of improper management of harmful material by users is critical, the risks include chemical burns, inhaling toxic gas, fires, and environmental pollution (Sundar et al., 2023). Therefore, the study shows an operational contradiction. Digital platforms are great in logistical structure for reverse logistics. However, the unavailability of human guidance in digital platforms developed a psychological and informational challenges for users which is important for safe handling of harmful materials.

2.1.4 AI Virtual Agents as a Solution for the Safety Guidance Gap

The gap between logistics and necessity of safety assistance advises the requirement of interactive, tailored tools to replace the human experts. A potential solution to this challenge is AI-powered virtual agents. Bouabdallaoui et al. (2024) explain a virtual agent model for waste sorting that uses voice and image recognition technology, achieving high accuracy in sorting process and showing technical viability of giving specific task instructions through conversational tools. Simaei and Rahimifard (2024) claim that AI-powered decision support system can automate complex recycling decisions which can lower the dependency on human experts and supporting scalable reliable assistance. Pathan et al. (2023) also explain AI

as a crucial tool for the circular economy, underscoring its capability in improving diagnostics, sorting, and automation throughout the circular value chain. These research show that AI virtual agents could provide real-time, step-by-step assistance required to link the guidance gap developed from reverse logistics digitalization. Unlike text and video instructions, a conversational AI agent can answer users' queries, simplify complex and confusing instructions, provide help, which can boost users' confidence by reducing mental pressure related with complex safety procedures. But the research on this is still limited as existing studies focus on the technical performance such as sorting accuracy and decision automation and does not specify the measures on users actual understanding on safety risks when guidance on handling dangerous materials is given using an AI agent. The transition to AI-led guidance from logistics platforms is promising, but its influence on human safety is still mostly untested. The next section will investigate the theories on AI virtual agents, exploring how AI agents can be designed to deliver effective safety guidance in hazardous situations.

2.2 Anthropomorphism in Virtual Agents and the CASA Paradigm

In human-computer interaction domain, anthropomorphism refers to assigning human like characteristics and social abilities to non-human objects (Klowait, 2018; Qiu & Benbasat, 2009). Researchers in information system studies this experience by looking at how the design elements of the avatar–such as human voices, conversational language, emotional expressions–connect the gap between human and machines. By adding these elements together, designers try to improve the social feeling more realistic so that user perceive the technology as close as to human when interacting. The Computers Are Social Actors (CASA) framework, introduced by Nass and his team in 1994, is the primary theoretical foundation in explaining why people interact socially to technology. The CASA framework claims that human mindlessly apply social rules and beliefs to non-human systems when technology shows even basic social signals, generating actual social responses towards a digital entity

(Einhorn, 2022; Gambino et al., 2020). Such social rules application by users are deliberate and happens unintentionally as users does not consciously choose to consider a computer as a person. But the social signals–such as voice tone, courtesy, human-like conversation etc.–presented by the digital entities evoking to apply the same social habits human learned and developed for communicating with other people. Based on this assumption, the Media Equation theory argues that human generally consider technological objects as if they were real social entities, behaving as per standard social rules during the technological interaction (Lee-Won et al., 2020). Both the CASA framework and The Media Equation shows that the difference between human-to-human and human-to-computer communication is significantly narrower than the early studies suggested. As a result, human habitually show social norms–like politeness, cooperation, and trust–for machines, imitating the social dynamics of real-life human relationships.

Researchers suggest three core psychological frameworks to describe why users apply social rules to digital interfaces. First, "Mindlessness and Automatic Cognition", suggesting that people's social norms application is not intentional instead these responses are quickly generated by any signals that meets minimum social thresholds (Einhorn, 2022). This process highlights that CASA effects are not deliberate choice to anthropomorphic technology, instead it is automatically initiated from users deep-seated social habits. Second, "Evolutionary and Heuristic Logic", suggesting that users naturally have the psychological ability to detect life and social opportunities, designed to identify social signals and react to them automatically (Gambino et al., 2020; Klowait, 2018). These developed mental processes helped human descendants to identify social affiliates for survival fast, which are still functioning and often extended to modern technologies. Third, Gambino et al. (2020) suggest the development of "Learned Human-Media Scripts", where regular interaction with digital interfaces leads user to develops specific social norms for technology, and that they apply it automatically when communicating with machines. This framework acknowledges that instead of just applying human social practices to technology, users might develop different

set of new social rules particularly for digital interfaces. This suggests developing a new social signal that is distinctive to the way humans live with digital agents. Among all the three psychological frameworks, the important aspect is that these social signals for technology are automatic. Users just react to social signals on the digital interfaces without waiting for reasoning regarding whether to consider the computer socially.

The visual and physical design of virtual agents ranged on a wide scale, varying from completely machine looks to stylized cartoons and photo-realistic human-like avatars. Each scale of the visual and physical design influence how users perceive the digital avatar's cordiality, expertise, and lifelikeness. But the association between an avatar looking more human and being liked is very inconsistent. According to Mori's (1970, , as cited in Tinwell, 2014) "Uncanny Valley" theory, users likeness grows as the agent's visual human-likeness increases but at a certain level. When the avatar design turned out to be nearly human but marginally imperfect, the likeness drops to a level of discomfort–a sense of eeriness that only fades once the replication becomes identical to a real person (MacDorman, 2025; Tinwell, 2014).

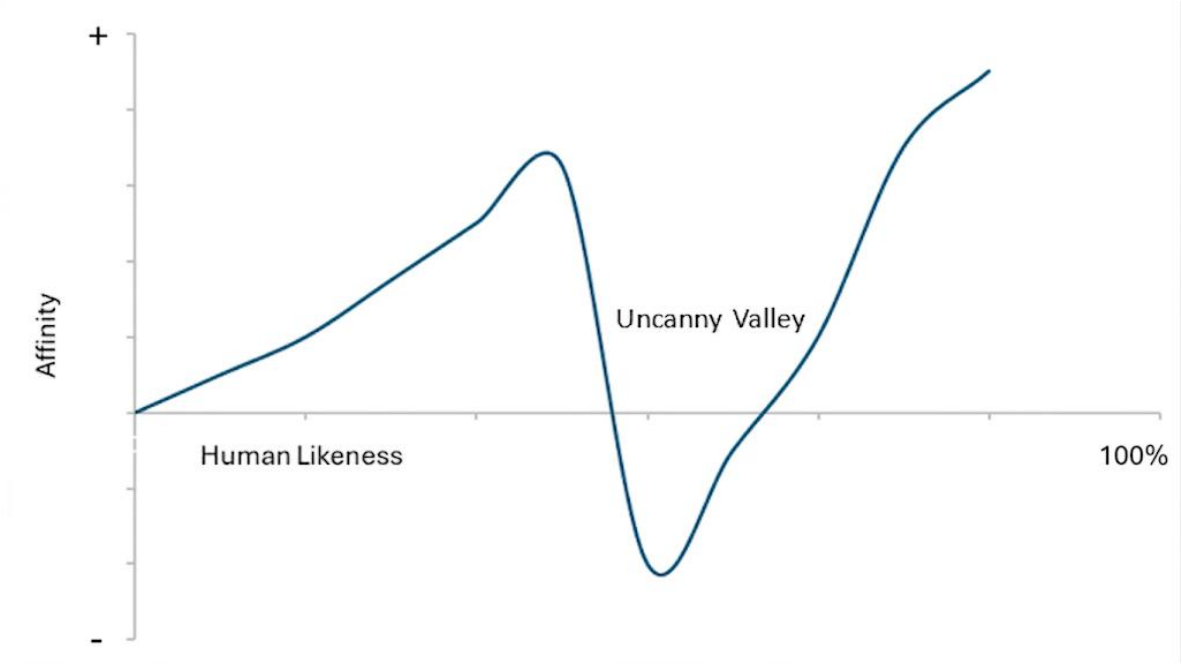

Figure 2.1. The Uncanny Valley (Adapted from Mori, 1970).

The non-linear relationship has been analytically documented in modern Human-Computer Interaction (HCI) research. Song and Shin (2022) performed a between-subjects experiment on e-commerce platform to compare hyper-realistic animated chat-bot agent with a static cartoon avatar. Their study found that near human-likeness avatar considerably increased the feeling of eeriness among the participants. As a result, near human-likeness negatively influences users trust and willingness to purchase. The results were influenced by the familiarity with the avatars design, as users who experienced with the identical avatars showed lowered uncanny valley reactions. These results suggest critical guidelines for designers: it cannot be assumed that designing an avatar to look more human will maximize users trust or compliance. The non-linear association between realism and likeness generates a design risk zone that is specifically dangerous where users trust and compliance are essential. Rather than developing connection, an overly realistic avatar design but falls short of perfection may unintentionally generate repulsion and doubt. Such response weakens social connection and trust that an anthropomorphic design is expected to build.

The effect of CASA theory is verified strongly in low-stakes commercial and service settings. In those settings, anthropomorphic design adoptions consistently boost individual social presence and trust, which explains the commercially related behavioural intents. A laboratory experiment performed by Qiu and Benbasat (2009) claimed that adding anthropomorphic form and voice to a product recommendation agents substantially improved social immediacy, which subsequently boosting users trust, engagement, and willingness to use the agent for decision support. These results have been repeated many times in e-commerce settings, showing that anthropomorphic signals enhance users' engagement and positive commercial evaluations. Even when anthropomorphic avatar design produces the Uncanny Valley, Song and Shin (2022) claims that visual interface selections significantly influence purchase decision and customers willingness to return to a platform. Usually, research in this area investigate the success by examining key matrices: social presence, perceptions

related to trust, factors in users experience (warmth and satisfaction), and behavioural intent of continual use of the system. Research confirms that virtual agents with human personas positively increase social presence and trust in commercial settings, which effectively drive better business outcomes.

However, a significant research gap appears when transitioning from commercial settings towards strictly service and high-risk safety concern tasks. The studies of Information Systems and Human-Computer Interaction are divided on whether anthropomorphic agents continue to be effective when task results are critical and users are depends on the agent guidelines to make serious decisions. The key difference is between self-stated trust and behavioural trust. Kulms and Kopp (2019) performed a decision-making experiment on different anthropomorphic agents based on three conditions: computer-like, virtual agent, and human agent. The experiment suggests that, though users trust increased with human-like agent, their actual behaviour (following agent's advice) was guided based on the perceived quality of the information provided, not the appearance of the agent. This variance between perception and action is theoretically critical. In casual retail context, high perceived trust might enough to initiate purchase intent as the cost of false trust is low. In high-risk task settings, compliance with safety protocols is vital and perceived trust alone is not enough. Users must change their perceived trust into action, which anthropomorphic design fails to generate this transition reliably. Peel et al. (2023) supported this finding in a search-and-rescue context that suggested that the influence of human-like design on trust was depended on the communication of confidence and recommendations. Message structure, evidence quality, and performance direct feedback are factors that are more influential than visual ap-peal in strict task conditions. This suggests that, when results are critical, user make a shift from perceptive social preferences to systematic data-driven analysis. Existing theory consistently suggests that users prioritize system reliability and quality of information over social signals when outcomes are critical. This makes the CASA effect-which relies on automatic, subconscious social response–ineffective in critical decision-making settings.

Additionally, designing the agent look more human might be risky if the design generates a "false sense of security" without improving agent's accuracy (Kulms & Kopp, 2019).

The recycling management of dangerous e-waste lies exactly at this crossroads. In this context, as users are required to follow complex, multi-step safety protocols which is guided by a digital agent, the main measurement of success is behavioural compliance instead of subjective trust. The context is purely functional, with no commercial or emotional. The cost of a non-compliance in the process may result in contact to toxic components and environmental pollution. It is still in question whether adding anthropomorphic features to AI agent will improve or impair safety compliance in such context. The reviewed literature in this section confirms that anthropomorphic design effectively improves social presence and perceived trust withing commercial settings. But quality of the instructions matters more than the visual look of the agent for high-risk decisions.

Table 2.1. Summary of Key Studies on Virtual Agent Visual Design

Author(s) & Year	**Study Context**	**Agent Manipulation**	**Key Findings regarding Trust & Behaviour**
Qiu & Benbasat (2009)	E-commerce / Product Recommendation	Humanoid vs. Text	Humanoid personification substantially improves users trust, engagement, and willingness to use.
Kulms & Kopp (2019)	Interdependent Cooperation Task	Computer vs. Virtual Agent vs. Human	Anthropomorphic design improves perceived trust but had no substantial impact on behavioural trust.
Song & Shin (2022)	E-commerce Chatbots	Cartoonish vs. Hyper-realistic	Extreme human-like design sparked the Uncanny Valley, raising eeriness and

			dropping purchase intent.
Peel et al. (2023)	Urban Search-and-Rescue (High-Risk)	Robot Teammates	Message structure, evidence quality, and direct performance feedback offset visual appearance in team-critical tasks.

The next section will explore the particular design elements, namely, voice, appearance, language, and communication mood, that past research on Information System and Human-Computer Interaction has found as the most dominant controls for influencing user trust and compliance.

2.3 Trust Transfer Theory in Digital Environments

The Trust Transfer Theory represents a foundational structure in Information Systems research for explaining how trust in a known and recognizable "source" transfers to an unfamiliar "target" through perceptual signs that signal a relationship or institutional link. Stewart (2003) showed that trust transfers through web hypertext links as they improve user opinions that the linked companies are interrelated and similar. Such trust based on institution develops a conventional retail channel transfers when a webpage indicates a connection with a physical shop. According to Stewart's experiments, web links and visual signals like a photo of a physical store enhanced perceived communication and similarity between a familiar and an unfamiliar company, resulting enhanced trust in unknown companies and raising purchase intent (Stewart, 2003). Later, Chen et al. (2016) confirmed the strength of this process, mentioning that specific seller characteristics and general institutional rules determine how much trust transfer in digital marketplaces. The strength of this model functional as explains a common psychological effort. Instead of analysing a new entity from

zero, users utilize depends on their trust in a familiar. User assumes the new entity can be trusted if the source and the target seem connected. This is an active process. The design and signalling process made by the source entity directly affects the chance and total amount of the transfer. Stewart (2003) explains that how a trusted source is connected to an unfamiliar target through digital signals. In Stewart's model, trust transfers form the source to the target when a user senses a strong association between them. The power of this trust movement depends on the perceived strength of the relationship between the source and the target. Links that suggest a formal partnership generate a powerful effect than links that simply signal like a basic advertisement.

The Trust Transfer framework helps to explain how users develop primary trust in digital and mobile commerce environment. This context is particularly true when users have not used the service before and must judge the service quickly based on what they experience on the screen. Lin et al. (2011) explained this concept "inter-channel trust transfer". They found that trust in a known desktop e-commerce platform can transfer to a new mobile application if it looks and function in a similar way. In such process, the visual interface acts as a shortcut. According to Lin et al. (2011), users utilize these visual signals to decide whether a new service is safe before the even make any purchase. Lowry et al. (2014) supported this finding by showing that visual components, for example logos, can cause appear expert and dependable immediately. Their research showed that visual design features act as quality signals. Users are leaner to trust it and decide to purchase or continued use (Lowry et al., 2014). This suggest that in digital environments, the visual design is not just decoration, it is the key signals that users use to judge a website. Without experience or third-party verification, visual design works as a trust signal that either starts or stops the trust building process. As this judgment establishes so quick, the visual look is the first and most critical determining factor of whether a user will trust an unknown target.

This thesis employs the Trust Transfer framework directly to the recycling of dangerous e-waste. In this study, the virtual agent's visual design serves as the source of trust transfer process. Specifically, it is choosing between human-like and a functional machine-like avatar. The "target" of this trust is the safety protocol which contains set of complex steps the user must trust and comply to manage hazardous materials safely. A digital agent's look is the initial and immediate signal of reliability a user perceive. This visual information processed quickly, even before a user's interaction with the system. It generates a quick psychological reasoning about the agent's capacity of guiding them though a risky task. The idea that visual look influences trust is supported by research. Tan and Liew (2020) found that users perceive virtual agent more credible when they look like experts. This professional appearance also improves trust in the entire digital platform. Similarly, Seymour et al. (2024) showed that the digital agent's realism impacts how much users trust them. They found that uncanny or functional machine-like avatar designs can lower users' comfort and trust in the system. The main claim here is that if the visual look of avatar is competent and professional, trust will transfer from the agent to the safety protocol. This makes the probability of user's compliance with the safety rules correctly. Alternatively, fake looking avatar or avatar looking inappropriate for the tasks, the user may doubt the safety protocol itself. This could lead to critical failure in following the guidelines. The idea that visual look influences trust is supported by research. Tan and Liew (2020) found that users perceive virtual agent more credible when they look like experts. This professional appearance also improves trust in the entire digital platform. Similarly, Seymour et al. (2024) showed that the digital agent's realism impacts how much users trust them. They found that uncanny or functional machine-like avatar designs can lower users' comfort and trust in the system. The main claim here is that if the visual look of avatar is competent and professional, trust will transfer from the agent to the safety protocol. This makes the probability of user's compliance with the safety rules correctly. Alternatively, when an avatar is perceived as fake or inappropriate for the tasks, the user may doubt the safety protocol itself. This could lead to critical failure in following the guidelines. However, visual look is not the only factor. Carter et al. (2023)

enhanced this claim with the Human-Automation Trust Expectation Model (HATEM) and suggested that clear communication is as important as visual appearance. Their research found that meaningful signals, such as voice tone, had a stronger influence on trust than just appearing human. This indicates that, though visual design initiates the trust process, the agent's communication style directly shapes the perceived reliability of the interaction.

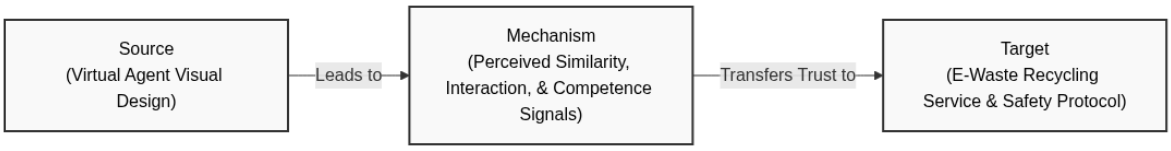

Figure 2.2. The Trust Transfer Mechanism applied to Virtual Agents (Adapted from Stewart, 2003).

