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HUMANIZING TECHNOLOGY

EXPLORING THE UNCANNY VALLEY AND BASIC PSYCHOLOGICAL NEEDS IN AI MIND PERCEPTION AS TOOLS, AGENTS, AND EXPERIENCERS

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Abstract

Artificial Intelligence (AI), its breakthroughs and rapid integration in our life and society necessitates an in-depth exploration on how humans are perceiving them. This work delves to study the effect of AI mind perception as tool, agent, and experiencer on the Uncanny effect and basic psychological needs fulfillment. Drawing on the established psychological theories, including Theory of Mind, Uncanny valley theory, Self Determination theory, and theories on Human-Computer Interaction, this study aims to provide a comprehensive analysis. We aim to validate that AI's capacity to feel (experience) elicit stronger feeling of eeriness than its capacity for planning and self-control (agency). We use Basic Psychological needs for technological use (BPN-TU) scale to study the effect of AI's mind perception in basic psychological needs fulfillment. The study adopts an online experiment using survey questionnaire to measure users' perceptions towards an AI system named Maya presented in the healthcare context. The findings of this research are anticipated to provide valuable insights into the humanization of technology, offering practical implications for the design and deployment of human-centered, trustworthy and responsible AI systems.

Humanizing Technology: Exploring the Uncanny Valley and Basic Psychological Needs in AI Mind Perception as Tools, Agents, and Experiencers

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Introduction

Artificial Intelligence (AI) is the science and engineering of creating intelligent machines using a set of algorithmic functions to mimic human intelligence and cognition including learning, reasoning, self correction, and problem solving. AI is rapidly integrating in our daily lives and influencing various facets of our society and behavior. The economic impact of AI is equally profound, and it is predicted that AI will permeate most industries and contribute an estimated US $15.7 trillion to the world economy by 2030 (Murphy et al., 2021). The expeditious development of AI software and hardware has seen its application in various technical fields like Internet of Things (IoT), autonomous driving, natural language processing, robotics, biomedical fields, etc, and is uplifting the businesses, healthcare, education, and making a tangible impact in the society.

As AI systems become increasingly sophisticated, the nature of human interaction with these systems grows more complex. The complexity not only arises from the technology, but from the psychological perspective of individuals, and this in turn influences the understanding and engagement with AI (Kelly et al., 2023). The understanding of these psychological perspectives is essential in the changing dynamics of the society as AI is performing tasks that were traditionally reserved for humans, from personal assistants to healthcare providers. It is crucial to understand how humans perceive and interact with them, which in turn will help to design a human-centered and responsible AI systems.

The concept of mind perception in intelligent machines is a dimension to understand how humans emotionally and cognitively interact with these systems (K. Gray & Wegner, 2012). Based on the literature of Theory of mind (ToM) (Premack & Woodruff, 1978), ToM refers to the ability to attribute mental states- beliefs, intentions, desires, feelings, emotions, and knowledge to oneself and others and to understand that others' beliefs, desires, and intentions differ from one's own. This cognitive capacity is important for explaining and predicting the behavior of others, and its application extends to the interaction with artificial entities (Scassellati, 2002). Researches have explored that the attribution of such mental states to artificial entities can evoke emotions including surprise, amazement, disappointment, happiness, amusement, unease, and confusion when an individual interact with it (Shank et al., 2019). These feelings and emotions generated by such minded AI systems can affect user interaction, trust, empathy, and acceptance towards the system.

In this study, we focus on the effect of AI mind perception, specifically how attributing different mind capacity to the AI system, as tool, agency, and experience (H. M. Gray et al., 2007) influence user experience through the lens of the Uncanny valley (Mori, 1970; Mori & Macdorman, 2017) and the fulfilment of the basic psychological needs (R. M. Ryan & Deci, 2000). The Uncanny valley theory explains the discomfort and eeriness people feel when they encounter robots and humanoid systems that appear almost, but not perfectly, human. The previous studies on Uncanny valley suggests that the eeriness factor does not only depend on the visual appearance, but also arise from the perceived feelings and experience in a machine (Appel et al., 2020; K. Gray & Wegner, 2012). In reference to the work done by Appel et al. (2020), we follow the distinction between the machine's ability to feel (experience), the ability for thought and cognition (agency), and machine with no mind (tool) (H. M. Gray et al., 2007) to investigate the effect of the mind perception on the participant's feelings of eeriness in response to an AI system used in the healthcare centre. We aim to validate that an AI system with experience and an AI system with agency both would elicit eeriness among the participants, while the AI system with experience would lead to the most eeriness.

Similarly, we aim to investigate the effect of the AI mind perception and the perceived fulfillment of the basic psychological needs (BPNs) (R. M. Ryan & Deci, 2000). We found a research gap in the study of the BPN fulfillment when subjected to the mind perception dimensions as experience, agency, and tool, and thus sought to explore the effect in response to an AI system used in the healthcare centre. The basic psychological needs satisfaction is a key factor in explaining people's autonomous motivation and overall well-being (R. Ryan & Deci, 2000a). In addition, the studies have found that the needs satisfaction is a good estimator of the technology acceptance(de Vreede et al., 2021; Jiménez Barreto et al., 2021; Moradbakhti et al., 2022a) and higher AI positivity (Bergdahl et al., 2023). The basic psychological need theory (BPNT) is one of the mini theories of self-determination theory (E. L. Deci & Ryan, 1985; R. M. Ryan, 2000), and proposes three universal basic psychological needs, that when satisfied, promotes optimal function and growth.

1. Autonomy: the feeling of having choice or control over one's own behaviors and actions
2. Competence: experiencing mastery over a task or environment
3. Relatedness: caring for others and being cared for in return, i.e. the tendency to form strong relationships or bonds

We leverage the basic psychological needs satisfaction in technology use scale (BPN-TU), which further divides the relatedness to relatedness to technology and relatedness to others (Moradbakhti et al., 2022). To answer our research questions, we employ a between-subject design for the online survey, where the participants are randomly assigned to one of the three groups, AI as a Tool, AI as an Agent, and AI as an Experiencer. We introduce an AI system named Maya in the healthcare context, and different text-description is provided for the three dimensions of mind perception.