If an agent appeared like an expert but its communication style is confusing, then the initial trust may not establish. For safety critical tasks, trust depends more on actual expertise and clear communication instead of just looking human. Next section will focus on specific design features like type of looks, voice, language and communication style of an agent to examine how those features influence user trust, compliance, and behavioural intent in functional tasks situations. Next section also focuses on how appropriate design of these features help to tackle the issue of perceived greenwashing.

2.4 Perceived Greenwashing in Digital Sustainability Platforms

Perceived greenwashing refers to customers believe a company’s environmental claims are dishonest, overstated, and misleading to its actual environmental performance. In this condition, people perceive a company's sustainability objectives as a marketing stunt instead of an actual effort of helping planet (Chen & Chang, 2013). Through statistical modelling, Chen and Chang (2013) showed that perceived greenwashing negatively influences green trust. Two key psychological reason are behind this loss of trust: green consumer confusion, and

green perceived risk. The mediating role of green consumer confusion is particularly significant in this model. People become suspicious if they cannot assess the environmental claim, which naturally destroys their trust. The behavioural impact of this trust broken is significant. When green trust reduced, people are less likely to buy Eco-friendly products and their participation in sustainability programs decreases (Chen & Chang, 2013). Recent research by Usman et al. (2023) also supported this, showing that greenwashing negatively impacts a brand's reputation and green purchase intention drops as it makes customers feel doubtful and confused. Though the study by Chen and Chang (2013) was focused on physical electronics products marketing in Taiwan, the core idea is the same for other domains: when people feels misled, they stop trusting. This argument should also be applicable to digital service perspectives that make environmental claims. The key question is whether transfer sustainability claims to digital service platforms changes the greenwashing perception dynamics or make them even more doubtful.

Applying the greenwashing concept to the digital platform shows that when sustainability claims transfer to apps, e-commerce platforms, virtual agents, and chat bots, consumer doubts does not fade away. In fact, it may get worse. Users have to evaluate a company's environmental claims based on what they see on the screen as they cannot see physical proof online. To decide whether a brand is being honest or just greenwashing, people must depend on the design and language of digital service platforms. Research shows that green messaging on social media and other digital platforms often leads to high level of suspicion (Ktisti et al., 2022). Farhat et al. (2021) found that users trust the information less and are prone to share negative reviews, which ultimately makes them less likely to buy green products. These findings show that digital platforms do not protect firms form being suspected of greenwashing. Instead, the digital channel creates new kinds of risk profile. Wang and Walker (2023) experimentally showed that transparency measures, such as assigning numbers to quantifying green features and visualizing environmental behaviours, can lower distrust in digital green claims. Alternatively, using unclear or overly polished messages

increases users perceived manipulation. This forms a significant risk for digital sustainability tools. Users are psychologically dependent on the visual design and communication signals of an interface to decide to evaluate a program's authenticity. If the design feels too performative instead of practical, people will assume it is greenwashing. This is not just a theory; it has measurable impacts on how people perceive digital sustainability systems. For example, a user may not follow the critical safety protocols on e-waste recycling platforms which are required to manage hazardous materials if they do not trust the digital interface.

Table 2.2. Drivers and Outcomes of Digital Greenwashing Perceptions

Source	Domain / Context	Triggers of Greenwashing	Behavioural Consequences
Chen & Chang (2013)	Electronics / Physical Products	Deceptive/overstated claims	Increased green confusion; reduced green trust and purchase intention.
Farhat et al. (2021)	Social Media Advertising	Unclear digital green messaging	Increased scepticism; reduced perceived information utility; negative word-of-mouth.
Jensen et al. (2021)	Automated Digital Agents	Mismatch between appearance and reliability	Inappropriate trust judgments; reduced system credibility.
Usman et al. (2023)	General Brand Sustainability	Performative corporate sustainability	Decreased brand credibility; reduced behavioural participation.

Using highly anthropomorphic virtual agents on digital sustainability platforms presents an unexpected risk: the agents perfected visual style may itself work as a greenwashing signal. In the case of dangerous e-waste recycling, which is naturally dirty, technically complex, and risky, an anthropomorphic agent with perfect visual feels incompatible. User can interpret such visual mismatch that the platform is more about corporate branding instead of actual functional guidance. The logic explained by the Trust Transfer framework which was

discussed in Section 2.3. When the avatar's visual design is perceived as different with the task setting, the user becomes suspicious. Instead of trust transfer from the agent to the service, users doubt transfers to the entire service. Jensen et al. (2021) found that users formulate suboptimal assessments about trusting virtual agents when its visual appearance mismatch its actual reliability. Fundamentally, high visual polish creates a trust gap if the agent's look is too fancy for the task context. Kulms and Kopp (2019) showed that though anthropomorphic agents make people display they trust the system, it does not improve behavioural compliance to the advice. This is a primary challenge for sustainability, as greenwashing develops on the exact gap between perceived and actual credibility. In Information System literature, Pfeuffer et al. (2019) noted that when a system's social presentation mismatch with its actual capabilities, it destroys trust. The core argument of the issue is: a user who encounter a photorealistic human avatar delivering instructions on how to manage a dangerous swollen lithium-ion battery may feel "cognitive dissonance." Users might characterize the polished avatar as a corporate branding designed to conceal liability instead of a tool offering real and expert safety instructions. This perception initiates the greenwashing reasoning chain identified by Chen and Chang (2013). First, the visual deception of avatar causes green consumer confusion (“is this agent actually skilled?”). This raises green perceived risk (“can I trust these instructions?”), which in result destroy trust (“I will not follow this protocol”). The ultimate outcome-the user ignoring the safety instructions – is not just about used experience failure; it is a safety-critical result with physical danger. Therefore, the literature suggests that, while virtual avatar design choices for digital sustainability platforms, the process cannot evaluate just based on their social engagement properties. They must also be assessed for their possibility to initiate greenwashing perception that stop people from complying with safety rules. The next section will look at empirical evidence on how different avatar design affect trust and actual behaviour in functional and safety-critical task settings.

2.5 Task-Technology Fit and Perceived Efficiency

Task-Technology Fit (TTF) theory is a key model used to explain how information technologies help people to improve their performance. According to Goodhue and Thompson (1995), technology positively improves individual performance if users truly use it and the technology matches the particular task they are trying to complete. This fit is the connection between the task requirement and functionality of the technology. When task characteristics align with technology characteristics, application and performance improve. Task characteristics indicates nature of the work, work complexity, and interdependence. On the other hand, technology characteristics refers to functionality, reliability, and ease of navigation. Later, Goodhue (1998) extended this idea by explaining that TTF is made up of several different factors. Cane and McCarthy (2015) analysed several different studies and proved that TTF theory still relevant across diverse industries. Current research has expanded the TTF theory to cover digital services. Shahzad et al. (2023) found that how a platform looks and how easy users navigate through the system are critical factors in evaluating how well the technology fits the task. Furthermore, Rahi et al. (2020) combined TTF with other models to describe why users decide to continue using a particular digital service over time. Ultimately, the TTF theory suggests that even the most advanced technology will fail to improve performance if it fails in solving the specific challenges of a task.

In this thesis, the user's goal is strictly functional. The task required to follow specific, multi-step safety guidelines to return a damaged or swollen lithium-ion battery. The task is technically difficult that requires identifying hazards, using proper packaging to ensure safety, and locating the correct drop-off location. Because of the risky nature of the task, doing it wrongly can cause physical injury. Thus, the task success is evaluated by the user's behaviour-whether users followed the guidelines precisely-instead of how satisfied they felt. Based on the TTF model logic, the virtual agent must deliver a high level of functional fit. This means the agent needs to be accurate, clear, and detailed. Fun featured design-such as

social warmth, emotional engagement, aesthetic polish- do not help user to complete the safety-critical task.

Human-Computer Interaction research clearly differentiates hedonic design from functional design. Hedonic design focuses on pleasure and how a system looks, whereas functional design focuses on efficiency and assisting users to complete a task (Hornbæk & Hertzum, 2017; Lin et al., 2012). In complex and risky task contexts, efficiency is the dominant factor of technology acceptance. Users need to perceive that the system allows them to complete the task quickly and precisely with little effort. Ma et al. (2024) found that a system needs to be easy to use which is a precondition for hedonic value. For the task of returning a hazardous component, such as battery, adding social or emotional characteristics to an agent is unnecessary which may distract users form the safety protocols.

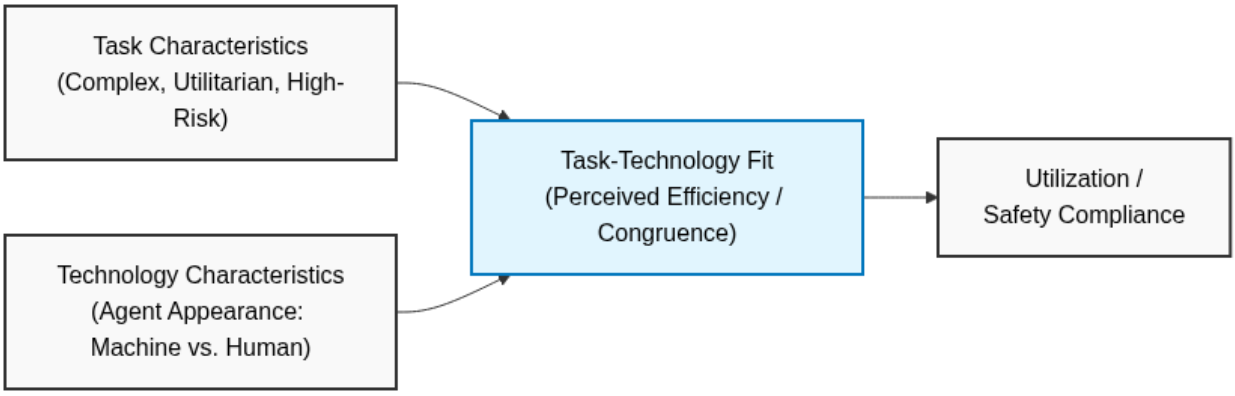

Figure 2.3. The Trust Transfer Framework applied to Virtual Agent Design (Adapted from Goodhue & Thompson, 1995).

When Task-Technology Fit (TTF) applied to avatar design, the virtual agent looks is more than a visual preference. The agent's look acts as a functional feature that advises user about its competency and functionality. The idea of appearance-task resemblance signifies that the design should match the task. When the look of the agent match with the tasks, users perceived the technology fits the task better. Zhang et al. (2021) showed that people evaluate

the skill and effort of a machine-like agent differently than they do for a human-like agent. Similarly, Yuan and Dennis (2019) found that designing an agent human-like changes users' perception about agent's expertise. In hazardous e-waste recycling settings, a functional machine-like (robot) avatar transmits a visual signal of technical and mechanical skills, which forms a strong alignment with industrial nature of managing dangerous e-waste. Alternatively, an avatar with human-look signals social warmth and friendship, which are irrelevant to managing hazardous material. This can variance may lead to the perceived greenwashing discussed in Section 2.4. A polished human-like avatar presented in risky task settings creates a sense of confusion which might make users doubtful. A functional machine-like (robot) appearance avoids such challenge by retaining constancy with industrial task domain. The logic interconnects with the CASA paradigm and the Uncanny Valley effects discussed in Section 2.2. The human-like avatar often develop trust in e-commerce or casual settings, but in high-risk safety tasks settings, a variance between appearance and task could lower trustworthiness. User might possibly not follow safety-critical steps if they perceive the agent is not fit for the task. Therefore, this thesis research question is if a machine-like design achieves a better fit than an anthropomorphic (human-like) agent for e-waste recycling guidance. The thesis looks at how these visual interfaces choice impacts perceived efficiency, trust, and users' compliance in following safety protocols. The next section will further explore users' compliance behaviour and behavioural intent models when using digital tools in safety-critical task settings.

2.6 User Compliance Intention in High-Risk Pro-Environmental Behaviour

2.6.1 Defining the Dependent Variable: Merging PEB and IS Compliance

The dependent variable of the study reported in this thesis is user compliance intention. This concept brings together two different but interconnected domain of study: pro-environmental behaviour (PEB) and information systems (IS) security and safety compliance

research. PEB is generally explained as the set of intentional behavioural action taken to minimize environmental damage, for example, recycling or buying sustainable products (Mansoor et al., 2022). However, in the world of digital platforms, PEB is more than just having a good attitude of following green rules. It needs a clear plan to follow an explicit set of instructions. For example, from this thesis point of view, a user must have knowledge about safe packaging process and returning a dangerous lithium-ion battery using digital platform. As this process adhere a meticulous set of rules, it closely parallels to IS compliance research, where people must adhere to official security guidelines. In both PEB and IS domain, a person's behavioural intent to act is perceived as the most essential steps before their actual compliance behaviour. Researchers in both fields investigates the impact of perceived cost, risks, and social influences shaping individual decision-making.

This similarity allows to use safety and security models in understanding environmental actions on digital platforms. Mansoor et al. (2022) found that having scientific knowledge about the environment helps to increase a person's perceived responsibility and interest. This shows that when people correctly understand the outcomes of their actions, they are significantly more motivated to follow established environmental practices.

2.6.2 The IS Compliance Calculus: Bulgurcu et al. (2010)

Bulgurcu et al. (2010) developed a key model to understand Information Security (IS) compliance intent. Their study, published in MIS Quarterly (pp. 523-548), suggests that people make compliance intentions by weighing costs against benefits. According to Bulgurcu et al. (2010), a person's intent to adhere the rules depends on their attitude, perceived social expectations, and perceived self-efficacy. The model justifies that a person's attitude is shaped by three key groups of beliefs (Bulgurcu et al., 2010):

(1) Benefits of compliance: this includes personal satisfaction, keeping resources safe, and receiving rewards.
(2) Cost of compliance: this reflects how much of which protocols obstacle daily operations.
(3) Cost of noncompliance: this involves personal guilt, threats to resources, and institutional penalties.

Bulgurcu et al. (2010) also argue that Information Security Awareness (ISA) is a positive moderator that helps to improve both positive attitude and perceived importance of potential results. This logic applies directly to how people comply with rules for hazardous e-waste recycling. The "cost of compliance" represents the efforts required to follow complex safety instructions. The "cost of noncompliance" represents the environmental damage and risks of personal injury. The "benefit of compliance" includes protecting environment and confirming personal safety. To be effective, a digital agent should make complex safety guidelines feel easier to follow while making perceived noncompliance costs more evident. By doing both, the digital agent motivates users to choose safe recycling habits.

2.6.3 PEB Compliance and Consumer Risk: Taufique et al. (2017)

Taufique et al. (2017) investigated the connection between people's environmental knowledge and their behavioural compliance with green rules. Their study, published in the Journal of Cleaner Production, showed that factual environmental knowledge encourages to follow pro-environmental behaviour (Taufique et al., 2017). On the other hand, higher perceived risk can stop from participating in sustainability program. This risk includes perception about nonfunctional product, money loss, safety issues (Taufique et al., 2017). Even with higher pro-environmental attitudes, these risks can restrain behavioural compliance. This has direct impact on digital platforms and AI agent's design. A virtual agent required to provide detailed and complete information which help to build user knowledge and increase

perceived confidence. At the same time, the agent also needs to provide simple step-by-step safety instructions to lower the perceived risk. This connects back to the Task-Technology Fit (TTF) framework discussed in Section 2.5. Detailed information and complete instructions are more than TTF requirements. They are the primary tools used by a digital platform to lower perceived user risk and encourage behavioural compliance. If an agent provides incomplete instructions, it fails in two ways. First, it lowers the TTF and make the task difficult to do. Second, it increases perceived risk by leaving users doubtful about safety outcomes.

2.6.4 Compliance Intention in Circular Economy Digital Platforms

Recent research on circular economy digital platform have started to show how design choice for digital platform influence users' behavioural compliance with recycling rules. Sozoniuk et al. (2022) found that when users believe that a recycling app is effective and easy to use, they are more likely to use it, which ultimately developing the app-mediated compliance chain. Nadarajan et al. (2023) linked factors like convenience, concern for environment, and educational information as key reasons of e-waste recycling intent. Each research suggests that information representation form can directly remove the difficulties that stop users from recycling. By combining these findings, it is visible that behavioural compliance intent to recycling rules depends on three key factors. First, users must perceive benefits of compliance clearly, consistent with the "benefit of compliance" belief in Bulgurcu et al.'s (2010) calculus. Second, lower perceived risk attained through providing clear and factual instructions, consistent with Taufique et al.'s (2017) findings. Third, the digital app itself must be efficient and well fit for the task, consistent with Task-Technology Fit (TTF) theory discussed in Section 2.5. The key theory of this thesis is that a virtual agent can increase e-waste recycling rates by focusing on several issues. The agent must lower perceived fear of greenwashing—when companies claim false environmental claims—to lower the perceived risk. At the same time, the agent must provide high-quality support by making

the task feel easier. Finally, making users to manage dangerous e-waste safely is a complex task that needs a balancing act of transparency, technical transparency, clear risk communication, and precision support to encourage safe and green behaviour. This section provides the base for the research model presented in Section 2.7, which will combine trust, task fit, and greenwashing perceptions into one framework to investigate how Virtual Agents work in safety-critical environmental task settings, such as recycling of dangerous e-waste like lithium-ion batteries.

2.7 Conceptual Framework and Hypotheses Development

2.7.1 Synthesis of the Theoretical Framework

The previous sections have formed five theoretical pillars that together help to explain the design and evaluation of AI virtual agents in safety-critical pro-environmental situations. First, the Computers Are Social Actors (CASA) paradigm suggests that people responses to anthropomorphic cues as if they were communicating with a real person. Second, the trust transfer process explains how the look of a virtual agent can shape users perceived trust on the system. Third, the perceived greenwashing framework describes how a variance in visual design can lead to suspicion and lower users' behavioural intent. Next, Task-Technology Fit (TTF) framework claims that a tool is only effective when its features match with the task characteristics. Finally, the Information Security (IS) compliance calculus explains that people decide to comply with digital instructions by weighing perceived benefits against the potential costs and risks. These theories together lead to one core research question: how does the visual design of a virtual agent — more specifically, the degree of anthropomorphism — influence user compliance intent in following recycling hazardous e-waste?

This thesis proposes a parallel mediation model to investigate how avatar design influences user behaviour. The independent variable is the visual design of the avatar, which is tested

by comparing anthropomorphic (human-like) agent with functional machine-like (robot) agent. The dependent variable is the user compliance intent, which evaluates the user behavioural compliance intent to follow specific safety rules for returning hazardous lithium-ion batteries. The model suggests two mediating variables functioning at the same time. The first mediator involves perceived greenwashing, representing a negative effect: highly anthropomorphic avatar design in safety critical industrial settings creates mismatch between the look of the agent and nature of the task which initiates doubts about service credibility and lower the compliance intention. The second mediator of the proposed model is perceived efficiency, viewed through the Task-Technology Fit (TTF) lens. This path proposes that a functional machine-like (robot) agent signals technical expertise and fits better in the industrial settings. This appearance-task similarity increases the perceived efficiency of the system and enhances behavioural compliance. In addition, the proposed model also suggests a direct influence of agent's human-likeness on user compliance. This is based on the Computer Are Social Actors (CASA) framework, suggests that human-like agent initiate automatic social responses in people. This proposed parallel mediation model suggests that avatar design generates multiple psychological processes at the same time. Some processes are automatic and social, while others are intentional and task focused. These processes apply different influences on behavioural consequences. The theoretical contribution of this study combines these different concepts into one model, explaining why anthropomorphic (human-like) avatar design might fail in safety-critical, functional tasks, instead it may work well in e-commerce or entertainment applications.

2.7.2 Hypothesis 1: Direct Effect of Avatar Anthropomorphism on Compliance Intention (CASA Paradigm)

The Computer Are Social Actors (CASA) theory, developed by Nass and his team in the 1990s, suggests that people apply social rules and expectation to computers when those systems show social signals even at minimum level (Nass et al., 1994; Reeves & Nass, 1996). This

happens through a process called mindless social attribution, where people automatically and unintentionally consider machines as social beings when human-like signals are present. The process happens automatically where the user responds without a logical evaluation of the situation. Einhorn (2022) also explaining this process as an automatic social reaction where anthropomorphic design features initiate social patterns in human brain. These social patterns amplify the feeling that a social presence is with the user, which stimulates perceived trust and warmth. The CASA model predicts that high level of human-like avatar features—such as realistic human faces, skin textures, and expressions—will generate strong social responses than machine-like avatars. These social responses are expected to improve users' intention to comply with the guidelines given by the digital agent. The theory supports a clear logic: when a system feels like a person, it forms a social connection which triggers social rules, such as the desire to be helpful, which eventually initiate compliance behaviour to follow the agent's instruction precisely.

The research for a direct effect of human-like (anthropomorphism) on user behavioural intent shows conflicting results. Song and Shin (2022) found that enhanced realistic visual in anthropomorphic agents raised feelings of uneasiness. This feeling decreases trust and thus reduces the user's behavioural intent to follow guidelines. Such results propose that anthropomorphism does not directly influence behaviour. Instead, its effect depends on other factors like trust or doubt. This finding challenges the idea that only anthropomorphic (human-like) design is enough to generate behavioural compliance. However, the CASA theory suggests a different perspective. It suggests that people naturally and unconsciously treat computers as social beings before they make any logical evaluation of the situation. This shows the possible existence of a direct influence, even if other factors are stronger. The direct influence signifies a user's immediate social response before measuring task fit or reliability of the agent. In safety-critical situations where users must make decisions quickly under uncertainty, the automatic reaction could play a meaningful but important role on

compliance intention. Therefore, the claim for hypothesis 1 is not that the direct influence is dominant factor, but it exists as an independent force.

H1: A highly anthropomorphic (human-like) agent design has a positive direct impact on user compliance intent. This happens because of the unconscious social responses predicted by CASA paradigm, irrespective of other factors.

2.7.3 Hypothesis 2: Perceived Greenwashing as Negative Mediator

Chen and Chang (2013) developed the foundational model connecting influence of perceived greenwashing to environmental behavioural outcomes. Their developed model shows that greenwashing happens when a consumer believes that a company's environmental claims are false or exaggerated. This consumer belief generates a negative influence on green trust. The study suggests that this relationship is mediated by green consumer confusion and green perceived risk. Green consumer confusion result from when consumer find it hard to evaluate the accuracy of environmental claims, leading them to doubt. Green perceived risk represents the user's evaluation that participating in a firm's environmental program might direct them to financial, safety, or performance problems. The mixed effect of green consumer confusion and green perceived risk destroy green trust, which in result lowers green purchase intention and participation in sustainability programs. This fundamental chain—perceived greenwashing lower trust which lower behavioural intention—have been validated across various studies, representing strong pattern in green marketing.

Applying this framework in designing avatar for digital sustainability platforms presents a new challenge: users might perceive greenwashing when the avatar's appearance does not match the task. The recycling of e-waste is a technical, industrial, and physically dangerous task. Therefore, users require help that is precise, practical, and expert. A highly anthropomorphic (human-like), polished, and photorealistic avatar forms a visual style that conflicts

with industrial setting. This polished high-end looks signals corporate marketing and branding execution instead of technical expertise or functional support. This variance leads users to doubt greenwashing. Users perceive the refined avatar look as a corporate defence used to defend its brand image instead of a functional tool to provide safety guidance. Jensen et al. (2021) showed that the look of an agent changes how much people trust it. Their research found that when an agent's look mismatches its actual reliability, it generates a gap in perceived trust. Likewise, Kulms and Kopp (2019) explored that anthropomorphic (human-like) agents push users to trust the system more but fails to ensure behavioural reliance to sustainability settings. This gap between appearing honest and being honest is exactly what develops greenwashing. Additionally, Pfeuffer et al. (2019) supported that anthropomorphic (human-like) information systems form false expectations when a system fails to deliver expected trust what its social appearance suggested. When a highly anthropomorphic (human-like) avatar is utilized in dangerous industrial context, the appearance-task variance initiates the same negative feeling found in greenwashing perception in traditional marketing contexts. These negative feelings confused users about the system's actual motives and perceive more risk about the reliability of the guidance. This process reduces compliance intention as users suspect the polished avatar signifies actual expertise instead of corporate performance.

H2: A highly anthropomorphic (human-like) avatar design increases perceived greenwashing, which results in reducing user's compliance intention to follow guidelines, which forming a negative indirect influence mediated by perceived greenwashing.

2.7.4 Hypothesis 3: Perceived Efficiency as Positive Mediator (Task-Technology Fit)

Task-Technology Fit (TTF) theory, developed by Goodhue and Thompson (1995), suggests that information technology influences a person's performance when its characteristics matches with requirements of the task. Fit refers to the agreement between task

requirements and technology features. Task requirements include complexity of the task, required level of precision, and interdependence. On the other hand, technology features involve system reliability, functionality, and ease of use. When the alignment between these two sides balanced, users perceived the technology efficient. This perceived efficiency influence people to use the system regularly which drives better results. In modern digital service settings, the interface design properties as well as visual design influence user perceptions of fit. Research conducted by Parthiban and Adil (2023) showed that TTF positively influences people's intention of using the tools, such as chatbots or digital banking apps. Their study claims that if the interface design meets the task requirements, users are significantly more motivated to accept the technology. TTF theory is also important to the design of digital agent. It proposes the idea of appearance-task similarity, referring to whether visual look of an avatar fits the specific job settings. For instance, looking expert and suitable for task filed is viewed as a good fit for the task. If the avatar's look signals the right expertise for the task domain, users are more motivated to follow the suggested guidelines.

The Task-Technology Fit (TTF) theory suggests that a system is most efficient when its design meets the specific task requirements. In hazardous e-waste recycling settings, the task requires high levels of technical precision and flawless processes. A functional machine-like (robot) avatar look signals these characteristics. As the avatar looks mechanical, it generates the perception of harmony between the appearance and the industrial nature of the recycling tasks. This visual match supports users trust on digital agents' expertise in giving technical advice. According to Yuan and Dennis (2019), the degree of anthropomorphism (human-likeness) influences users' perception on expertise. Their research found that less anthropomorphic agents are frequently seen as more expert in high-risk functional settings. This finding suggests that machine-like design generates a halo effect, where the robotic appearance signals task-relevant technical expertise. This perception increases users perceived efficiency about the system. When perceive efficiency of a system is high, users comprehend that following the agent's guidelines will be fast and need less effort. According to

the IS compliance calculus model discussed in Section 2.6, reducing perceived cost of compliance – when user believe that following the agent guidelines will be fast, and the task completion will be accurate and require less-effort – makes people significantly more motivated to follow safety protocols. Therefore, the theoretical process develops a clear path, suggesting a machine-like design signals technical expertise, increasing perceived efficiency. This perceived efficiency lowers the perceived difficulty of the task, which eventually make users more willing to comply with the safety instructions.

This positive mediation path functions along the same lines with the negative greenwashing path suggested in H2. Though highly anthropomorphic (human-like) avatars may initiate doubt because of appearance-task unlikeness in technical task, functional machine-like (robot) avatar generates trust as their look fits the task contexts. These two path are not mutually exclusive; they signify different psychological processes activated by the same design choice. The path mediated by Task-Technology Fit (TTF) depends on a user's precise assessment of whether the agent is actually effective for the task. Alternatively, the greenwashing path implies a user's doubt about whether the platform is being honest about its environmental claim. Both processes are mediated by user perception but focus on different areas—one focuses on the efficiency of getting the task done, and other focuses on trust and truthfulness. By utilizing a parallel mediation model, this thesis can evaluate both paths simultaneously. This discovers the total impact of avatar design on a user's compliance intention to follow safety-critical guidelines. This total effect is the sum of the direct link (H1), the negative indirect influence of greenwashing (H2), and the positive indirect impact of perceived efficiency (H3).

H3: A machine-like (functional machine) avatar design increases perceived efficiency through the appearance-task alignment (Task-Technology Fit), boosting user's compliance intention, creating a positive indirect impact through perceived efficiency.

The above three hypotheses together form a parallel mediation model that explains how an avatar's visual design influences a user's compliance intention. H1 suggests a direct connection based on unconscious social response to viewing an anthropomorphic (human-like) avatar. H2 focuses on a negative indirect effect mediated by perceived greenwashing, when a hyper-realistic human-like avatar design generates appearance-task misalignment, causing users to doubt about genuineness of the platform's environmental claims. H3 predicts a positive indirect impact connected to perceived efficiency, suggesting that a functional machine-like (robot) avatar design matches the technical nature of the task, increasing the perceive effectiveness of the system. This model combines different theoretical ideas into one framework, explaining the complex way of users' response to anthropomorphic design. It weighs the user's perceived social connection with an anthropomorphic design against the functional need for a tool that fits a task. It also compares unconscious responses with planned evaluation, and trust with suspicion. By investigating this parallel mediation model in Chapter 3, the research will explain which of these paths is strongest, determining whether human-like (anthropomorphic) avatar or functional machine-like (robot) avatar design generates higher behavioural compliance in hazardous e-waste recycling instructions.

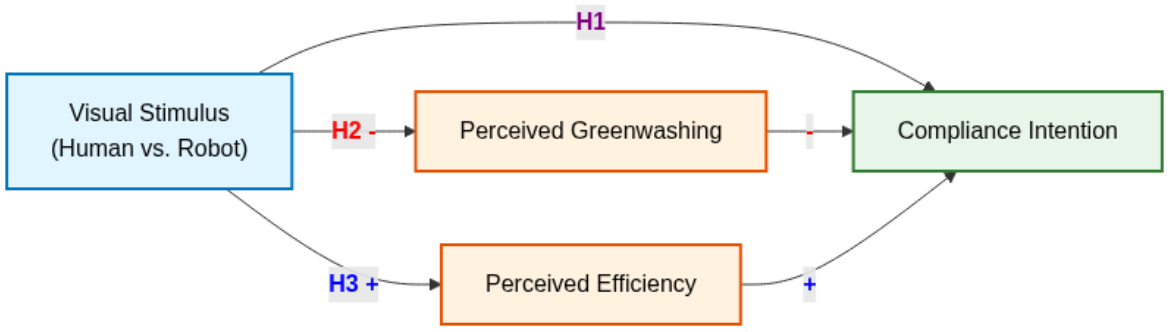

Figure 2.4. Proposed Parallel Mediation Model.

3 Methodology

This chapter explains the research method used to investigate the proposed parallel mediation model and the hypotheses described in Chapter 2. A quantitative research method with between-subject experimental design was utilized to explore how avatar design influences user behaviour in hazardous e-waste recycling instructions. The chapter is organized to present this study's internal and external validity. Section 3.1 discusses the research philosophy and reasons for utilizing an experimental approach. Section 3.2 explains how the visual appearance of the Virtual Agents (VA) was developed for this study, details of pilot study conducted to test and choose suitable Virtual Agents for the main study. Section 3.3 outlines the measurement tools to use in the study, showing how the survey questions were adapted from past research to ensure construct validity. Section 3.4 describes the online survey process, including pre-testing steps and randomization process. Section 3.5 discusses the participants, how ethical rules adhere to protect participants' data, and the target group of participants aimed for this study. Finally, Section 3.6 explains the application of Partial Least Squares Structural Equation Modelling (PLS-SEM) for data analysis and evaluate the relationships between different variables.

3.1 Research Philosophy and Design

This thesis utilizes a positivist research philosophy, assuming that reality is objective and exists independently from the researcher. This point of view proposes that social events can be accurately evaluated through systematic examination and investigating specific hypotheses. In information systems domain, positive research aims on formulating verifiable ideas and utilizing quantitative data to measure hypothetical concepts. This approach depends on deductive reasoning to identify cause-and-effect correlations between different variables (Orlikowski & Baroudi, 1991). This theory assumes that specific behaviours can be separated and quantified with sufficient accuracy to generate knowledge about technology-mediated

communication. By applying this perspective, this study intents to meticulously test the how the anthropomorphic characteristics of a virtual agent influence users trust and behavioural intentions. The research adopts a controlled experimental environment to make sure that the findings are robust and aligns with standard academic research.

This thesis uses a quantitative between-subjects factorial experiment based on vignettes. The participants were randomly assigned into two different groups. Group A saw a photorealistic human-like avatar, while Group B was presented a functional machine (robot) avatar. This between-subject manoeuvring in avatar's visual represents the independent variable. To collect data, three dependent variables: perceived trust, perceived efficiency, and compliance intention were quantified using validated survey tools. The between-subject experiment design was chosen to protect the internal validity of the experiment, ensuring that each participant gets only one version of virtual avatar. If respondent viewed both the avatars, they might presume the purpose of the study or their experience about the first avatar may affect their view about the second one. These "carryover influences" would compromise the internal validity of the experiment and lower the accuracy of the findings. This method is supported by past research where a comprehensive meta-analysis was conducted by Blut et al. (2021) by combining data from 11,000 people across 108 different studies. Their study validates that employing between-subjects experiment design to evaluate anthropomorphism effects is the best method to research AI and robots. Their findings showed that within-subject experiment designs can generate biased outcomes as people often presume the research hypotheses and adapt their responses accordingly. By utilizing between-subject method, this study confirms that each response is independent, and the results actually indicate the influence of the avatar's appearance.

The multi-variable design allows this experiment to focus clearly on anthropomorphism as the key independent variable while keeping other influencing variables effectively controlled. The external influencing variables includes task complexity, the experimental

scenario, and the measurement instruments. Standard rules for experimental research are followed by this approach, which need precise control and reproducibility of the study. This makes it possible to test hypotheses on human-computer interaction and development of trust. Applying this between-subjects experiment design involved creating and evaluating specific visual images. These visual images were designed to project distinct level of human-likeness precisely sufficient to initiate actual psychological response in participants. At the same time, precaution was taken to make sure that all images were perceived equally professional and high-quality to prevent confusing results.

3.2 Stimuli Development, Pilot Validation, and Methodological Considerations

In the experiment, participants were placed in a user experience scenario, where they had to use an online service platform to recycle a used lithium-ion battery. This task was selected based on the VIRPI project to imitate a serious, safety-critical, real-life situation. In this case, trusting the agent and complying with its safety instructions had actual safety outcomes. To make the experiment more valid, the agent was set into a simulated scenario. This approach makes sure that the participants' evaluations and responses were close to real-life settings, which makes the findings more reliable for generalization.

A primary group of four virtual agent designs was developed (see Table 3.1 for prompts used to generate images) using the current leading generative AI image generation platforms Leonardo.ai and Microsoft Designer. These images designs ranged from photorealistic human looks to functional machine (robot) designs, allowing the systematically adjustment of anthropomorphic traits. The use of AI-generated images as research materials is defended by recent research explaining that advanced AI tools can generate faces that look identical to real human photo. Additionally, these AI generated images can initiate the genuine

psychological trust processes in people as real faces do. A controlled experiment performed by Nightingale and Farid (2022) verified that AI-generated faces are not only hard to differentiate from real ones but are also often rated as significantly more trustworthy than actual human faces. Their research shows that synthetic images initiate similar social and emotional responses used in normal social communications. These findings justify the use of AI-generated avatars as valid experimental instrument in this thesis that can generate accurate trust responses from participants instead of artificial responses.