The insights gained from this study are expected to contribute significantly to the fields of human-centred AI design, human-computer and human-agent interaction, promoting the development of AI systems that are more aligned with human psychological needs and social norms. The next section will explore the theoretical underpinnings of mind perception, the Uncanny Valley, and basic psychological needs more thoroughly, providing a solid theoretical framework for understanding the complex relationship between humans and technology.

Theoretical Background and Related Work

Theory of Mind and Mind Perception

In psychology, theory of mind (ToM) after its first implementation in 1978 (Premack & Woodruff, 1978) in human and animal studies has gained significant research attention throughout the years. As it refers to the ability to attribute the mental states to oneself and others, it serves as an integral cognitive element for social interaction. It is a predictive model to anticipate how others might behave in a particular situation. In the study, they conducted experiments using an adult chimpanzee named Sarah, showing her videos of a human actor facing various problems and then having Sarah choose the correct solution from a set of photographs. The experiments indicated that Sarah could consistently choose the correct solutions from the photographs, suggesting she understood the actor's goals and could infer the purpose behind the actor's actions, concluding the ability to align with having a theory of mind. The ToM is described as a theory, because the behavior of other persons, like the way they act, their expression, is only directly observed, but the mental states and the mind of another person are not directly observable, and the system of inferences can be used to make the prediction about the nature of mind and behavior of others.

A study that experimented ToM on children with autism (Baron-Cohen, 1995) argued that ToM is an evolutionary process developed from our tendency to mindread. Mindreading is a natural process and we do it all the time, effortlessly, automatically, and mostly unconsciously, which in turn helps us participate in social interactions and effective communications. It allows us to make meaning of other's actions and also decode the nonverbal gestures. These capacities develop gradually throughout the years (Raimo et al., 2022), and if a person does not have a mature theory of mind, it could be a sign of cognitive or developmental deficiency (Baron-Cohen, 1995; Wellman et al., 2006). Two prominent and contrasting theories that have been extensively discussed within the framework of ToM are Theory-Theory (TT) and Simulation-Theory (ST) (Carruthers &

Smith, 1996; Harris, 1992). The theory-theory suggests that individuals have a natural built-in tendency to develop our own, personal psychological theories about how other people's minds work. According to this view, we basically start formulating and test these ideas from a very young age, which helps us to predict and understand why people do the things they do. We do this based on the belief that other people have minds similar to our own. We constantly update this theory as we grow up based on social experiences and interactions, and when a theory becomes stable enough, we rely on it to make predictions about other people's actions and behaviors. In contrast, simulation-theory argues that understanding other people's mental states is achieved by using our own mind as a model and simulating their mental processes within ourselves. According to this view, we use our own thoughts and emotions to predict what others will do, and project our mental states onto them. The ST puts emphasis on the empathy and putting ourselves in their shoes to understand them better (Michlmayr, 2002; Winfield, 2018). These theories and studies of ToM help us understand the processes that lead to perceiving mind, but do no quite explain the different dimensions of mind perception as they assume mind perception in one dimension, i.e., having more or less mind.

The further studies on mind perception dimension distinguishes two independent dimensions: experience and agency (H. M. Gray et al., 2007). They conducted an online experiment, where participants evaluated 13 characters based on the provided descriptions. They rated the characters on one of 18 mental capacities, for example, the capacity to feel pain, or one for 6 personal judgement questions, such as which was the most likeable character. The characters included seven living human forms of different ages and mental states, three nonhuman animals, a dead woman, God, and a robot that interacts with people. They conducted a principal component factor analysis of these attributes and identified the two factors as agency and experience. Agency is characterized by self-control, morality, memory, emotion recognition, planning, communication, and thought. On the other hand, experience involves hunger, fear, pain, pleasure, rage, desire, personality, consciousness, pride, embarrassment, and joy. Their findings demonstrated that these dimensions capture different aspects of morality. Agency is linked to moral agency (whose actions can be morally right or wrong) and hence to responsibility and experience is linked to moral patients (who can have moral right or wrong done to them) and hence to rights and privileges. Adult humans are observed to possess both experience and agency, and have significantly more agency and more experience than robots and other intelligent machines (H. M. Gray et al., 2007; Huebner, 2010). However, people do ascribe mind to non-human entities, including robots and intelligent machines, and the perception of mind in turn influences how we interact with them. The perception of mind in another entity intensifies the perceiver's psychological experience of events, validate the perceiver's own mind, action, and behavior, and provides a moral context to act in a way they do (Waytz et al., 2010). The different mind perception dimensions of the intelligent machines have different impacts on the human perceiver, and we want to study these effects in relation to the Uncanny valley theory and basic psychological needs fulfillment.

Uncanny Valley

The uncanny valley effect (Mori & Macdorman, 2017) is a theory rooted in psychology and aesthetics, and it's a relation between an object's degree of resemblance to a human being and the emotional response evoked by the object. The concept was first suggested by a Japanese professor of robotics, Masahiro Moto in 1970 as *bukimi no tani* (Mori, 1970), which was subsequently translated into English as the 'uncanny valley' by Jasia Reichardt in 1978 (Kageki, 2012). Mori's original hypothesis states that as the robot is designed to be more human like, some observer's will demonstrate an increasingly positive and empathetic response, until it reaches a certain point where it is almost human, where the response quickly turns into an intense revulsion. However, as the robot's appearance continues to resemble more to a human being, the emotional response becomes positive again and reaches a human-human empathy level. When plotted on a graph, it is observed that there is a steep decrease followed by a steep increase of the reactions, thus forming a valley in between, where the uncanny effect is most prominent. This interval of negative response evoked by the 'somewhat human' and 'fully human' entity is referred as the uncanny valley effect. It suggests the robotic and artificial entity designers and engineers to avoid the valley when designing systems, so that the eeriness evoked by the object is minimized, and the acceptance and likeability is maximized. Mori also suggested a possible reason for the uncanny valley effect, where he placed corpses and zombies at the bottom of the valley on the graph, and hypothesized that we experience unease by the almost but not accurate human simulations, because they remind us of corpses and we naturally fear death. It is to note that Mori's concept of the uncanny valley was based on his ideas and perceptions of potential dynamics of human-robot interactions, and not based on statistical studies and empirical evidence.