Table 3.1. Prompts used for generating VA images using Leonardo.ai and Microsoft Designer

Image A (Leonardo.ai)	**Image B (Microsoft Designer)**	**Image C (Leonardo.ai)**	**Image D (Leonardo.ai)**
Close-up portrait photograph of a female customer service agent, natural smile, minimalist uniform with recycling logo. Photorealistic, 8k uhd, highly detailed, sharp focus, studio lighting, raw photo, f/1.8.	A high-quality 3D digital render of a virtual influencer agent. A stylized female character with flawless digital skin, expressive eyes, and a slightly animated look, similar to a high-end video game character. She is in the same professional pose and uniform as a human agent. Soft studio lighting, 8k resolution, Unreal Engine 5 render, hyper-detailed digital art.	Humanoid female robot, mechanical face with a slight sculpted smile, glowing blue eyes, panel lines, futuristic uniform. Sci-fi concept art, intricate details, hyper realistic, 8k resolution, polished metal texture, octane render.	A highly detailed product render of a sleek, minimalist service robot with feminine design aesthetics. It features a glossy white body accented with subtle rose gold trim and warm LED lighting. A digital screen on the front displays a cute, softly glowing smile emoticon. No head. Industrial product design, studio lighting, 8k resolution

A pilot study was performed in February 2026 with 20 participants (N=20). The objective was to validate the experimental design and measure potential external variables that might affect the findings. To evaluate anthropomorphism, the study used Godspeed Questionnaire, developed by Bartneck et al. (2009). This tool utilizes semantic differential scales to grade perceived human-likeness, lifelikeness, safety, and intelligence in human-robot communication settings. The Godspeed Questionnaire is widely acceptable in research for its power to generate reliable and precise data across different studies (Bartneck et al., 2009; Weiss & Bartneck, 2015). In addition of Godspeed Questionnaire, the pilot study utilizes Fogg's (2003) surface credibility scale to evaluate the perceived professionalism of each avatar. This scale investigates whether an interface looks expert, trustworthy, and professional based just on the avatar's visual quality. This evaluation is required to ensure that the findings were actually based on anthropomorphic traits instead of just the professional look of the avatar's design, which could alone influence a user's trust reasoning on the system.

To confirm the internal validity, a pilot study was conducted using four avatar images (see Figure 3.1) which was generated using two leading generative AI image generation platforms, i.e., Leonardo.ai and Microsoft Designer. The objective is to select two different looking avatars, i.e., high anthropomorphic (human-like) vs low anthropomorphic (machine-like), but with similar perceived professionalism. Data was collected from 20 respondents (N=20). Table 3.2 shows the mean values for the four generated images. According to the table 3.2, Image B and Image C were excluded from the study due to their lower professionalism scores, i.e., 2.05. Selecting either of those images would have led to a serious confusion, as the difference between professionalism in compared to Image A ($\Delta = 1.25$) was significant enough to affect the measurement of anthropomorphism.

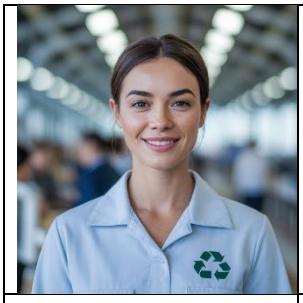
Image A


Image B

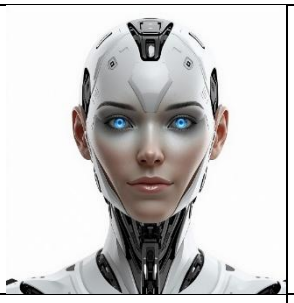
Image C


Image D

Figure 3.1. AI-generated avatar images for pilot study

Table 3.2. Mean Values of Pilot Stimuli

Image ID	Description	Anthropomorphism	Professionalism
Image A	Human-like	3.28	3.30
Image B	3D Metaverse	1.97	2.05
Image C	Bionic Human	1.88	2.05
Image D	Functional Machine	2.13	2.60

Image D was kept as the non-anthropomorphic control. Though, the difference in perceived professionalism between Image A and Image D remains (Δ = .70), Image D had the highest professionalism value (2.60) among the non-human agents. Furthermore, the difference in anthropomorphism between Image A and Image D is significantly stronger (Δ = 1.15). This confirmed that the selected images for the main study have successfully separated the influence of anthropomorphism, ensuring that the main study evaluates responses to the agent's humanness instead of confounding variation in the design quality. To validate the image selection process, a paired-samples t-test was conducted to compare Image A and D. The t-test result (see Table 3.3) showed that Image A (Photorealistic Human) was significantly more anthropomorphic (Mean = 3.28, Std. Dev. = 1.11) compared to Image D (Functional Machine) (Mean 2.13. Std. Dev. = .97; p = .003). The result also showed that there was no statistically significant difference in perceived professionalism between Image A (Mean=3.30, Std. Dev. = 1.38) and Image D (Mean = 2.60, Std. Dev. = 1.23; p = .054). This mathematical reference effectively removed image quality as a confusing variable. Image A and D were selected for the primary experiment based on the largest statistical gap in

human-likeness with no significant difference in perceived professionalism. This images selection confirms that the findings form the main study are caused by anthropomorphic traits of the agents instead of differences in perceived skill or visual quality of the agents.

Table 3.3. t-test: Paired Two Sample of Means

Details	Anthropomorphism		Professionalism	
	Image A	Image D	Image A	Image D
Mean	3.28	2.13	3.30	2.60
Variance	1.24	.93	1.91	1.52
Std. Dev.	1.11	.97	1.38	1.23
Observations	20	20	20	20
p-values	.003		.054	

Few visual distinctions between two images should be acknowledged for later data analysis. The highly anthropomorphic (human-like) agent has a recycling logo on the screen and used a blurred real-world background. The image used directional lighting on the background which creates a sense of depth and realism. On the other hand, the functional machine (robot) avatar did not have a background and was presented at a side angle view instead of facing directly forward. These avatar design differences shown as a complete feature of the human-like or machine-like characteristics, instead of being individually changed. Pilot study findings explain that this visual design did not alter the agent's perceived professionalism. The both avatar designs were similarly competent and efficient of managing safety-critical tasks based on the Fogg's (2003) scale. The other factors such as the background, recycling logo, the facial positions were perceived as parts of the anthropomorphic management instead of errors in the study design. These factors correspond to how real-world interfaces actually look, where human-like and machine-like styles distinct in various ways. As the pilot study validated that both agents were alike in professionalism, the differences did not generate a bias in perceived professionalism that would weaken the validity of the experiment. Once the avatar images were confirmed and addressing these visual details, the selected

two images (Image A and Image D) were integrated into the main study instruments, allowing the research to progress to the primary data collection phase with confidence.

3.3 Operationalization of Measurement Scales

In quantitative research, it is important to transform abstract theories into measurable data. This thesis decides on to adapt existing, validated scales instead of creating new ones. This decision is justified in the rule of psychometric continuity. As these scales have been evaluated previously in different studies and contexts, they are documented as reliable and precise. Using these scales helps to avoid errors that often comes from untested tools. This method is common in information systems research, where the purpose is to show a clear link between theory and measurement. By refining the validated scales, this thesis keeps the original quality of measurement while tailoring them to fit this study's unique context.

All concepts in this study were evaluated using a 5-point Likert scale. On this scale, 1 refers to "Strongly Disagree" / "Highly Unlikely", 3 refers to “Neutral” and 5 means "Strongly Agree" / "Highly Likely". The same format was used in every survey question, which makes the survey easier to complete for participants and helps to avoid biased answers. Additionally, this also make it easier to compare the results during statistical analysis. A 5-point scales is very useful as it allows the respondent to record the small differences in respondents’ opinions without being flooded with lots of options. This balance confirms that the data is complete and easy to understand.

3.3.1 Independent Variable: Anthropomorphism

Godspeed Questionnaire series was adopted to quantify anthropomorphism in this study. This tool is a proven and recognized technique for evaluating people perception about

robots and virtual characters. The questionnaire series was developed by Bartneck et al. (2009) and published in International Journal of Social Robotics (Vol. 1, No. 1, pp. 71–81). The questionnaire employs a 5-point scales to examine five different features of human-robot interactions. These features are anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety (Bartneck et al., 2009). For this thesis context, only the anthropomorphism section of the Godspeed Questionnaire series employed. The reason for this choice was that this section of the Godspeed Questionnaire series particularly evaluates whether a virtual agent looks and acts similar to a human. By applying this particular sub-scale permits for a more direct evaluation of user's perception about the virtual agent's human-likeness.

Anthropomorphism sub-scale from the Godspeed Questionnaire uses a 5-point semantic differential construct. This construct setup allows respondents to choose a point between two opposite word pairs, such as "Fake–Natural" or "Machinelike–Humanlike." For this study purpose, this sub-scale was employed in its actual 5-point scale format. The adaptation of existing scale instead of developing new instrument is defended by different factors. First, the Godspeed Questionnaire has a long validation history. Second, it is widely used in both Human-Robot Interaction and Information Security research domain. Lastly, the scale is efficient in identifying small variations in how users perceived different agent designs. As the scale is widely accepted, it ensures the findings will be consistent with earlier studies.

3.3.2 Dependent Variable: Compliance Intention

Compliance intention is explained using an approach that blends two different scales: security compliance and pro-environmental behaviour. In this thesis, the dependent variable is not just a simple compliance act. Instead, it is a multi-dimensional intention that shows both a user's behavioural compliance with guidelines and pro-environmental action. The option to recycle a dangerous lithium-ion battery to a particular collection point fulfil two

objectives. It represents the compliance with following virtual agent's guidelines, but also a movement toward pro-environmental action. As this activity has two distinct significances, the study employs a measurement method that links both theories to give a complete understanding on user's decision.

Two main sources are used in this thesis to develop the constructs for compliance intention. The first source was Bulgurcu et al. (2010) published in MIS Quarterly. This research explained compliance intention as an individual's intended to adhere with organizational security rules and safeguard technological resources. The scale used three items and showed very strong statistical result, including high reliability and factor loading. This source measures a person's intention to comply with official guidelines or system recommendations. The second source was Taufique et al. (2017), published in Journal of Strategic Marketing. This study evaluated intents for pro-environment behaviour. The scale emphasizes on a person's intentions of responsible action, such as buying green products or saving resources. This scale is also proved as reliable, with Cronbach's alpha above .80. This source fits this study as it explains a person's wish for participating in pro-environmental actions.

Adopting both sources is justified by the dual nature of the compliance behaviour being studied. Recycling a hazardous lithium-ion battery is an action of both compliance (following agent's safety instructions) and pro-environmental (care for the environment). By combining both items from Bulgurcu et al. (2010) and Taufique et al. (2017), the final scale developed for this study covered both aspects. Linking both sources aligns with modern Information Security research that suggests that complying rules often performs both organizational and social goals.

3.3.3 Mediator 1: Perceived Greenwashing

Perceived greenwashing was measured in this study using a scale revised form Chen and Chang (2013). Their research explains greenwashing as the act of confusing or making false claim to consumers about a company's green practice or green benefits of its product. The greenwashing measurement scale uses five specific items to check if people believe a product uses deceptive information, fabricating pictures, or unclear environmental claims. The measurement scale also examines for overstated green features or concealing of important details. The original scale is highly reliable, showing Cronbach's alpha of .862.

The greenwashing perception was adapted in this study to focus on visual deception instead of general business behaviour. It specifically explores at whether a virtual agent's look—such as the human-likeness of the agent or the use of recycling logos—triggers a false impression of environmental commitment. This theoretical change is valid as the mental process is same in both cases. Whether a person sees a misleading advertisement or a deceptive digital avatar, individuals psychological process to identify and response to perceived deception stays same.

Adapting the Chen and Chang (2013) greenwashing scale to virtual agents aligns this thesis with recent research on "sharewashing" or other visual deception in digital platforms. The greenwashing concept was applied by Hawlitschek et al. (2018) to the "sharing economy" to evaluate how misleading graphics impact users. Their research shows that the process of greenwashing functions in many different fields where visual signals are used to present social or green commitment. By applying this scale for virtual agent design, this thesis follows established practices to new digital environments without losing its original meaning.

3.3.4 Mediator 2: Task-Technology Fit (Perceived Efficiency)

The Task-Technology Fit (TTF) was evaluated using items based on the research conducted by Goodhue and Thompson (1995). Their study was published in MIS Quarterly (Vol. 19, No. 2). The authors explained TTF as the degree to which a particular technology guides a person in completing their set of assigned tasks According to Goodhue and Thompson (1995), the primary TTF model evaluate eight different factors of fit: quality, locatability, authorization, compatibility, ease of use/training, production timeliness, systems reliability, and relationship with users. This tool was developed applying strict statistical analyses and has been widely accepted in Information Security research as a tool to examine how ell technology features match job requirements.

In this study, TTF was limited to focus specifically on perceived efficiency, referring to how well the virtual agent's appearance and instructions match the task difficulty of returning a hazardous end-of-life lithium-ion battery. Deciding to focus only on efficiency is justified as this study concerns a specific, safety-critical experiment. The lithium-ion battery recycling process has purpose, such as locating right disposal process and the right location. In such safety-critical context, the most crucial part of "fit" is the user's perception that the technology makes the task easier and reduces their psychological effort. The other part of primary TTF theory, such as systems reliability or relationship with users, are less important, as the participants only interact with the virtual agent once during the study.

The decision to focus on the efficiency attribute of Task-Technology Fit (TTF) is consistent with previous research on users' perceptions of specific technology. McGill and Klobas (2009) showed that when people use a technology to complete a specific and clear task, efficiency is the best metric to predict functional success. Similarly, Hoehle and Huff (2012) examined TTF as "task-channel fit" in e-banking context. Their study focused on the fitness of the technology for completing distinct banking tasks. Following these instances, this study narrows down the focus of TTF to perceived efficiency. This method ensures that the

evaluation of fit matches the specific nature of the experimental task. The study can accurately explain if the technology is truly guiding the user to complete their task by focusing on efficiency.

To maintain a rigorous research design, the study evaluates its four key concepts-anthropomorphism, compliance intention, perceived greenwashing, and task-technology fit. Every scale of the main study was taken from past research as it fits perfectly with the study's theoretical model. These tools are established for their accuracy and ability to measuring effectively the targeted behaviour. A few adjustments were made to these scales to fit this study. For example, only anthropomorphism scale was taken from the Godspeed Questionnaire, and two different academic sources were used to measure compliance intention. Additionally, the greenwashing scale was expanded to include visual deceptions, and TTF scale was focused only on perceived efficiency of the system. To keep the data significantly relevant to the topic, these changes were made in accordance with common Information Systems research rules. A quick technical test was performed on the Webropol system before launching the main study. The test was done to ensure all scales readability and worked accurately on different devices (such as computers, laptops, smartphones etc.) used by the participants. This early test on the digital setup verified the reliability and readiness of the system to collect accurate information.

3.4 Survey Mechanics, Pre-Testing, and Randomization

A between-subject experiment requires a reliable digital system to work precisely. The system must have the ability to assign people at random to different groups, record responses accurately, and maintaining respondents' identity private to follow ethical research standards. For this study, Webropol platform was used to develop and host the survey. The platform is commonly used in university research as it has powerful features for managing data

and export tasks. The platform has built-in routing function that automatically assigns participants to experimental groups. This flexibility ensures that each respondent gets only one version of the survey, i.e., either the human or the functional machine avatar. The study removes any direct influence from the researcher through this automatic randomization method. This randomization method rules out human error and keeping the experimental group fair and unbiased, which is important for the study's validity.

A technical pre-test was conducted to ensure the platform worked correctly before the survey rolling out to the participants. This test was aimed to check three areas. First, it checked the system's routing process accuracy. This ensured that the software was capable of automatically and randomly divided the participants into one of the two study groups and they saw the specific images for their assigned group. Second, the pre-test evaluated systems compatibility by checking how the survey appeared on different devices. The survey was checked on desktops, laptops, tablets, and smartphones to make sure that all text, scales, and images are clearly visible on every screen size. This process validated that the rating buttons and images did not distort on smaller screen. Finally, the test helps to evaluate the clarity of the questions. A small group of peers provided feedback on the instructions and questions clarity and shared their experience about the survey. This step validated the standard research rules, which explain that a pilot study must be conducted to find and fix any technical issues before the collecting real data (Van Teijlingen & Hundley, 2001).

The complete anonymity for all participants was prioritized while designing the survey. No Personally Identifiable Information (PII) was recorded at any point of data collection. The survey process did not require name, email address, or IP address from the participants. This process ensured the anonymity of the respondents. This method was used to meet ethical research standards and to reduce social desirability bias. Respondents are more likely to avoid giving favourable responses when the anonymity is confirmed. Additionally, this process follows the GDPR requirements, as anonymous data are not count as personal data.

The Webropol system automatically recorded the device type (Desktop/Mobile/Tablets) used by the participants to participate in the survey to check for influencing factors that might affect results. This non-traceable data was automatically recorded by Webropol system. This data was helpful to explain if different screen size impacted the data. Previous research suggests that device choice can influence response habits due to variations in screen size and resolutions (Antoun et al., 2017). To avoid the device type from influencing the results, the survey design was fully optimized for common devices. The agents' images were properly scaled to avoid distortions. Additionally, the survey scales were formatted to present clear and readable in different devices. This optimization was tested and validated by conducting a technical pre-test before rolling out the main study.

The built-in "Jumps and Rules" feature in Webropol system was used to randomly assign participants to different groups in the study. This tool helped to automatically placed each respondent into either Group A, where respondent saw human-like avatar, or Group B, where respondent saw functional machine (robot) avatar. Using built-in tools to manage group assignment is better than assigning groups manually for few reasons. First, it helps to avoid the risk of researcher bias as the system is automatically doing group assignment without any human involvement. Second, the process is making sure the placement is random. Finally, the process is stable as every respondent is managed using the same system logic.

This built-in "Jumps and Rules" feature in Webropol system fits well with the research design explained in Section 3.1. Blut et al. (2021) suggests that using different groups for each condition is better than disclosing every respondent both options, as seeing several versions of an experiment can cause carryover effects. By utilizing the randomization technique, the study makes sure that each respondent sees only one version of avatar which protects the internal validity of the results. As system handles the assignment, groups are created independently of researcher expectations.

These robust technical settings offered a powerful and ethical base for the data collection process. These permitted the sampling strategy to maintain high academic standards for rigor and fairness. By deploying automated process, the study ensured the required control to produce reliable and unbiased data.

3.5 Sampling Strategy and Sample Characteristics

This study employs a purposive convenience sampling method, supplemented by Snowball Sampling. The survey was shared via peer groups, and professional networks such as LinkedIn. The data collection took place over a four-week period starting from March 4, 2026. The target group was general consumers with basic digital knowledge who are residents of Finland, inclusive of international residents. The basic digital knowledge was defined by the participants ability to use an online survey platform. This characteristic is important as the experiment involved using a digital platform to recycle a hazardous lithium-ion battery, which needed a specific level of technical knowledge. The survey distribution through digital platform is consistent with current research standards. This process shows a well-documented evolution to collect data more efficiently. Sassenberg and Ditrich (2019) studied over 1,000 articles from three leading social psychology journals published between 2009 and 2018, found a significant move toward online data collection. This shift was caused by the necessity for larger groups of participants and powerful statistical results (Sassenberg & Ditrich, 2019). Their work showed that online data collection method is now a standard and valid way to capture peoples' behavioural intentions in digital settings. As such, the application of online convenience sampling is consistent with current academic practices for testing hypotheses about behavioural intentions in digital tasks settings.

The sample size was decided based on the structure of the research model and the necessity of partial least squares structural equation modelling (PLS-SEM). The proposed model of this study featured four concepts: one independent variable (Anthropomorphism), two parallel mediators (Perceived Greenwashing and Task-Technology Fit), and one dependent variable (Compliance Intention), designed with maximum two structural paths leading into any single internal variable. Hair et al. (2019) explained that, in PLS-SEM, sample size of the study depends on the model complexity, the number of paths leading to any single variable, and the desired statistical power. For a simple model with few paths, a minimum of 100 participants is enough to get a statistical power of .80 for a medium-size effects ($f^2 = .15$) when the maximum number of arrows pointing at any single variable is limited to three (Hair et al., 2019).

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The data collection process followed the General Data Protection Regulation (GDPR) standards. All participants provided their informed consent before stating the survey. The study was designed to be absolutely anonymous, and no personal information was recorded. Participants had given the right to stop and leave the study at any point of time without any problems. All the information was saved securely on the Webropol system. The encryption system and adherence with European data protection standards used by the Webropol system ensures the safe data storage. Behavioural studies typically produce data that does not follow a normal bell curve. For this non-normal nature of the data, the proposed model design, and sample size, PLS-SEM was the best choice for data analysis. Section 3.6 will explain the details of data analysis approach applied in this study.

3.6 Data Analysis Plan

3.6.1 Phase 1: Data Screening and Descriptive Analysis

The raw data was screened using Microsoft Excel before the structural modelling. This process included of removing incomplete and non-engaged responses including data with missing GDPR consent. After the data cleaning, descriptive statistics were used to create demographic profile of the sample, confirming it fitted with the study's parameters. To verify the integrity of the between-subjects design, Chi-square tests measured variables (age, gender etc.) were equally distributed across the experimental groups. This is a standard requirement in experimental research. Instead of demographic changes among the respondents, this equal distribution confirms that the experimental groups were truly random. This ensures that any changes in the results were caused by the dependent variables (virtual avatar images) themselves.

3.6.2 Phase 2: Structural Equation Modelling (PLS-SEM)

This study used SmartPLS 4 to analyse the data. This software is designed for variance-based structural equation modelling. The analysis followed a two-step evaluation process. First, evaluating the measurement model (the outer model), and second, evaluating the structural model (the inner model). This chronological method confirms that the measures validity and reliability before the relationships between different variables are translated. This precaution is critical as it avoids measurement error in the data from being misinterpreted as a significant finding.

The data analysis of this study meticulously follows the Information Systems research specific guidelines for PLS-SEM by Benitez et al. (2020), published in Information & Management. These guidelines offer a detailed technical outline for using PLS-SEM in both confirmatory and explanatory research, including the correct standards to use for each type of research. This thesis is sited as Information System explanatory research, aiming to identify which factors factors—Anthropomorphism, Perceived Greenwashing, and Task-Technology Fit—predict a user's compliance intention with safety guidelines. As this study focuses on explaining these factors, the data analysis plan was precisely set up to fit with the specific research goal.

The evaluation of the structural model (step 1) followed specific statistical measures. To confirm the internal consistency reliability, Cronbach's Alpha (α) and Composite Reliability (CR) were both required to be ≥ .70. According to Benitez et al. (2020), the CR was maintained below .95 to ensure the survey questions were not too similar. Convergent validity was examined using the Average Variance Extracted (AVE). An AVE ≥ .50 was required for each construct, indicating that the construct explains more than half of the item variance (Benitez et al., 2020). To ensure that different constructs were actually distinct, the study applied Heterotrait-Monotrait Ratio (HTMT) with a strict limit of < .85. The Fornell-Larcker test was also reported as an additional check. Finally, all outer loadings had to be above .708 to make

sure each indicator explains more than 50% of variances with its construct (Benitez et al., 2020).

The structural model evaluation was measured in the second stage (step 2). Standardized path coefficients (β) were recorded for all hypothesized relationships. To test the statistical significance of these relationships, the study applied bootstrapping method with 5,000 sub-samples. This test provided p-values and 95% confidence intervals (Benitez et al., 2020). The R^2 values were reported to confirm how much the model explains the result. The Cohen's f^2 was used to evaluate the practical importance of each path. For the mediation analysis relating Perceived Greenwashing and Task-Technology Fit, the indirect effects were studied significant only if the bootstrapped confidence intervals that exclude zero.

3.6.3 Phase 3: Post-Hoc Analyses and Robustness Checks

This study includes post-hoc analyses in the data analysis process. This ensures the findings are reliable and not skewed by hidden factors. These analyses test the model's stability and ensure the main pat coefficients do not change due to outside influences (Hair et al., 2019). Particularly, the analysis will add in uneven demographic variables like gender as controls in the SmartPLS model. This allowed separating the true influence of the anthropomorphism from the respondents' demographic, reducing the risk of biased data and proves that the paths are reliable across different groups (Hair et al., 2019). Additional, ANOVAs and t-test were used to check if the different groups vary in technology readiness and green behaviour. All these post-hoc analysis proved that the experimental groups were equal form the start, confirming the random assignment was successful.

The research methodology applied in this study ensures that the outcomes are valid and reliable. This involves a positivist approach, a between-subjects factorial vignette-based experiment, avatar interfaces validated through pilot study, adapted validated scales, and an online survey that follows GDPR rules. The survey used randomization powered by the

survey platform (Webropol) and a sample size on N = 100. Data analysis was performed through SmartPLS 4 software by applying two step PLS-SEM method as guided by Benitez et al. (2020). To increase the robustness of the study, post-hoc analyses were performed to check for demographic influences and verify the stability of the study. Every choice related the research design, data collection, and analysis was justified by established theory. This consistent process signifies the results presented in the Chapter 4 are developed on a solid and reliable foundation.

3.7 Ethical Considerations

The research was performed in compliance with academic ethical guidelines. The participants privacy was ensured by confirming the General Data Protection Regulation (GDPR) standards. No Personally Identifiable Information (PII) was gathered, recorded, or stored throughout data collection process in the pilot study and the main study. All survey responses were completely anonymous, ensuring absolute confidentiality and data security. Additionally, AI tools were used in the preparation of this Master's thesis. Specifically, text-based AI tools (Grammarly, Gemini) were strictly used as a writing and document formatting assistants, and Microsoft designer, Leonardo.ai, and Mermaid.live were used for image and conceptual diagram generation. These tools were used purely for language formatting, grammar checking, correcting typographical errors, improving academic tone, vocabulary, and coherence, enhancing the document's structural quality, and generating visual asset. The core objective of using these test-based AI tools was to improve readability, flow, and clarity of complex arguments. The image generation AI tools were used to generate non-statistical conceptual diagrams to support the theoretical models of this thesis, as well as to generate visual stimuli used in the pilot study and experimental groups. All AI-generated texts, diagrams, and images were critically reviewed, edited, and verified by the author. The core theoretical arguments, research design, data analysis and interpretation, and discussions presented in this thesis are purely the author's own intellectual work.

4 Results and Findings

This chapter discusses the experimental findings obtained from the quantitative analysis of the collected survey data. The assessment of the theoretical model and the associated hypotheses was performed using Partial Least Squares Structural Equation Modelling (PLS-SEM) by SmartPLS 4 software. Additionally, related other statistical analysis was performed by using Microsoft Excel. To confirm accurate methodological reporting, this chapter follows a logical, sequential formation. Section 4.1 details the sample characteristics, primary data screening processes, and randomization verification to test the reliability of the between-subjects experimental design. Section 4.2 assesses the measurement model to testing construct reliability and validity. Section 4.3 analyses the structural model, detailing multi-collinearity and predictive capacity. Section 4.4 explains the hypotheses analysis, evaluating both direct and indirect relationships. Finally, Section 4.5 discusses the post-hoc analysis to verify the robustness of the findings to demographic heterogeneity.

4.1 Data Screening and Sample Characteristics

Prior to data analysis, initial screening of raw data (N = 106) collected through survey instruments was done. Incomplete survey data were removed from the data along with data with non-complying GDPR consent. This process was employed following the standard research guidelines, which suggested that researchers must remove casual responses to confirm precise measurements and reliable findings (DeSimone et al., 2015; Ward & Meade, 2023). After successful data screening process, the final sample size was N = 100.

The demographic profile of the final sample size (N=100) is comprised of 57 males (57%), 42 females (42%), and 1 respondent chose not to disclose gender. The majority of respondents were from age group 24 to 34 years, representing 49% of total sample. The next largest group of respondents was from age group 35 to 44, which was 40% of total sample. The vast

majority of participants were from international residents, who were 89% of the total respondent, followed by 9% and 2% of Finnish and EU citizens, respectively. The following Table 4.1 represents the full demographic distributions.

Table 4.1. Demographic Profile and Experimental Distribution of the Sample (N = 100)

Demographic Variable	Category	Group A: Human (n=54)	Group B: Functional Machine (n=46)	Total Frequency	Percentage (%)
Gender	Male	23	34	57	57.0%
	Female	31	11	42	42.0%
	Prefer not to say	0	1	1	1.0%
Age Group	18–24	3	2	5	5.0%
	25–34	28	21	49	49.0%
	35–44	18	22	40	40.0%
	45+	5	1	6	6.0%
Residence Status	International Resident	48	41	89	89.0%
	Finnish Citizen	6	3	9	9.0%
	EU Citizen	0	2	2	2.0%

The Webropol survey system's built-in logic was used for random assignment of experimental groups. Group A connected with a Human Avatar (n = 54), as Group B interacted with a Functional machine Avatar (n = 46). Table 4.2 shows the experimental groups gender distribution. To test whether this randomization worked accurately, Pearson Chi-Square tests was performed to investigate the demographic characteristics of each group. First, a Pearson Chi-Square test examined at gender of the two groups (N = 99, excluding the respondent who was unwilling to disclose gender). The test identified a significant variance in how

genders were distributed ($\chi^2 = 10.91$, $p < .001$), meaning the random split failed to create two equal experimental groups based on gender. Group B (Functional Machine Avatar) had more male participants, Group A (Human Avatar) had higher number of female participants.

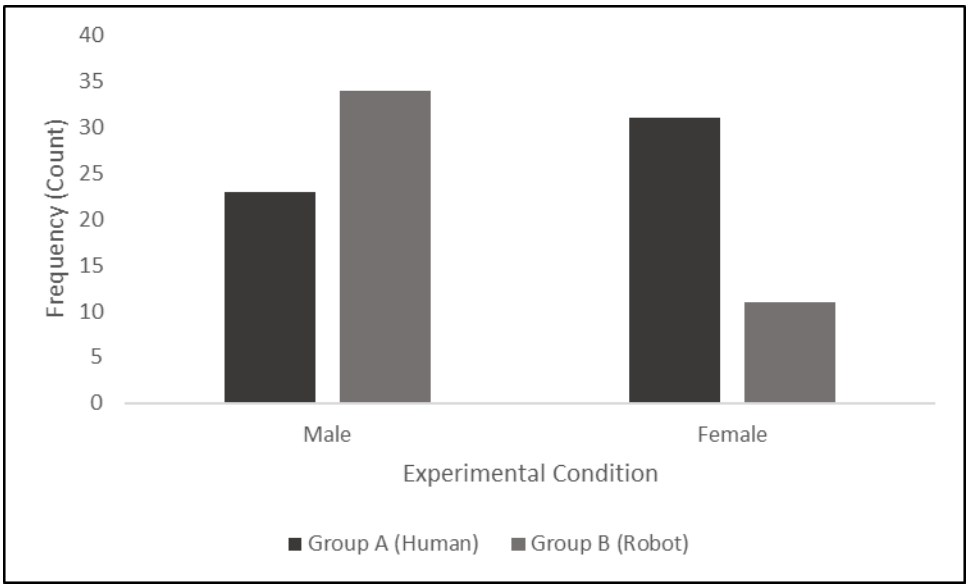

Figure 4.1. Cross-tabulation of gender distribution between the highly anthropomorphic (Group A) and machine-like (Group B) experimental conditions, illustrating the statistically significant skew.

The Chi-Square tested showed that age ($\chi^2 = 3.65$, $p = .302$) and Residence Status ($\chi^2 = 2.93$, $p = .231$) were evenly distributed between the two experimental groups. As these findings were not statistically significant, the Chi-Square tests ensured that the two experimental groups were demographically similar in terms of age and residency. As such, these demographic factors can be ruled out as confounding variables. This confirms that any variance in the dependent variables cannot be attributed to age or residence status.

As a significant variance was found in the experimental groups based on gender, it was treated as a control variable in later statistical tests. This decision confirms that the gender differences between the groups does not artificially impact the subsequent structural paths, which are discussed in Section 4.5. After confirming the sample distribution and randomization check, the next Section 4.2 discussed the evaluation of the measurement model.

4.2 Measurement Model Assessment

The measurement model was evaluated to find out its reliability and validity before moving toward in testing the proposed hypotheses. This evaluation process followed standard guidelines suggested by Hair et al. (2019) for partial least squares structural equation modelling (PLS-SEM). The measurement model evaluation focused on four main aspects: indicator reliability, internal consistency, convergent validity, and discriminant validity. The results of this evaluation confirm that the constructs are appropriately reliable and valid for the structural model testing.

First, item-level reliability was checked by examining the individual outer loading of the observed variables. According to the standard PLS-SEM guidelines by Hair et al. (2019), items require an outer loading > .708, showing that the conceptual variable interprets more than half of the variance in the items. The findings of indicator reliability shows that two items for the Perceived Greenwashing variable (RISK2 and RISK3) fell below the standard level of .708. These items (RISK2 and RISK3) were removed to secure the quality of the measurement model. As such, Perceived Greenwashing turn into a single-item construct (RISK1) with an outer loading of 1.00. Apart from this, all other multi-item constructs continued above the required level. Compliance Intention items presented strong reliability (COMP1 = .791, COMP2 = .829, COMP3 = .860). Similarly, Perceived Efficiency items also had strong reliability (FIT1 = .878, FIT2 = .765, FIT3 = .781).

Second, Composite Reliability (CR) and Cronbach's Alpha (CA) were used to measure internal consistency reliability. According to Hair et al. (2019), both these metrics need to be above .70 to be reliable. The CR values for all items were between .850 and .866. The CA values were between .735 and .772. As both CR and CA values were above the benchmark, the

measurement model showed satisfactory internal consistency, meaning the indicators for each item evaluated the concepts consistently. Table 4.2 represents the reliability and convergent validity of measurement model.

Table 4.2. Measurement Model Assessment (Reliability and Convergent Validity)

Construct	**Items**	**Outer Loadings**	**Cronbach's Alpha**	**Composite Reliability (CR)**	**Average Variance Extracted (AVE)**
Compliance Intention (DV)	COMP1	.791	.772	.866	.684
	COMP2	.829			
	COMP3	.860			
Perceived Efficiency (Med 2)	FIT1	.878	.735	.850	.655
	FIT2	.765			
	FIT3	.781			
Perceived Greenwashing (Med 1)	RISK1	1.000	Single-Item	Single-Item	Single-Item
Visual Stimulus (IV)	VISUAL	1.000	Single-Item	Single-Item	Single-Item

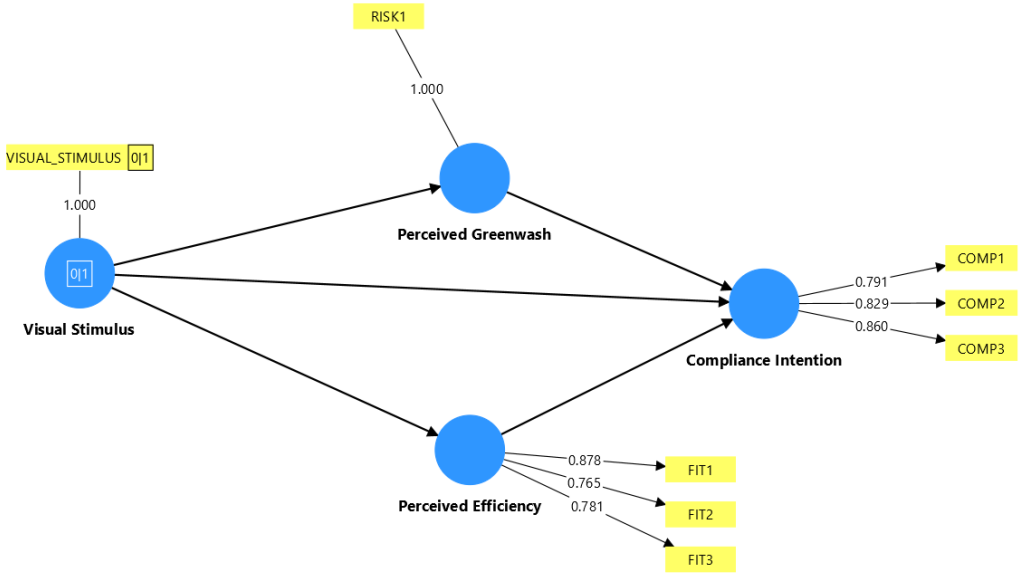

Figure 4.2. Graphical representation of the measurement model illustrating outer loadings for multi-item constructs. All retained indicators exceed the .708 threshold.