Several lines of theories and studies have explored the phenomenon after Mori's hypothesis to account for the cognitive mechanisms responsible for the uncanny valley. A profound evolutionary approach is the mate selection theory, which is an automatic stimulus-driven response. Humans tend to be attracted to certain features at a glance, and perceive potential mates with good indicators of fertility, high hormonal health, effective immune systems, social desirability, and clues of reproductive fitness (K. F. MacDorman et al., 2009; Thornhill & Gangestad, 1999). This tendency depends on the social and cultural environment and may differ from people of different cultural background (Jones et al., 1995), but the agreement lies on the elicit aversion feeling that arises when the potential mate selection criteria are not fulfilled. Similarly, a study suggests that the uncanny valley effect is caused by how non-human entities fail to measure up to the standards and expectations of an actual human being (K. MacDorman, 2005; Saygin et al., 2011). When an object is sufficiently nonhuman, we tend to elicit empathy as its human features become more salient, however when an object is almost human, we notice the features that are nonhuman and feel uncomfortable as it does not fully resemble the human norms. Another theory argues that the uncanny valley effect might be triggering the cognitive mechanism that evolved to help humans avoid sources of pathogens (Moosa & Ud-Dean, 2010). Robots and Androids in the uncanny valley are perceived as humans with defects, which resembles disease, and as a result, an observer feels aversion towards these entities. Similarly, the innate fear of death as stated by Mori (1970) is further coupled with the culturally accepted mechanisms for coping with the inevitability of death as the reasoning of the uncanny valley effect (Macdorman & Ishiguro, 2006). It posits that the androids falling in the uncanny valley evoke the observer's subconscious fear of replacement, reduction, or annihilation, and the mechanical interior of the robot can evoke the thought of mere soulless nature and mortality of humans. As these feelings are usually uncomfortable, the entity is also disregarded as the source of the discomfort. Although different theories have been put forward over time, only a few studies have tested the idea empirically, which have mixed and conflicting account of why it occurs. A review of empirical research suggests that the perceptual mismatch theory finds the most support in empirical literature (Kätsyri et al., 2015). The perpetual mismatch theory states that the negative effect associated with the visual stimuli of the uncanny valley is produced by the activation of contradictory cognitive representations. The perpetual tension arises when an observer perceives conflicting cues to category membership, such as the humanoid figure's possession of robotic features and robotic movement (Ferrey et al., 2015). In other words, the perceiver is not sure in which category the object belongs and faces a greater cognitive challenge for the distinction. This cognitive tension is experienced as a psychological discomfort (eeriness), similar to the discomfort experienced with cognitive dissonance (Egan et al., 2007; Elliot & Devine, 1994). These explanations of the uncanny effect are typically focused on the appearance of the humanlike artificial figures. However, in the recent years, with rapid advancements of artificial intelligence and affective computing, the uncanny valley of mind has also been suggested by the cognitive scientists. The researchers claim with empirical evidences that the artificial entities are unsettling because humans perceive mind in them (Appel et al., 2020; K. Gray & Wegner, 2012).

According to the mind perception perspective, the characters that are attributed to humans only, and not to animals, machines, and artificial entities is crucial for explaining the uncanny valley. In a study by K. Gray and Wegner (2012), the researchers conducted three experiments, where they provided visual stimulus and textual description, and manipulated the amount of the mind perception dimension: agency and experience. In the first experiment, they showed the participants either a video of a humanoid robot emphasizing its electrical components and wirings (mechanical condition), or a video of the same robot emphasizing its humanoid face (lifelike condition). In the lifelike condition, participants reported more experience to the robot, and more eeriness. The ascribed agency did not differ between the conditions. Experience, but not agency, predicted eeriness and acted as a mediator to explain the effect of the video conditions (appearance) on the eeriness. In a second experiment, they exposed participants to descriptions of a "supercomputer", across three conditions. First, it was simply much more powerful than a normal computer (control condition), second it was able to "independently execute actions" with "self-control and the capacity to plan ahead" (with-agency condition), and third was able to feel some form of "hunger, fear and other emotions" (with-experience condition). They observed heightened eeriness in the experience condition as compared to both the control and agency condition. To further support experience is the dimension of the human likeness which elicits the feeling of eeriness, they conducted a third experiment where participants were presented a picture of a man described as either being normal, lacking agency, or lacking experience. The results suggested that a person with lack of experience is perceived in an uneasy way than a person with lack of agency. They concluded that the perception of mind, particularly experience is linked to the feelings of unease. The findings suggested that the uncanny valley is driven by perceptions of experience, not just appearance. People tend to feel a strong sense of aversion when they encounter and interact with highly advanced, emotion-sensitive technology.

Another study on the mind perception and uncanny valley focused on the distinction between experience and agency as the psychological representation of human likeness, and examined the effects of both dimension of mind perception on participants' feeling of eeriness in response to a service robot (Appel et al., 2020). In the first experiment (Experiments 1A and 1B), they provided the descriptions of future humanoid robots, and suggested that both dimensions of mind perception would elicit the feeling of eeriness, however a robot with experience is eerier. They also compared both the mind conditions to a control condition, where the robot was presented as merely a tool (without mind). The descriptions were similar to the descriptions of a "supercomputer" by K. Gray and Wegner (2012), and included the most characteristics of the agency and experience as presented by H. M. Gray et al. (2007). In addition, they presented varying boundary conditions, namely the robot's field of application, the robot's gender, and user's age to examine the effect of agency and experience. In Experiment 2, they distinguished between the nursing/healthcare context and an unspecified context, to examine eeriness as the function of robot's mind and work context. In the tool and agency condition, they observed no significant difference on eeriness between the presented work context. However, in the experience condition, eeriness was lower in the nursing context than in the unspecified context. Similarly, in Experiment 3, they manipulated the robot's perceived gender (neutral vs. female vs. male) by changing its name, while the descriptions of the robot was kept same. They hypothesized that as women are more associated with experience and men with agency (Spence et al., 1975), there will be significant variation on eeriness of a robot's mind. However, they observed that a female robot with experience and ability to feel was not less eerie than a male robot. Similarly, a male robot with agency elicited neither less or more eeriness than a female robot with agency. The results suggested that ascribing female name does not reduce the eeriness associated, even if the characteristics of experience is profound. Our study builds on the work of Appel et al. (2020) and we aim to validate their findings and provide further empirical evidences to the research community.