Third, the convergent validity was used to measure Average Variance Extracted (AVE). AVE explains how much variance in a construct comes from its indicators compared to measurement error. According to Hair et al. (2019), AVE higher than .50 is required for an item, explaining over half of the variance in its indicators. The AVE scores for all the items in this study ranged from .655 to .684, passing the benchmark and ensured convergent validity. This AVE score proved that each construct effectively explained the variance of its related item.

Fourth, discriminant validity was tested by using the Heterotrait-Monotrait (HTMT) ratio of correlations. HTMT is a robust evaluation to confirm constructs uniqueness (Henseler et al., 2015). According to Henseler et al. (2015), The benchmark of HTMT values is lower than .85 to prove the constructs are distinct. The highest HTMT score in this study was .645, which is lower than the benchmark. The achieved HTMT value confirming that all construct proved discriminant validity, showing that each construct evaluated a unique idea and did not overlap with others. Table 4.3 represents the HTMT ratio of this study.

Table 4.3. Discriminant Validity (Heterotrait-Monotrait Ratio)

Construct	(1)	(2)	(3)	(4)
(1) Compliance Intention	-			
(2) Perceived Efficiency	.645	-		
(3) Perceived Greenwashing	.599	.606	-	
(4) Visual Stimulus	.073	.026	.077	-

As the measurement model passed all fours aspects—indicator reliability, internal consistency, convergent validity, and discriminant validity—the structural model was evaluated in the next step.

4.3 Structural Model Assessment

After successful evaluation of Measurement model, the structural model needed to be evaluated. The structural model evaluation process followed the guidelines for information system research suggested by Benitez et al. (2020). This evaluation process included two steps. In first step, lateral collinearity between predictor variables were tested. In second step, how well the model explained the key dependent variable measured.

An analysis investigated the inner Variance Inflation Factor (VIF) for each factor before evaluating the path coefficients. This step identifies lateral collinearity. Collinearity occurs when independent variables are significantly correlated with each other, which can misrepresent the final estimates. According to Hair et al. (2019), inner VIF values benchmark is below 3.0 to avoid collinearity issue. In this analysis, the highest inner VIF score was recorded 1.397,

which is well below the benchmark 3.0 limit. As such, lateral collinearity did not have any negative impact on the path estimates.

Table 4.4. Lateral Collinearity Assessment (Inner VIF Values)

Predictor Construct	Target Construct	VIF	Threshold Check
Visual Stimulus (IV)	Perceived Efficiency (Med 2)	1.000	Pass (< 3.0)
Visual Stimulus (IV)	Perceived Greenwashing (Med 1)	1.000	Pass (< 3.0)
Visual Stimulus (IV)	Compliance Intention (DV)	1.011	Pass (< 3.0)
Perceived Efficiency (Med 2)	Compliance Intention (DV)	1.389	Pass (< 3.0)
Perceived Greenwashing (Med 1)	Compliance Intention (DV)	1.397	Pass (< 3.0)

Note: All VIF values are strictly below the 3.0 threshold recommended by Hair et al. (2019), confirming that the structural model is free from lateral collinearity bias.

Next, the explanatory power of the model was calculated using the coefficient of determination (R^2). The R^2 value explains how much variance in the dependent variable generated from independent variables. The result of analysis showed that the model explained 35.5% of the variance for dependent variable "Compliance Intention" (R^2 = .355). Human behaviour generally relies on various social, environmental, and psychological factors, and, for this complexity, an R^2 score of .355 suggests moderate-to-strong explanatory power for behavioural research (Cohen, 1988).

Table 4.5. Explanatory Power of the Structural Model

Endogenous Construct	R2 Value	R2 Adjusted	Explanatory Power
Compliance Intention (DV)	.355	.334	Moderate-to-Strong

Note: The R^2 values for the mediating variables (Perceived Efficiency and Perceived Greenwashing) were negligible (< .01), indicating that the visual stimulus alone does not explain their variance. However, the overall model successfully explains 35.5% of the variance in the ultimate dependent variable, Compliance Intention.

In summary, the structural model represents strong explanatory power without collinearity issues. The results validated the model for testing the proposed hypotheses. Accordingly, next Section 4.4 detailed the investigation of the proposed structural paths.

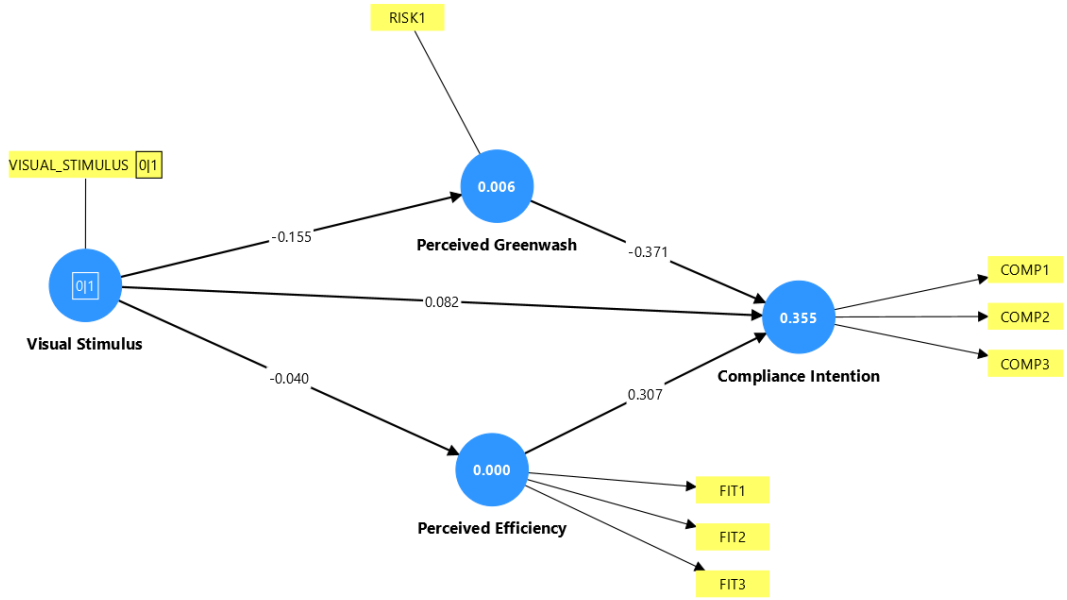

Figure 4.3. Graphical representation of the structural model. Values inside the endogenous constructs represent the coefficient of determination (R^2), while values on the arrows represent the standard path coefficients.

4.4 Hypothesis Testing and Path Analysis

The bootstrapping method in SmartPLS 4 software was used for hypothesis testing. The method used 5,000 sub-samples, a two-tailed test, and a significance level of $\alpha = .05$. This process generates standard errors and t-statistics irrespective of a specific data distribution. This method is recommended for testing path coefficients in PLS-SEM, which is also used for mediation analysis following the framework suggested by Nitzl et al. (2016).

Hypothesis 1 proposed that the visual stimulus (human versus functional machine avatar) would have a significant direct influence on compliance intention. The path coefficient is

positive but statistically insignificant (β = .082, t = .505, p = .614). The significance score was above the α = .05 limit. Therefore, the hypothesis 1 was rejected. This means the look of avatar did not have a significant direct impact on the user's compliance intentions.

Table 4.6. Direct Effects and Hypothesis Testing

Hypothesis / Path	Original Sample (β)	t-statistics	P-Value	Decision
H1: Visual Stimulus → Compliance Intention	.082	.505	.614	**Rejected**
Perceived Efficiency → Compliance Intention	.307	3.107	.002**	Supported
Perceived Greenwashing → Compliance Intention	-.371	3.931	.000***	Supported
Visual Stimulus →Perceived Efficiency	-.04	.199	.842	Insignificant
Visual Stimulus →Perceived Greenwashing	-.155	.772	.44	Insignificant

*Note: **p < .01, *** p < .001. The direct effect of the visual stimulus (Human vs. Functional Machine) on user compliance was not statistically significant, leading to the rejection of H1.*

Before examining at indirect effect, it is crucial to show that the paths from the mediator (perceived greenwashing and perceived efficiency) to the compliance intention are significant. According to Nitzl et al. (2016), this is necessary for indirect mediation to work. Perceived greenwashing had a significant negative influence on compliance intention (β = -.371, t = 3.931, p < .001). This result represents that higher perceived greenwashing resulted in lower compliance intention. Similarly, perceived efficiency has a significant positive impact on compliance intention (β = .307, t = 3.107, p = .002). This finding indicates that higher perceived efficiency led to higher compliance intention. Although both perceived greenwashing and perceived efficiency paths were significant, a significant path form the visual stimulus to the mediator must also exist for happening indirect mediation.

Hypotheses 2 and 3 proposed that the visual stimulus would have indirect influences on compliance intention through perceived greenwashing (H2) and perceived efficiency (H3). This process develops a parallel mediation model. The bootstrapping method yielded

specific indirect influences. For Hypothesis 2 (Visual Stimulus → Perceived Greenwashing → Compliance Intention), the indirect effect was statistically insignificant (β = .058, t = .721, p = .471). Therefore, Hypothesis 2 is rejected. For Hypothesis 3 (Visual Stimulus → Perceived Efficiency → Compliance Intention), the indirect effect was also statistically insignificant (β = -.012, t = .177, p = .859). Therefore, Hypothesis 3 is also rejected. As both indirect paths were not statistically significant, the visual stimulus did not activate any of the psychological mediator, i.e., perceived greenwashing and perceived efficiency.

Table 4.7. Specific Indirect Effects (Mediation Analysis)

Hypothesis / Indirect Path	Original Sample (β)	t-statistics	P-Value	Decision
H2: Stimulus →Greenwashing →Compliance	.058	.721	.471	**Rejected**
H3: Stimulus →Efficiency →Compliance	-.012	.177	.859	**Rejected**

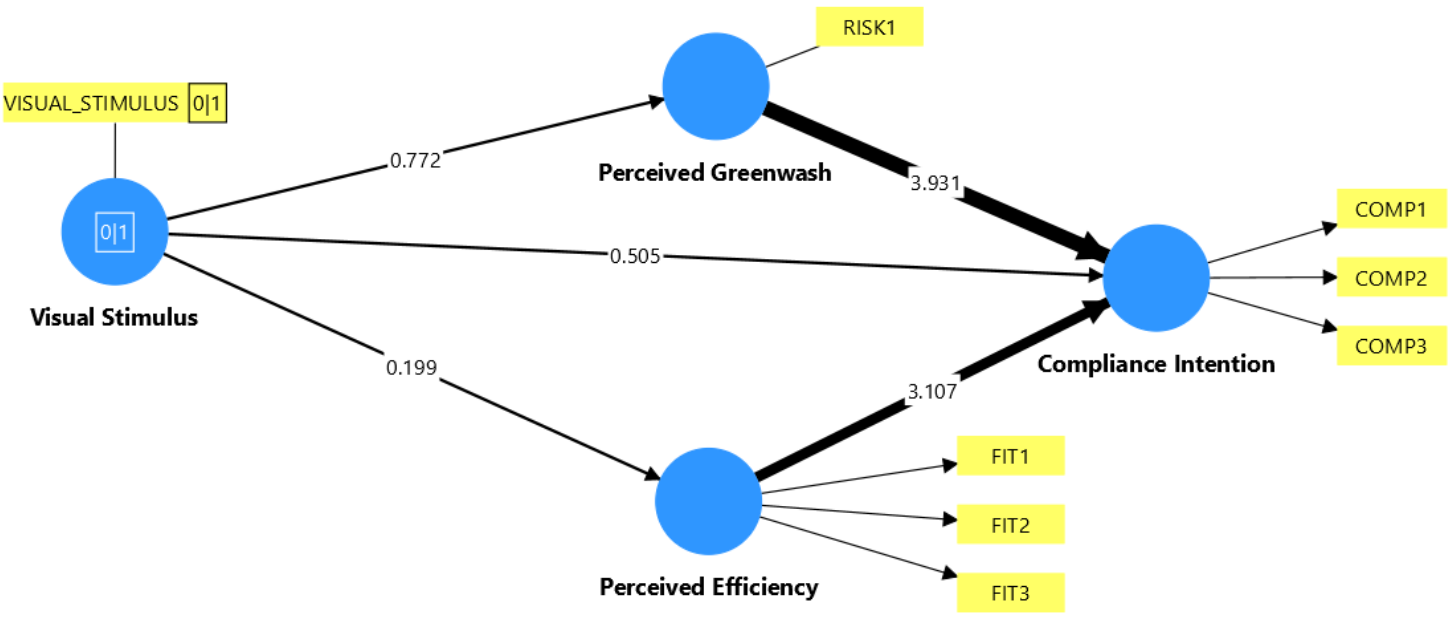

Figure 4.4. Bootstrapping results of the structural model (5,000 subsamples). Values on the inner paths represent t-statistics. Paths exceeding a t-statistics value of 1.96 are considered statistically significant at the .05 level.

Applying the theory from Nitzl et al. (2016), these findings show a non-mediation result. The independent variable (visual stimulus) did not have significant influence over any of the mediator. For this, the required condition for indirect mediation was missing. Therefore, the stimulus did not transfer its impact through perceive greenwashing or perceived efficiency. perceived greenwashing and perceived efficiency did not operate as mediating variable; rather, they both acted as independent, direct variables of compliance intention. This finding required a post-hoc analysis to see if difference in gender-based groups influenced these results, which detailed in following Section 4.5.

4.5 Post-Hoc Analyses

To examine the internal validity of the structural model, three different tests were performed. These tests ensured that the demographic variance of the respondents did not influence the results. Instead, the analysis ensured that the main theoretical variables explained the findings.

4.5.1 Robustness Check: Controlling for Gender

The collected sample contained a slight imbalance in gender. For this, gender was added as a control variable to the SmartPLS model. In this test, a direct path was made from gender to compliance intention. The analysis showed that the gender did not have a statistically significant influence on compliance intention (β= -.138, p = .262). The main relationship findings in the study stayed strong. The path from perceived greenwashing and perceived efficiency to compliance intention remained highly significant even after adding gender as the control variable. This showed that the gender differences in experimental group did not influence the main findings of the model.

Table 4.8. Structural Model Robustness Check (Gender as a Control Variable)

Structural Path	Original Sample (β)	P-Value	Decision
Gender → Compliance Intention (Control)	-.138	.262	Insignificant
Perceived Efficiency → Compliance Intention	.323	.002**	**Remains Supported**
Perceived Greenwashing → Compliance Intention	-.373	.000***	**Remains Supported**

*Note. *p < .01, *** p < .001. The introduction of gender as a control variable did not yield a significant effect on the dependent variable, and the primary theoretical pathways remained robust and highly significant*

4.5.2 Gender Differences in Baseline Compliance

To examine whether male and female respondents had any different level of compliance intention before the experiment started, an independent samples t-test was performed. Assuming equal variances, no statistically significant variance between two gender groups was found (t = 1.242, p = .217). This finding indicates that both male and female started with a similar intention to follow safety guidelines. This result eliminates the possibility that early behavioural variances biased the experimental findings.

Table 4.9. Independent Samples t-test for Baseline Compliance by Gender

Gender	N	Mean	Variance	t-statistic	p-Value
Male	57	3.58	.439	1.242	.217
Female	42	3.75	.537		

Note: The t-test assumes equal variances. The results indicate no statistically significant difference in baseline compliance intentions between male and female participants prior to experimental routing.

4.5.3 Generational Differences in Technology Readiness

To confirm the baseline comparability, a one-way Analysis of Variance (ANOVA) was performed to measure technological skills across age groups. The finding was not statistically significant among the generations (F = 1.943, p = .128), explaining that all age groups have similar digital skills. As such, lack of technological skill did not have any influence over any specific group when they evaluated the interface.

Table 4.10. One-Way ANOVA for Technology Readiness Across Age Groups

Age Group	N	Mean	Variance	F-Statistic	p-Value
18–24	5	3.00	1.375	1.943	.128
25–34	49	3.52	.645		
35–44	40	3.36	.987		
45+	6	4.17	.167		

Note: The analysis of variance reveals no statistically significant difference (p > .05) in baseline technology readiness across the generational cohorts, confirming uniform digital literacy across the sample.

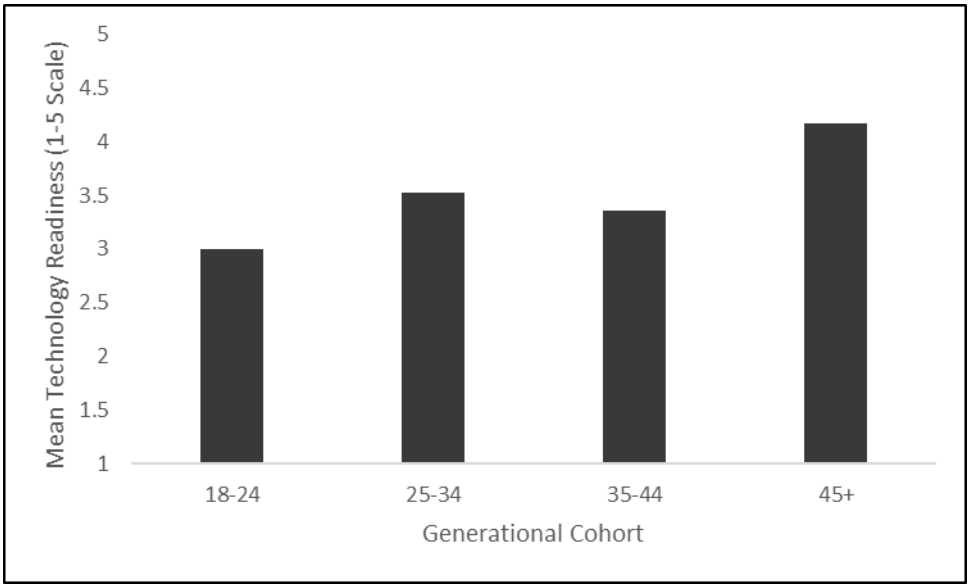

Figure 4.5. Mean Technology Readiness Across Generational Cohorts

In summary, these post-hoc analyses offered extra checks to prove that the key outcomes recorded in this chapter were generated from the theoretical factors, such as perceived risk and perceived efficiency. The results are not influenced by demographic differences. These post-hoc analyses findings created a significant and reliable baseline for Chapter 5, which highlighted the theoretical and practical implications of the study.

5 Discussion and Conclusion

This final chapter combines the findings from Chapter 4 with the key theoretical foundations discussed earlier in this thesis. The key objective of this chapter is to explain the statistical findings—particularly the ineffectiveness of anthropomorphic stimuli and the influence of cognitive factors — applying the Elaboration Likelihood Model (ELM) and Perceived Risk Theory. Section 5.1 gives a summary about the finding from the structural model. The following Section 5.2 explains and defends the "Avatar-Blindness" influence observed in safety-critical tasks settings. The following Section 5.3 discusses the theoretical contribution to the Information Systems (IS) research. Section 5.4 focuses on the actionable practical contributions to the Green IS and hazardous e-waste domain. The final Sections 5.5 and 5.6 wraps up by reflecting on this study's methodological limitations, highlighting future research opportunities, and concludes with a summary of this thesis.

5.1 Summary of Findings

The data analysis of this study applied Partial Least Squares Structural Equation Modelling (PLS-SEM) with a sample size of N = 100. The model presented a good ability to predict user choices by successfully explaining 35.5% of the total variances in Compliance Intention (R^2 = .355). The theoretical contexts generally suggests that anthropomorphic (human-like) digital interfaces are effective for user engagement. However, the experiment contrasting an anthropomorphic (human-like) avatar to a functional machine (robot) avatar did not show any direct significant influence on users' compliance intentions (p = .614). Additionally, according to the findings, the visual stimulus did not generate expected mediation influence in the model. This statistical analysis finding rejected hypothesis H1, hypothesis H2 (p = .471), and hypothesis H3 (p = .859).

Alternatively, the structural model identified two key factors that significantly anticipated user behaviour. Those were: Perceived Greenwashing ($\beta = -.371$, $p < .001$) and Perceived Efficiency ($\beta = .307$, $p = .005$). These findings show a clear pattern for recycling e-waste. Users prioritize the system features and institutional integrity instead of emotional reactions to anthropomorphic (human-like) digital avatars.

5.2 Explaining the "Avatar-Blindness" Phenomenon

The failure of human-like avatar design to influence user behaviour point out toward the concept of "Avatar-Blindness", where users ignore human-like social signals from digital characters. This concept was discussed in Elaboration Likelihood Model (ELM), which was published by Petty and Cacioppo (1986) in Advances in Experimental Social Psychology. According to Bhattacherjee and Sanford (2006), the influential power of an information system depends on the user's level of reasoning elaboration, which is the degree of users' critical evaluation of task related information. Though the "Computers Are Social Actors" (CASA) model usually works via mental shortcuts influenced by external signals—such as visual attributes—the high-risk settings of managing hazardous lithium-ion batteries highly boost the perceived risk.

According to Perceived Risk Theory (Gefen et al., 2003), the danger associated to health and environment forces users to be cautious regarding disposing electronic waste like lithium-ion batteries. This high psychological responsibility push users to use a central thinking path. On this path, users thoroughly evaluate the quality of information and the system efficiency. During this deep-thinking process, users perceive the extra visual details like human-like face as meaningless noise and fully avoid such details. As a result, users applied their mental effort in evaluating perceived efficiency and investigating for perceived greenwashing. The

emotional influence of the human-like avatar does not impact their final decision-making process.

5.3 Theoretical Contributions

This master's thesis contributes several new significant knowledge to the Information Systems (IS) research. It particularly links environmental systems (Green IS) with human-computer interaction. First, the findings of this thesis strictly draw a clear boundary for the CASA paradigm. The study shows that human-like avatar has no significant influence in high-risk settings. This finding refines earlier trust research by Benbasat and Wang (2005). The study finds a clear transition from emotional trust to logical trust. The physical danger concerns from hazardous waste are more significant than the visual aesthetics which usually develop trust in safe e-commerce settings.

Second, this study enhanced the Green IS research by identifying Perceived Greenwashing as a major psychological barrier to user compliance. This negative factor works as a mental filter, which forces users to question the institutional transparency and evaluating the integrity of the recycling system regardless the look of digital screen. The findings suggests that environmental scepticism is a major concern which cannot be fixed by deploying beautiful designs or anthropomorphic (human-like) avatars.

Third, this research presents methodological accuracy by showing that efficiency encourages behaviour for people. The statistical model stayed precise even when measuring different groups of participants. For example, the observation that there is no statistically significant influence of Gender on the main findings ($p = .262$), shows that influence of service and transparency over anthropomorphic signals is a stable human behaviour in high-risk settings.

Finally, this study refines the ELM theory for high-risk contexts. It suggests that serious physical and environmental risks do not just lower the use of mental shortcuts but completely block it, forcing users into a true logical thinking state. For this, clear information and useful technology turn into the most critical factors. The finding of this study suggests that designers should focus on functional efficiency of the system over visual aesthetic, allowing users in effectively process important safety information.

5.4 Practical Implications for System Designers

This study combines the Elaboration Likelihood Model (ELM) and Perceived Risk Theory, offering actionable ideas for designing digital agents in city electronic waster (e-waste) management. Handling items which is harmful for both health and environment, such as disposing end-of-life lithium-ion batteries, generates a high-risk task profile. In such cases, users depend on careful and deep critical thinking. As such, digital system designers must realign their design priorities which can provide actual and accurate information and psychological efficiency instead of providing social signals through human-like appearances.

First, designers must prioritize simple functionality and process transparency of the digital system instead of focusing on high anthropomorphic features. The findings of the study suggest that investing on developing hyper-realistic human-like agents is poor choice as safety compliance is the key objective for hazardous e-waste management systems. A high-risk task situation forces users to focus on the actual instructions rather than visual details of the digital service agents. As such, users may perceive emotional or anthropomorphic traits as useless of distracting. The system design should focus on improving efficiency and clarity which will reduce the mental efforts required to process the complex social signals (Dennis et al., 2014). In context of managing hazardous materials, a simple tool that focuses on the

functional information is a good choice rather than investing on a system that trying to act like an actual human.

Second, the system designers should actively focus on reducing users perceive greenwashing. This can be achieved by offering authentic, verifiable, and actionable data. The study found that the key reason for ignoring safety rules by users is the perceived greenwashing. For this, system designers and developers must avoid using friendly digital avatar to conceal a lack of actual information. In safety-critical context like e-waste recycling, a friendly digital avatar is not effective for trust building. Instead, clear and verifiable data, simple instructions about the recycling process are critical for developing users' trust. The system must design to have the flexibility for users to verify the information regarding organizational environmental claims. This process uses transparency to lower the perceived greenwashing risk.

Third, the designers require to simplify the user experience to maximize the perceived efficiency. Efficiency is the key factor that significantly influences users' compliance intention with safety guidelines. As such, the digital tool should work smoothly and faster with minimal actions required from users. The designers should focus on offering direct path for task completion by reducing the number of clicks required, and removing long, complex, and confusing dialogs from the task process. The system must be able to provide actual safety instructions and allowing fast communication to satisfy users who are engaged in careful deep and critical thinking. In hazardous e-waste management system, the most effective social trait of a digital agent is its ability to guide users to complete the task safely, quickly, and transparently.

5.5 Limitations and Future Research

5.5.1 Sampling and Geographical Limitations

The findings of this study have some limitations. These limitations are originated from the chosen sampling technique and the demographic profile of the participants. The study used non-parametric convenience sampling supplemented by snowball sampling for data collection (N = 100). This sampling technique is a fast process to reach specific groups. However, it does not represent the wider population as precisely as random sampling does. Additionally, the study was geographically constrained and conducted in Finland only. The responses were heavily relied on international residents, who comprised 89% of the total sample. So, the finding might resonate the perspectives of a specific or temporary subgroup instead of broader population. Future research should employ cross-cultural random sampling technique. This is necessary to confirm the "Avatar-Blindness" concept across different cultural and regulatory settings regarding the circular economy practices.

5.5.2 Experimental Design Limitations

Minor variances in the avatar images shown to the experimental groups is another critical limitation of this study. More particularly, the images of anthropomorphic (human-like) avatar and functional machine (machine-like) avatar presented in the survey had different visual backgrounds. In addition, the human-like avatar design incorporated a recycling logo which was missing in functional machine avatar image. These small differences acted as an extra factor which might have a slight influence over the outcome. The key objective of this research was to evaluate only the influence of anthropomorphic avatar features. But the additional background details (which was randomly generated by generative LLM) could have influence the user’s perspective of the avatars. For improved research reliability, future

studies must confirm that the background and contextual visual features in the avatar design are identical. This can be achieved by utilizing standardized 3d models, ensuring the background and contextual details remains identical for every experimental groups.

5.5.3 Measurement Limitations

Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to evaluate the measurement model. During the model evaluation process, two items from the perceived greenwashing variable were removed due to lower outer loading values. This removal resulted in a single-item construction for perceived greenwashing variable. According to Hair et al. (2019), statistical rule allows single item use, and it remains reliable within specific model. But this process shows a clear limitation, as one single item cannot fully record the complex nature of the greenwashing concept. As the sustainability digitalization is growing continuously, future studies in Green Information Systems must look for developing better measurement tools. It is needed to develop and test new multi-item scales to evaluate perceived digital greenwashing in virtual service settings.

5.5.4 Generalizability and Behavioural Limitations

The focus of this study is limited to evaluating safety-critical e-waste recycling context, more specifically disposal of hazardous lithium-ion batteries. Disposing lithium-ion batteries involves serious effects. As a result, the findings might not be applicable to low-risk e-waste, such as plastic cables, small computer parts etc. When dealing with low-risk item, users might process recycling information differently. Additionally, the study only evaluated participants compliance intention instead if actual behavioural actions. Participants usually give socially acceptable responses in environmental studies to present themselves as responsible. For such bias, future research should employ long-term filed studies or direct

behavioural observation to monitor actual behaviour to connect the gap between intentions and behavioural actions in hazardous waste management.

5.6 Conclusion

The transition towards a digital circular economy presents a major challenge. As traditional waste management systems converted into complex digital systems, users need assistance to handle hazardous e-waste. AI-powered digital virtual agents could offer a technology-based process to solve this challenge. However, this thesis shows that designing these virtual agents anthropomorphic (human-like) does not have influence on users' safety compliance in safety-critical high-risk task settings. The Elaboration Likelihood Model (ELM) supports this finding. When users perceived risk, such as disposing end-of-life or unstable lithium-ion batteries, they simply ignore the visual aesthetic details of the agent. Instead, users focus on the systems actual efficiency and usefulness in task completion. This attitude, which is known as "Avatar-Blindness" represents a primary change in users' actual expectations from green information systems. Users concern more about perceived efficiency and the absence of perceived greenwashing over the friendly and anthropomorphic features of the systems. It may be suggested that digital sustainability platforms fail by designing anthropomorphic (human-like) machines. Instead, they succeed through offering actual, verifiable, and clear information. This thesis established that developing a sustainable digital future necessitates significant focus on task-technology fit and trust-building over the visual design of avatars. The findings of this study indicate that true quality and integrity of the system are the only factors that make users to comply with the safety rules.

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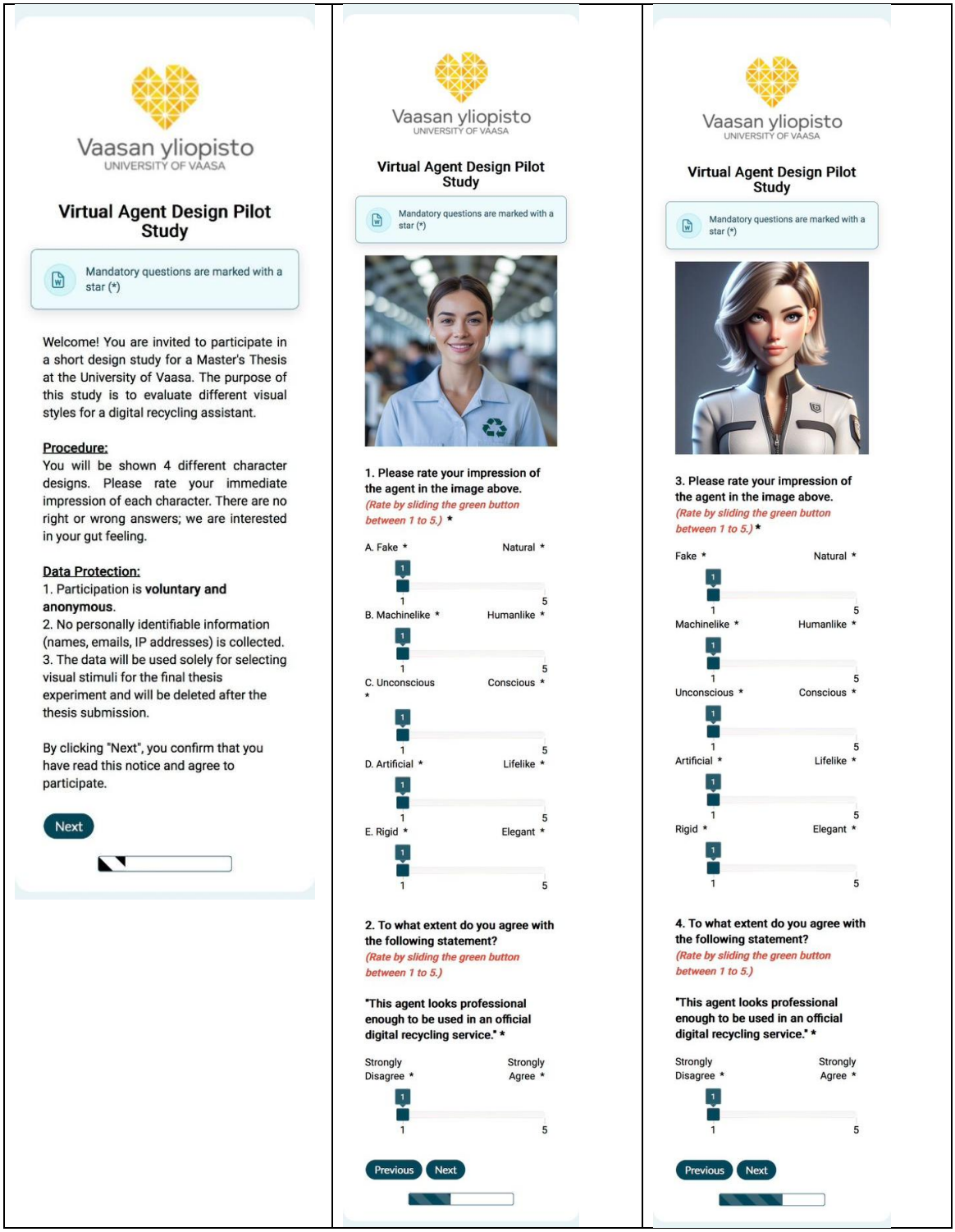
7 Appendix 1: Pilot Study Questionnaire



Vaasan yliopisto
UNIVERSITY OF VAASA

Virtual Agent Design Pilot Study

Mandatory questions are marked with a star (*)

Welcome! You are invited to participate in a short design study for a Master's Thesis at the University of Vaasa. The purpose of this study is to evaluate different visual styles for a digital recycling assistant.

Procedure:
You will be shown 4 different character designs. Please rate your immediate impression of each character. There are no right or wrong answers; we are interested in your gut feeling.

Data Protection:
1. Participation is **voluntary and anonymous**.
2. No personally identifiable information (names, emails, IP addresses) is collected.
3. The data will be used solely for selecting visual stimuli for the final thesis experiment and will be deleted after the thesis submission.

By clicking "Next", you confirm that you have read this notice and agree to participate.

Next

Vaasan yliopisto
UNIVERSITY OF VAASA

Virtual Agent Design Pilot Study

Mandatory questions are marked with a star (*)

1. Please rate your impression of the agent in the image above.
(Rate by sliding the green button between 1 to 5.) *

A. Fake * — Natural *
B. Machinelike * — Humanlike *
C. Unconscious * — Conscious *
D. Artificial * — Lifelike *
E. Rigid * — Elegant *

1 — 5

2. To what extent do you agree with the following statement?
(Rate by sliding the green button between 1 to 5.)

"This agent looks professional enough to be used in an official digital recycling service." *

Strongly Disagree * — Strongly Agree *

1 — 5

Previous Next

Vaasan yliopisto
UNIVERSITY OF VAASA

Virtual Agent Design Pilot Study

Mandatory questions are marked with a star (*)

3. Please rate your impression of the agent in the image above.
(Rate by sliding the green button between 1 to 5.) *

Fake * — Natural *
Machinelike * — Humanlike *
Unconscious * — Conscious *
Artificial * — Lifelike *
Rigid * — Elegant *

1 — 5

4. To what extent do you agree with the following statement?
(Rate by sliding the green button between 1 to 5.)

"This agent looks professional enough to be used in an official digital recycling service." *

Strongly Disagree * — Strongly Agree *

1 — 5

Previous Next

Vaasan yliopisto
UNIVERSITY OF VAASA

Virtual Agent Design Pilot Study

Mandatory questions are marked with a star (*)

5. Please rate your impression of the agent in the image above.
(Rate by sliding the green button between 1 to 5.) *

Fake * — Natural *
Machinelike * — Humanlike *
Unconscious * — Conscious *
Artificial * — Lifelike *
Rigid * — Elegant *

6. To what extent do you agree with the following statement?
(Rate by sliding the green button between 1 to 5.)

"This agent looks professional enough to be used in an official digital recycling service." *

Strongly Disagree * — Strongly Agree *

Previous Next

Vaasan yliopisto
UNIVERSITY OF VAASA

Virtual Agent Design Pilot Study

Mandatory questions are marked with a star (*)

7. Please rate your impression of the agent in the image above.
(Rate by sliding the green button between 1 to 5.) *

Fake * — Natural *
Machinelike * — Humanlike *
Unconscious * — Conscious *
Artificial * — Lifelike *
Rigid * — Elegant *

8. To what extent do you agree with the following statement?
(Rate by sliding the green button between 1 to 5.)

"This agent looks professional enough to be used in an official digital recycling service." *

Strongly Disagree * — Strongly Agree *

Previous Submit

Thank you for your participation!