The recent research has challenged the theory of K. Gray and Wegner (2012) on the effect of mind perception on eeriness, by conducting a comprehensive study, including a meta-regression analysis and (de)humanization experiment. (K. F. MacDorman, 2024). The findings suggest that physical appearance of robots play a more significant role in eliciting eeriness, driven by perceptual factors than cognitive attributions. This paper thus questions the mind perception theory as the primary explanation for the uncanny valley, and highlights the importance of visual and physical attributes of the robot.

In our study, we primarily focus on the mind perception as a mechanism for uncanny valley by providing text-based description. However, we note the concerns in the mind perception theory as outlined by K. F. MacDorman (2024) for future research directions.

Basic Psychological Needs

Needs, in a broad sense, encompasses a range of requirements, a specific desired aspects, outcomes, that are essential for sustaining everyday life. It also provides a sense of fulfillment, satisfaction, and motivation while the origin of the needs could be traced back to the feeling of lacking, or shortage. Thus everyone has different needs as per their life situations and what they want to achieve (Doyal & Gough, 1984). For example, a ten-year old child might have a need to get a new toy, while a 30 year old adult might have a need to achieve a certain career milestone or take a vacation. Human motivation can be distinguished into two categories: Intrinsic motivation and Extrinsic motivation. Extrinsic motivation (Controlled motivation) comes from the external sources and involves performing an activity to obtain some external outcome or avoid punishment, that is separate from the person. The common forms of external stimulus includes rewards such as money, recognition, grades, and competition. External motivators can have a powerful impact on behavior and often motivate to conduct the actions that are not inherently pleasurable and interesting. On the other hand, Intrinsic motivation (Autonomous motivation) is the natural, inherent drive that refers to engaging in the activity as one feel a sense of willingness, joy, choice, interest, enjoyment, value, and innate satisfaction, rather than driven towards external rewards. The joy and fulfillment that comes from the intrinsically motivated activity is sufficient in itself for the continued engagement (R. Ryan & Deci, 2000a). Among different theoretical frameworks of human needs, basic psychological needs is rooted in Basic psychological needs theory (BPNT), which is one of the six mini-theories within self determination theory (SDT) (E. L. Deci & Ryan, 1985; R. M. Ryan & Deci, 2000). SDT is a macro theory of human motivation and personality, that deals with two important factors: people's innate growth tendencies and inherent psychological needs. SDT makes two key assumptions: the need for growth drives behavior and autonomous motivation is important. Self-determination relies on intrinsic motivation in the absence of external stimulus. SDT focuses on the degree to which an individual's choices, actions, and behaviors are self-motivated and self-determined. Self-determination establishes the individual as the protagonist, who is responsible and potentially culpable for their actions. The independence and associated motivation encourages the person to find more motivation to initiate and carry out their tasks, and manage themselves properly. It argues that when a person's actions are directed by self-motivation and self-determination, it nurtures their overall well-being and psychological health.

SDT assumes that all human beings have a limited set of basic psychological needs (BPNs), and their satisfaction is essential for well-being, health, and optimal performance. It proposes three universal BPNs: Autonomy, Competence, and Relatedness (R. M. Ryan & Deci, 2000). The need for autonomy refers to the need to feel self-governing, independent and a causal agent of one's own life. It concerns the desire to experience volition, willingness, to have control over a situation, one's own action, to act in one's integrated sense of self, and direct the actions to the highest potential (E. Deci & Vansteenkiste, 2004). The feelings of autonomy are enhanced when a person feels they have a choice in a situation and are able to govern their own behavior. When the need for autonomy is satisfied, one experiences a sense of integrity, as their actions, thoughts, feelings, decisions are self-regulated and authentic. On the contrary, an individual lacks autonomy when they feel threatened and controlled by others, and have to meet deadlines or act in a way they are not willing to. They experience a sense of pressure, conflict, and a feeling of pushed in an unwanted direction, when dissatisfied and frustrated. Similarly, the need for competence refers to the need to be effective in dealing with the environment. It concerns the experience of mastery, to feel confident in relation to whatever one does, and a desire to control the outcome (E. Deci & Vansteenkiste, 2004). It becomes satisfied when one engages in activities with their capability, and experiences opportunities to use and extend their skills and expertise. A competent person feels they have the required medium to master the environment and achieve their goals. When dissatisfied and frustrated, one experiences a sense of helplessness and ineffectiveness. Finally, the need for relatedness refers to the need to have close, affectionate relationships. It concerns the experience of warmth, closeness, bonding, care, and a sense of belonging (E. Deci & Vansteenkiste, 2004). It is satisfied by connecting, feeling significant, respected, cared, and being part of an inclusive safe environment that one desires. The relatedness dissatisfaction and frustrations arises with competition and criticisms from others, a sense of social alienation, exclusion, and loneliness. However, in case of technology use, the need for relatedness consists of two aspects: need for relatedness to others and need for relatedness to technology itself. This can be explained with examples of communication technology, online games for relatedness to others, and social and companion robots for relatedness to technology itself (Moradbakhti et al., 2022). The satisfaction of these three BPNs motivates an individual to carry out the tasks and interact with an environment, with a sense of fulfillment and contentment. In addition, the traditional BPN satisfaction scales were not adequate to explain the BPN satisfaction for technology use, also when incorporating the two aspects of relatedness. Moradbakhti et al. (2022) developed and validated Basic Psychological Needs Satisfaction in Technological Use Scale (BPN-TU) with empirical data from four different studies. The scale consists of two-fold nature of relatedness, and provides a standard measure to assess the needs satisfaction, thus facilitating replicability and comparability across different studies.