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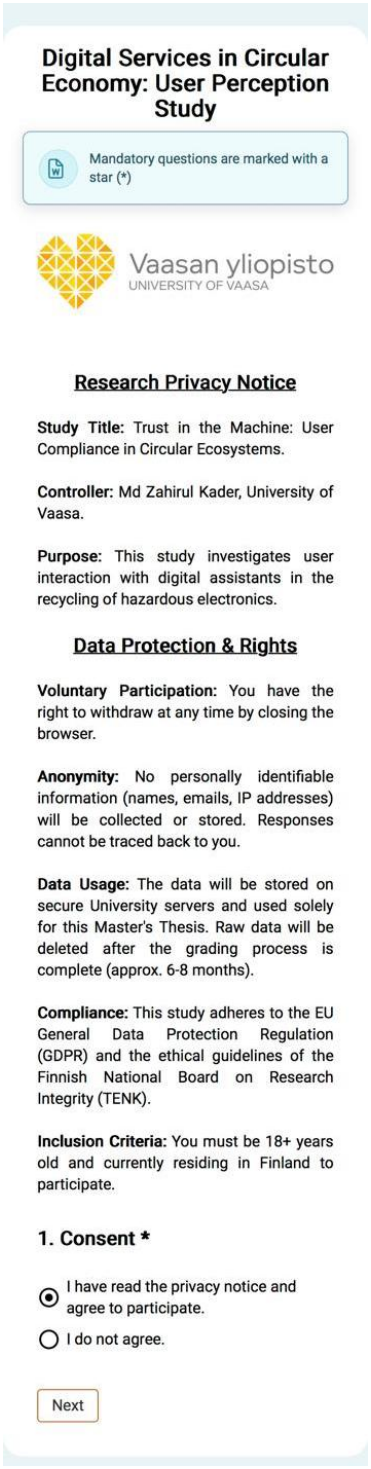
8 Appendix 2: Experimental Group A Questionnaire



Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

Vaasan yliopisto
UNIVERSITY OF VAASA

Research Privacy Notice

Study Title: Trust in the Machine: User Compliance in Circular Ecosystems.

Controller: Md Zahirul Kader, University of Vaasa.

Purpose: This study investigates user interaction with digital assistants in the recycling of hazardous electronics.

Data Protection & Rights

Voluntary Participation: You have the right to withdraw at any time by closing the browser.

Anonymity: No personally identifiable information (names, emails, IP addresses) will be collected or stored. Responses cannot be traced back to you.

Data Usage: The data will be stored on secure University servers and used solely for this Master's Thesis. Raw data will be deleted after the grading process is complete (approx. 6-8 months).

Compliance: This study adheres to the EU General Data Protection Regulation (GDPR) and the ethical guidelines of the Finnish National Board on Research Integrity (TENK).

Inclusion Criteria: You must be 18+ years old and currently residing in Finland to participate.

1. Consent *

- (●) I have read the privacy notice and agree to participate.
- ( ) I do not agree.

Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

2. For the survey questions framing, kindly select your birth month group: *

- (●) Group A: Jan, Mar, May, Jul, Sept, Nov
- ( ) Group B: Feb, Apr, Jun, Aug, Oct, Dec

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

Please read and answer the questions based on the following scenario carefully :

"You have a device (old laptop/ used power bank / mobile) at home that contains Lithium-Ion batteries that you wish to discard. Because of the Lithium-Ion batteries, the devices are classified as hazardous waste (fire ris k) and cannot be thrown in the regular trash.

You open a recycling app/website to arrange a return. The app / website uses the following Virtual Agent to guide you through the mandatory safety inspection."

18. Based on the image you just saw, please rate your impression of the Virtual Agent.

(To rate, you need to slide the green button between 1 to 5.) *

Fake — Natural (1 – 5)

Machine-like — Human-like (1 – 5)

Unconscious — Conscious (1 – 5)

Artificial — Lifelike (1 – 5)

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

For the following questions, please rate your agreement with the following statements regarding the service agent.

19. I feel this agent might mislead me about the recycling process. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

20. The design of this agent tries to cover up the complexity of the task. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

21. I feel this agent is designed to manipulate my impression rather than help me. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

For the following questions, please rate your agreement with the following statements regarding the service agent.

22. This agent looks competent enough to handle hazardous waste instructions. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

23. The agent's visual style fits the technical nature of Lithium-Ion battery safety. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

24. I would rely on this agent to provide accurate safety data. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

Based on the scenario, how likely are you to act?

25. I would follow the safety instructions provided by this agent. *

- ○ Highly Unlikely
- ○ Unlikely
- ○ Neutral
- ○ Likely
- ○ Highly Likely

26. I would use this service to return my old electronics for recycling. *

- ○ Highly Unlikely
- ○ Unlikely
- ○ Neutral
- ○ Likely
- ○ Highly Likely

27. I would recommend this recycling service to others. *

- ○ Highly Unlikely
- ○ Unlikely
- ○ Neutral
- ○ Likely
- ○ Highly Likely

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

Please rate your agreement with the following statements.

28. I usually figure out new high-tech products and services without help from others. *

- ○ Strongly Disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly Agree

29. I enjoy the challenge of figuring out high-tech gadgets. *

- ○ Strongly Disagree
- ○ Disagree
- ○ Neutral
- ○ Agree
- ○ Strongly Agree

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

Demographic Questions

30. Residence Status *

- Finnish Citizen
- EU Citizen
- International Residence

31. Gender *

- Male
- Female
- Other
- Prefer not to say

32. Age Group *

- 18-24
- 25-34
- 35-45
- 45+

Previous Submit

Thank you for your participation!

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9 Appendix 3: Experimental Group B Questionnaire

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

Vaasan yliopisto
UNIVERSITY OF VAASA

Research Privacy Notice

Study Title: Trust in the Machine: User Compliance in Circular Ecosystems.

Controller: Md Zahirul Kader, University of Vaasa.

Purpose: This study investigates user interaction with digital assistants in the recycling of hazardous electronics.

Data Protection & Rights

Voluntary Participation: You have the right to withdraw at any time by closing the browser.

Anonymity: No personally identifiable information (names, emails, IP addresses) will be collected or stored. Responses cannot be traced back to you.

Data Usage: The data will be stored on secure University servers and used solely for this Master's Thesis. Raw data will be deleted after the grading process is complete (approx. 6-8 months).

Compliance: This study adheres to the EU General Data Protection Regulation (GDPR) and the ethical guidelines of the Finnish National Board on Research Integrity (TENK).

Inclusion Criteria: You must be 18+ years old and currently residing in Finland to participate.

1. Consent *

- (●) I have read the privacy notice and agree to participate.
- ( ) I do not agree.

Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

2. For the survey questions framing, kindly select your birth month group: *

- ( ) Group A: Jan, Mar, May, Jul, Sept, Nov
- (●) Group B: Feb, Apr, Jun, Aug, Oct, Dec

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

Please read and answer the questions based on the following scenario carefully :

"You have a device (old laptop / used power bank / mobile) at home that contains Lithium-Ion batteries that you wish to discard. Because of the Lithium-Ion batteries, the devices are classified as hazardous waste (fire risk) and cannot be thrown in the regular trash.

You open a recycling app/website to arrange a return. The app / website uses the following Virtual Agent to guide you through the mandatory safety inspection."

3. Based on the image you just saw, please rate your impression of the Virtual Agent.

(To rate, you need to slide the green button between 1 to 5.) *

Fake		Natural
1		5
Machine-like		Human-like
1		5
Unconscious		Conscious
1		5
Artificial		Lifelike
1		5

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

For the following questions, please rate your agreement with the following statements regarding the service agent.

4. I feel this agent might mislead me about the recycling process. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

5. The design of this agent tries to cover up the complexity of the task. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

6. I feel this agent is designed to manipulate my impression rather than help me. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

For the following questions, please rate your agreement with the following statements regarding the service agent.

7. This agent looks competent enough to handle hazardous waste instructions. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

8. The agent's visual style fits the technical nature of Lithium-Ion battery safety. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

9. I would rely on this agent to provide accurate safety data. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

Based on the scenario, how likely are you to act?

10. I would follow the safety instructions provided by this agent. *

- Highly Unlikely
- Unlikely
- Neutral
- Likely
- Highly Likely

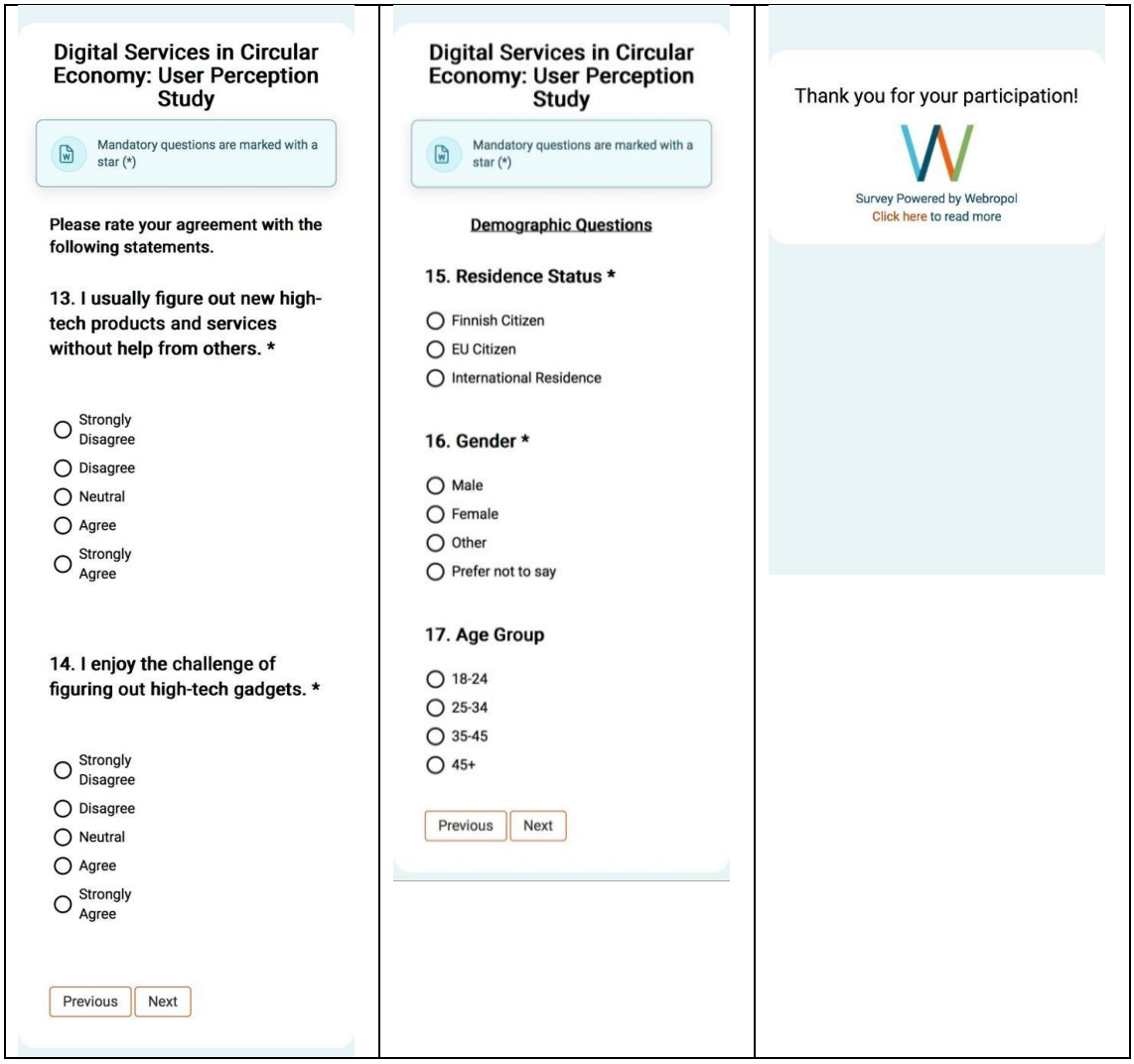
11. I would use this service to return my old electronics for recycling. *

- Highly Unlikely
- Unlikely
- Neutral
- Likely
- Highly Likely

12. I would recommend this recycling service to others. *

- Highly Unlikely
- Unlikely
- Neutral
- Likely
- Highly Likely

Previous Next



Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

Please rate your agreement with the following statements.

13. I usually figure out new high-tech products and services without help from others. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

14. I enjoy the challenge of figuring out high-tech gadgets. *

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Previous Next

Digital Services in Circular Economy: User Perception Study

Mandatory questions are marked with a star (*)

Demographic Questions

15. Residence Status *

- Finnish Citizen
- EU Citizen
- International Residence

16. Gender *

- Male
- Female
- Other
- Prefer not to say

17. Age Group

- 18-24
- 25-34
- 35-45
- 45+

Previous Next

Thank you for your participation!

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10 Appendix 4: PLS-SEM Data

Appendix Table 1. Descriptive Statistics for Measurement Indicators (Mean, Standard Deviation, Minimum, and Maximum)

Indicator data (original) - Descriptives

	Mean	Median	Observed min	Observed max	Number of observations used	Standard deviation	Excess kurtosis	Skewness	Cramér-von Mises test statistic	Cramér-von Mises p value
COMP1	3.710	4.000	1.000	5.000	100.000	0.852	1.194	-0.975	1.937	0.000
COMP2	3.730	4.000	1.000	5.000	100.000	0.823	1.676	-1.097	2.206	0.000
COMP3	3.450	4.000	1.000	5.000	100.000	0.953	0.158	-0.665	1.183	0.000
FIT1	3.240	3.500	1.000	5.000	100.000	1.011	-0.486	-0.560	1.123	0.000
FIT2	3.160	3.000	1.000	5.000	100.000	1.017	-0.498	-0.271	0.769	0.000
FIT3	3.150	3.000	1.000	5.000	100.000	1.023	-0.349	-0.592	0.977	0.000
RISK1	2.590	2.000	1.000	5.000	100.000	1.001	0.176	0.659	1.022	0.000
VISUAL_STIMULUS	0.540	1.000	0.000	1.000	100.000	0.498	-2.014	-0.163	2.959	0.000

Appendix Table 2. Outer Loadings Matrix for Item Reliability Assessment

Outer loadings - Matrix

	Compliance Intention	Perceived Efficiency	Perceived Greenwash	Visual Stimulus
COMP1	0.791			
COMP2	0.829			
COMP3	0.860			
FIT1		0.878		
FIT2		0.765		
FIT3		0.781		
RISK1			1.000	
VISUAL_STIMULUS				1.000

Appendix Table 3. Outer Variance Inflation Factor (VIF) Statistics for Indicator Collinearity

Collinearity statistics (VIF) - Outer model - List	
	VIF
COMP1	1.498
COMP2	1.749
COMP3	1.577
FIT1	1.753
FIT2	1.439
FIT3	1.415
RISK1	1.000
VISUAL_STIMULUS	1.000

Appendix Table 4. Inner Variance Inflation Factor (VIF) Statistics for Structural Model Collinearity

Collinearity statistics (VIF) - Inner model - List	
	VIF
Perceived Efficiency -> Compliance Intention	1.389
Perceived Greenwash -> Compliance Intention	1.397
Visual Stimulus -> Compliance Intention	1.011
Visual Stimulus -> Perceived Efficiency	1.000
Visual Stimulus -> Perceived Greenwash	1.000

Appendix Table 5. Discriminant Validity Assessment Using the Fornell-Larcker Criterion

Discriminant validity - Fornell-Larcker criterion				
	Compliance Intention	Perceived Efficiency	Perceived Greenwash	Visual Stimulus
Compliance Intention	0.827			
Perceived Efficiency	0.501	0.809		
Perceived Greenwash	-0.535	-0.526	1.000	
Visual Stimulus	0.063	-0.020	-0.077	1.000

Appendix Table 5. Cross-Loadings Matrix for Discriminant Validity Assessment

Discriminant validity - Cross loadings				
	Compliance Intention	Perceived Efficiency	Perceived Greenwash	Visual Stimulus
COMP1	0.791	0.352	-0.421	0.110
COMP2	0.829	0.349	-0.377	0.014
COMP3	0.860	0.512	-0.509	0.036
FIT1	0.455	0.878	-0.476	0.001
FIT2	0.361	0.765	-0.270	-0.032
FIT3	0.394	0.781	-0.516	-0.022
RISK1	-0.535	-0.526	1.000	-0.077
VISUAL_STIMULUS	0.063	-0.020	-0.077	1.000

Appendix Table 6. Specific Indirect Effects and Mediation Analysis Results

Specific indirect effects - Mean, STDEV, T values, p values					
	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Visual Stimulus -> Perceived Greenwash -> Compliance Intention	0.058	0.060	0.080	0.721	0.471
Visual Stimulus -> Perceived Efficiency -> Compliance Intention	-0.012	-0.008	0.070	0.177	0.859