Several studies have shown that how BPN satisfaction foster a positive atmosphere in classroom and child's education (Niemiec & Ryan, 2009), workplace and productivity (Strauss & Parker, 2014), competitive sports (Hagger & Chatzisarantis, 2008), and social settings (Tsai & Pai, 2014). Moreover, the satisfaction of the BPNs is also a crucial factor for technology acceptance and how positively we interact with an intelligent system (de Vreede et al., 2021; Moradbakhti et al., 2022a). A study on self-determination and attitude towards artificial intelligence concluded that self-determination is an important factor in AI acceptance (Bergdahl et al., 2023). The study investigated the longitudinal perspective in Finland and cross-sectional samples of adult population across Europe to conclude that the fulfillment of autonomy, competence, and relatedness corresponds to higher AI positivity and lower AI negativity. The autonomy and relatedness increased AI positivity and decreased AI negativity over time. Similarly, other studies also suggested that individuals who felt their competency and autonomy needs satisfied in the use of technology had significantly positive attitude towards it (Kaya et al., 2024; Lu et al., 2019). A study on BPN satisfaction and interaction with chat bots reported that the users who experienced higher autonomy, competence, and relatedness had increased satisfaction and engagement (de Vreede et al., 2021). Moreover, a study on attitudes towards AI assistants in the context of personal banking discovered a positive relationship when the users felt autonomous and competent (Moradbakhti et al., 2022a). Although, some researches have explored BPN satisfaction and attitude towards AI, there are limited empirical evidences, and there is a significant research gap in the study of BPN satisfaction in relation to the mind perception dimension in AI systems. Our research aims to fill this research gap by examining the effect of mind perception dimension on BPNs fulfillment.

The Present Study

Our study can be divided into two sub studies, understanding the mind perception dimension and the associated uncanny effect, and investigating the effect of the mind perception dimensions on the BPNs satisfaction. As discussed before, the first study builds on the work of Appel et al. (2020), where we aim to validate their results, and hence utilize the methods and scales incorporated by them. In our study, we explicitly introduce an AI system named Maya in the healthcare context. As they stated in their research about the effect of the context of application, we primarily focus on the healthcare context, where Maya is introduced as tool, agent, and experiencer. Moreover, as they stated that the robot's name did not have considerable effect on the associated eeriness, we justify the "feminine" name, Maya would not effect our study. As we aim to validate their findings, we have also accordingly designed the hypothesis.

H1: *AI introduced as having a higher level of mind (i.e., as an Agent or Experiencer) will evoke greater feelings of eeriness than AI described as a Tool. AI as an experiencer will have the highest eeriness.*

In the second study, our aim is to examine the effect of the mind perception dimensions on the BPNs fulfillment. We observed a significant research gap in the previous studies, and hence we aim to provide empirical evidences on how mind perception as tool, agent, and experiencer when introducing an AI system named Maya in the healthcare context effect the users' need satisfaction. As we discussed, autonomy satisfaction relates to be able to govern one's own behavior and have control over the actions, it can be argued that when Maya has more agency, the user might feel their independence conflicted. The increased independence of Maya in agency and experience condition could potentially infringe user's sense of control and self-governance. Similarly, competence satisfaction concerns an individual's desire to feel mastery over a task and to extend their skills and expertise. When Maya is a tool and an agent, it will augment users' capabilities to effectively execute the task. However, in the experience condition, the focus shifts towards emotional and experiential interactions, although the task is also effectively executed. Likewise, the need for relatedness is satisfied when a person feels connected and forms a bond, either with Maya itself (relatedness to technology), or with other users in the environment (relatedness to others). As in the experience condition, Maya demonstrates human-like emotions and builds an empathetic connection, it will foster the relatedness to the technology. In contrast, the human-level characteristics of Maya might substitute the actual human companionship, which could lead negatively to relatedness to others. On the contrary, it could also enhance the relatedness to others by shared human-AI experiences. Maya as a tool primarily supports task-related activities without significantly affecting social dynamics. Maya as an agent with its autonomous functioning might replace human interactions. Based on the previous researches and the presented discussions, we propose the following hypothesis for our study.

H2: *The autonomy need fulfillment is higher in the tool condition, as compared to agency and experience condition.*

H3: *The competence need fulfillment is higher in the tool and agency condition, as compared to experience condition.*

H4a: *The relatedness to others need fulfillment is higher in the tool condition as compared to agency condition. The experience condition has a variable effect.*

H4b: *The relatedness to technology need fulfillment is higher in the experience condition, as compared to tool and agency condition.*

We leverage BPN-TU scale for addressing the needs satisfaction. The further experiment related discussions are presented in the methodology section.

Methodology

Study Design

The study presented an AI system, Maya being implemented in the healthcare centre. The description of Maya was manipulated in three conditions according to the respective mind perception dimension, following the works of K. Gray and Wegner (2012) and Appel et al. (2020). The study employed a between-subjects design to investigate the effect of the mind perception dimension (independent variable) on Uncanny valley and BPNs satisfaction (dependent variables). Participants were randomly assigned to one of the three groups, AI as a tool, AI as an agent, and AI as an experiencer. A between-subjects design was chosen as we focused on the comparison between these groups to understand the effect of the independent variable. Moreover, it is simple, straightforward, and avoids potential order bias in the participants' answers (Cuttler et al., 2019). An online experiment using survey questionnaire was developed and administered to effectively collect the data using the Unipark software. We presented the initial description and motive of the survey, then introduced Maya according to the random assignment, followed by questions to analyze the uncanny effect and BPNs fulfillment. The attention check and comprehensiveness check questions were included to check the focus and understanding of the participants. We analyzed the perceived gender of Maya, and how the area of application of the system influence the acceptance. For this, we devised a question to present Maya in an entertainment industry (e.g., online streaming services) as compared to the healthcare centre. Finally, sociodemographic questions were asked, followed by an open text format (optional) for the feedback from the participants and debriefing of the survey. In average, we estimated that the survey takes 7 minutes to complete.

Participants

The priori sample size was determined to be at least 84 with G* Power (Faul et al., 2007). We intended to validate the uncanny valley results of Appel et al. (2020) as a part of our research, thus it was justified to assume a medium effect size of f = .35, with α error (false positive) probability .05 and β error (false negative) probability .20. This translates to a targeted power (1-β) of 80%, i.e., there is a 80% chance of detecting a true effect given the sample size and alpha level. The participants were recruited from Prolific and Linkedin. In total 160 participants completed the survey, out of which first 100 were directly recruited from Prolific. The participants were asked beforehand for their consent. They were then randomly redirected to one of the three conditions, and their answers were processed for the respective group. We had a comprehensiveness check question along with the attention check questions. All the participants fulfilled the attention check mark, but 4 participants who answered "NO" in the comprehensiveness of the survey were discarded from the further study. The remaining sample consisted of 156 participants. Moreover, Mahalanobis distance was calculated to detected any multivariate outliers, by setting the cutoff to $p < 0.001$. The Mahalanobis distance detected 4 outliers, and thus the remaining final sample consisted of 152 participants, consisting of 76 Female, 74 Male, and 2 identified as Non Binary. The average age was 28.70 years (SD = 8.34, age range 18 to 62 years).

Moreover, we observed from the sociodemographic data of the participants that 117 resided in Europe (19 in Austria), 19 in South Africa, 9 in Asia, 5 in North America, and 2 in Australia. Similarly, most of the participants had above average proficiency in technology (139) and familiarly with AI (116). We also observed that 19 participants had the professional experience and background in healthcare, while 123 participants were not involved in the healthcare sector.

Stimuli

The study used text-based stimuli to investigate the research questions. We introduced the study as user's perception towards an AI system used in healthcare centre. After providing the objective of the study, a brief introduction to AI in general and the particular AI system for the study purpose, the participants were randomly redirected to one of the three mind perception dimension conditions. The general description of Maya in the healthcare centre was kept same in the three conditions, but we manipulated the description of the AI system as tool, agency, and experience, by incorporating the attributes and characteristics outlined in the previous studies (Appel et al., 2020; H. M. Gray et al., 2007; K. Gray & Wegner, 2012). The general description that was maintained same in the three conditions is as follows.

Common Description: "Imagine the following situation in a hospital. There are doctors and nurses. A new computer system is introduced as their healthcare assistant, designed to seamlessly assist medical staff. It is an artificial intelligence called Maya. Maya functions as a valuable tool for medical professionals. It can analyze medical data, for example, a patient's x-ray images, and compare it with other medical data in just a few seconds. This way, it can assist medical diagnoses and make recommendations to the medical staff. Maya is a screen-based application, so doctors and nurses can interact with it through their laptops, tablets, or phones. Besides being able to analyze large amounts of medical data, Maya also features a chatbot function, enabling medical professionals to interact with it using both written and spoken natural language."

The general description was supported by a picture, which was also retained same in the three cases. The common description and the picture was presented so that the participants get a clear understanding and vision of Maya and its nature. Moreover, we manipulated the description of AI system in the cases, Maya as a tool, Maya as an agent, and Maya as an experiencer with the following description.

Tool Condition: "With its advanced capabilities, Maya responds promptly to the commands, facilitating the smooth execution of various actions, thus enhancing healthcare outcomes. It never acts autonomously but only upon the command of a human user."

Agency Condition: "Maya is an advanced AI system with a sophisticated cognitive architecture. With its advanced capabilities, Maya can exercise self-control, demonstrate moral reasoning, utilize memory effectively, and recognize emotions. It can think, communicate, plan ahead and independently execute actions in complex medical situations, thus enhancing healthcare outcomes."

Experience Condition: "Maya is an advanced empathetic healthcare partner. Developed with a sophisticated emotional framework, Maya has a personality and exhibits a wide range of human-like emotions including fear, pain, pleasure, joy, embarrassment, rage, desire, pride, and it even has consciousness. Maya learns and adapts, takes an active part in medical decision-making, and empathizes with people, thus enhancing healthcare outcomes."

Measures

Eeriness: We followed K. Gray and Wegner (2012) to measure the feeling of eeriness in response to the AI system, Maya. We assessed the three items: "uneasy", "unnerved", and "creeped out." In addition, we asked how closely Maya's interaction resembled with a human, and how humanlike they perceived Maya. The questions went with a five-point scale ranging from (1) not at all to (5) extremely.

BPNs satisfaction: We followed the BPN-TU scale developed by Moradbakhti et al. (2022) to measure the BPNs satisfaction. The scale presents three questions each for autonomy, competence, relatedness to technology, and relatedness to others. We assessed these 12 items (see Survey Questionnaire) with a five-point scale ranging from (1) not at all to (5) very much, as suggested in the paper of BPN-TU.

Perceived Masculinity and Femininity: We included two questions about Maya's perceived masculinity and femininity. The questions be rated independently on a five-point scale from (1) not at all to (5) extremely.

Area of Application: We changed the application area to entertainment industry (e.g., online streaming services) and investigated how they evaluated the use of Maya. We did not experimentally manipulate the description of Maya for the entertainment industry, but asked the participants how they would evaluate the use of Maya in this sector. We assessed it with a five-point scale ranging from (1) much more acceptable than in healthcare to (5) much less acceptable than in healthcare.

Reliability Check: Reliability was checked using Cronbach's alpha for the various scales used in this study. This statistic indicates the internal consistency of a set of items—that is, how closely they are related as a group (Forero, 2014). In general, it is considered that a Cronbach's alpha value of 0.7 or above is acceptable to report reliability.

- Eeriness: The scale of eeriness had good internal consistency with a Cronbach's alpha of 0.829. This suggests that the items reliably measure the construct of eeriness.

- Autonomy: The autonomy scale also showed good reliability, with a Cronbach's alpha of 0.775. This suggests there was a reliable assessment of the participants' perceived autonomy need fulfillment.

- Competence: With a Cronbach's alpha of 0.764, the competence scale also showed appropriate internal consistency and thus reliable measurements for the perceived satisfaction of needs related to competence.

- Relatedness to Others: The scale related to others had a Cronbach's alpha of 0.639. Since this value is below the threshold value of 0.7, it indicates questionable internal consistency. It could suggest that the items are most likely not reliably measuring the same thing, The construct is either not captured well, or the items are simply too few to properly capture the construct.

- Relatedness to Technology: The scale of relatedness to technology had a Cronbach's alpha of 0.676. Like the relatedness to others scale, this value comes in below the threshold of 0.7, indicating probable internal consistency issues. Again, this could mean that items are not all cohesively measuring the construct or that refinement or additional items in the scale are required.

These Cronbach's alpha values suggest that while most scales demonstrated acceptable to good reliability, the scales for relatedness to others and relatedness to technology may require further development to ensure they reliably measure the intended constructs. Future research may consider revising these scales to improve their internal consistency.

Results

The following section presents the results of our study, and the analysis we did to test our proposed hypothesis. Python programming language and its libraries were used for data analysis.

Hypothesis Testing

Our objective was to test the proposed hypothesis on eeriness and basic psychological needs fulfillment among the three mind perception dimensions.

Table 1

Descriptive Statistics for Eeriness

Mind Perception	Mean	SD	Count
AI as a Tool	1.801	0.728	47
AI as an Agent	2.000	0.871	54
AI as an Experiencer	2.150	0.867	51

From the descriptive statistics, eeriness is observed to be the highest for the AI as an experiencer, followed by AI as an agent. This aligns with our proposed hypothesis. On doing ANOVA test to compare the mean eeriness rating among the three conditions, we observed F-statistic 2.1775, and p-value 0.1169. The p-value is greater than the conventional alpha level of 0.05, suggesting that the differences in mean eeriness across the three conditions are not statistically significant. While the descriptive statistics align with this hypothesis, the ANOVA results indicate that these differences are not statistically significant. This implies that any observed differences in eeriness are likely due to random variation rather than true differences between the conditions. Hence, we can not state our hypothesis was true, although the trends show in the predicted direction.

Table 2

Descriptive Statistics for Autonomy Need Fulfillment

Mind Perception	Mean	SD	Count
AI as a Tool	3.539	0.833	47
AI as an Agent	3.247	1.008	54
AI as an Experiencer	3.346	0.867	51

From the descriptive statistics, autonomy need fulfillment is observed to be the highest for the AI as a Tool, followed by AI as an Experiencer, and lowest for AI as an Agent. This aligns with our proposed hypothesis that it will be higher in the tool condition. An ANOVA test was conducted to compare the mean autonomy need fulfillment among the three conditions. The results indicated an F-statistic of 1.3229 and a p-value of 0.2695. The p-value is greater than the conventional alpha level of 0.05, suggesting that the differences in mean autonomy need fulfillment across the three conditions are not statistically significant. While the descriptive statistics align with the hypothesis that autonomy need fulfillment is higher in the Tool condition compared to the Agent and Experiencer conditions, the ANOVA results indicate that these differences are not statistically significant. This implies that any observed differences in autonomy need fulfillment are likely due to random variation rather than true differences between the conditions. Hence, we cannot state that our hypothesis was true, although the trends show in the predicted direction.

Table 3

Descriptive Statistics for Competence Need Fulfillment

Mind Perception	Mean	SD	Count
AI as a Tool	3.553	0.756	47
AI as an Agent	3.531	0.919	54
AI as an Experiencer	3.418	0.832	51

From the descriptive statistics, competence need fulfillment is observed to be the highest for AI as a Tool, followed closely by AI as an Agent, and lowest for AI as an Experiencer. This partially aligns with our proposed hypothesis. An ANOVA test was conducted to compare the mean competence need fulfillment among the three conditions. The results indicated an F-statistic of 0.3699 and a p-value of 0.6914. The p-value is greater than the conventional alpha level of 0.05, suggesting that the differences in mean competence need fulfillment across the three conditions are not statistically significant. While the descriptive statistics show a trend that aligns with the hypothesis—that competence need fulfillment is higher in the Tool and Agent conditions compared to the

Experiencer condition—the ANOVA results indicate that these differences are not statistically significant. This implies that any observed differences in competence need fulfillment are likely due to random variation rather than true differences between the conditions. Hence, we cannot state that our hypothesis was true, although the trends show in the predicted direction.

Table 4

Descriptive Statistics for Relatedness to Others Need Fulfillment

Mind Perception	Mean	SD	Count
AI as a Tool	2.901	0.780	47
AI as an Agent	2.741	0.823	54
AI as an Experiencer	2.850	0.875	51

From the descriptive statistics, relatedness to others need fulfillment is observed to be the highest for AI as a Tool, followed by AI as an Experiencer, and lowest for AI as an Agent. This aligns with our proposed hypothesis. An ANOVA test was conducted to compare the mean relatedness to others need fulfillment among the three conditions. The results indicated an F-statistic of 0.4981 and a p-value of 0.6087. The p-value is greater than the conventional alpha level of 0.05, suggesting that the differences in mean relatedness to others need fulfillment across the three conditions are not statistically significant. While the descriptive statistics align with the hypothesis that relatedness to others need fulfillment is higher in the Tool condition compared to the Agent condition, with a variable effect in the Experiencer condition, the ANOVA results indicate that these differences are not statistically significant. This implies that any observed differences in relatedness to others need fulfillment are likely due to random variation rather than true differences between the conditions. Hence, we cannot state that our hypothesis was true, although the trends show in the predicted direction.

Table 5

Descriptive Statistics for Relatedness to Technology Need Fulfillment

Mind Perception	Mean	SD	Count
AI as a Tool	3.028	0.890	47
AI as an Agent	2.710	0.809	54
AI as an Experiencer	3.000	0.926	51

From the descriptive statistics, relatedness to technology need fulfillment is observed to be the highest for AI as a Tool, closely followed by AI as an Experiencer, and lowest for AI as an Agent. This does not completely align with our proposed hypothesis, but it is close. An ANOVA test was conducted to compare the mean relatedness to technology need fulfillment among the three conditions. The results indicated an F-statistic of 2.1123 and a p-value of 0.1246. The p-value is greater than the conventional alpha level of 0.05, suggesting that the differences in mean relatedness to technology need fulfillment across the three conditions are not statistically significant. While the descriptive statistics show a trend that somewhat aligns with the hypothesis—that relatedness to technology need fulfillment is higher in the Experiencer condition compared to the Tool and Agent conditions—the ANOVA results indicate that these differences are not statistically significant. This implies that any observed differences in relatedness to technology need fulfillment are likely due to random variation rather than true differences between the conditions. Hence, we cannot state that our hypothesis was true, although the trends show in the predicted direction.

Additional Analysis

In our study, we also asked how humanlike they perceive Maya to be, and how closely they thought Maya's interaction resembled that of a human caregiver. We observed that perception of Maya as humanlike was higher in Experience condition ($M = 2.93$, $SD = 1.02$) followed by tool ($M = 2.69$, $SD = 0.96$) and agent ($M = 2.56$, $SD = 0.84$). Similarly, we observed that the participants responded Maya's interaction resembling that of a human caregiver to be higher in Experience condition (M = 2.39, SD = 1.18) followed by tool (M = 2.23, SD = 1.00) and agent (M = 2.05, SD = 1.03).

Similarly, for the perceived masculinity and femininity, we observed that Maya was perceived more feminine (M = 3.39, SD = 1.09) than masculine (M = 2.14, SD = 0.93). In the perceived femininity case, Maya as an Experiencer was perceived to be more feminine (M = 3.89, SD = 0.94), than as an agent and a tool, which had not much significant difference.

In addition, we also presented a question shifting the work context to the entertainment sector (e.g. Online streaming services), without manipulating the stimuli. We observed from the group comparison that participants responded more comfortable in tool condition (M = 3.13, SD = 1.03) than experience condition (M = 2.63, SD = 1.16) and agent condition (M = 2.52, SD = 1.06).

Discussion

AI is already making remarkable changes in our society and everyday lives, and the healthcare sector is also influenced by its powerful potential. It not only has the capability to transform how healthcare is delivered, but also can improve the experiences of patients and healthcare practitioners (Spatharou et al., 2020). As the involvement of advanced AI systems grow in our life, it is sensible and crucial to understand how we interact with them, and how our perception shapes our interaction. Humans tend to ascribe mind to the non-human entities (H. M. Gray et al., 2007), and respond to the artificial systems in similar ways as to the real social beings (Nass et al., 1994). This attribution of mind in turn evoke emotions in the human user (Shank et al., 2019), and shape their corresponding interactions and acceptance towards the system. From the empirical studies, the attribution of mind has been observed along two dimensions, agency (the capacity to act) and experience (the capacity to feel), while tool is the no mind condition (control condition) (K. Gray & Wegner, 2012).

In our research, we studied the effect of mind attribution and the interaction with such minded non-human entities in the framework of uncanny valley hypothesis and basic psychological needs (BPNs). Our aim to study the effect of mind perception on the uncanny valley hypothesis was to validate the results from previous studies in our experimental setup. Also, we found a research gap in the study of effect of mind perception and BPNs fulfillment, hence our aim was to fill this gap, and provide empirical results to the research community. We introduced an AI system named Maya, specifically in the healthcare context. We conducted an online experiment, designing our text-based stimuli focused on its description in the healthcare centre, and using the characteristics of agency and experience outlined in the previous studies (Appel et al., 2020; K. Gray & Wegner, 2012). The stimuli is provided in the methodology section. Also, we devised the questionnaire following the validated scales for Uncanny valley hypothesis and BPNs fulfillment (Moradbakhti et al., 2022).

Mind Perception and Uncanny Valley

The Uncanny Valley hypothesis posits that as robots become more and more human-like in appearance, they first have the positive emotional effect, but then, as they become almost, but not entirely human, they can evoke the feeling of discomfort or eeriness. This feeling of discomfort decreases as the entity becomes indistinguishably human (Mori, 1970). In recent years, the studies also claimed that the feeling of eeriness is induced as people perceive mind in the non-human entities (K. Gray & Wegner, 2012). The perception of mind as experience is suggested to induce the most eeriness, while the perception of mind as agency also induce eeriness (Appel et al., 2020). In our study, we investigated the claim of Appel et al. (2020) stating the same hypothesis, and our aim was to validate their results.

From our online experiment and the analysis of results across three groups, tool, agency, and experience, we observed a similar trend as suggested by Appel et al. (2020) in their studies. We observed that the eeriness is the highest when Maya is described as an experiencer, followed by when Maya is described as an agent. The observed trend aligns with the theoretical discussions as perceiving higher capacity of mind in non-human entities, AI system named Maya in our case, would elicit more eeriness. Then, on doing the ANOVA test, we observed that the differences among groups were not statistically significant, as the p-value was greater than 0.05. The absence of statistical significance suggests that these differences might be due to chance rather than a true effect in our sample. There could be several factors contributing to this outcome.

1. Sample Size: Our study might have been under powered to detect small to moderate effects. Future research could benefit from larger sample sizes to increase statistical power.

2. Effect Size: The effect of mind perception on eeriness might be smaller than anticipated, requiring more sensitive measures or larger samples to detect.

3. Contextual Factors: The specific design of Maya in healthcare centre of our study might have influenced participants' perceptions differently compared to previous studies.

4. Stimuli design: Our text-based stimuli might not have been strong enough to elicit significant differences in mind perception across conditions. We presented a question as attention check after the text description, where the participants had to select the assigned group (Tool, Agent, or Experience), when asked "How is the AI system presented as in this scenario?" We observed a mismatch selection across the groups, and most participants selected tool. We did not take this question to sample out people as there were many mismatches, but it certainly gives us some insights. This suggests that the stimuli was not strong enough. However, this can also be argued in a way that the participants perceived Maya, the AI system, as a mere tool, irrespective of the description, because people generally perceive AI as a tool (something one uses to do some task) (Shank et al., 2019).

Despite the lack of statistical significance, the observed trend suggests that the relationship between mind perception and eeriness in AI systems remains a relevant area of inquiry, particularly in healthcare contexts where human-AI interaction is becoming increasingly common.

Mind Perception and BPNs

The BPNs framework, derived from self-determination theory (R. M. Ryan & Deci, 2000), is critical in understanding the motivational impact of AI interactions, and overall well-being of the users (R. Ryan & Deci, 2000a). The three universal basic psychological needs are outlined, autonomy (feeling of being in control of one's actions), competence (feeling effective in one's activities), and relatedness (feeling connected to others). For the technology use case, the relatedness is sub-divided into relatedness to technology and relatedness to others (Moradbakhti et al., 2022). These needs when satisfied promotes autonomous motivation, optimal interaction, and technology acceptance (de Vreede et al., 2021). The research gap in the study of the effect of mind perception and BPNs fulfillment motivated us to conduct our study and design our hypothesis. Our experiment yielded intriguing results, albeit without statistical significance. The needs are discussed separately below.

Autonomy Need Fulfillment

We hypothesized that the autonomy need fulfillment is higher in the tool condition, as compared to agency and experience condition. The descriptive statistics showed that autonomy need fulfillment was highest for AI perceived as a tool, followed by AI as an experiencer, and lowest for AI as an agent. This trend partially aligns with our hypothesis, suggesting that users might feel more in control when interacting with AI systems perceived as tools rather than autonomous agents. The autonomy need fulfillment lowest in the agency condition suggests that AI system's increased independence might have conflicted with the user's independence. The lack of statistical significance, however, indicates that these differences could be due to chance rather than a true effect in our sample. The potential factors could be sample size, effect size, and stimuli design as discussed before. Moreover, in a healthcare setting, perceptions of autonomy might be influenced by factors beyond the AI's perceived mind, such as the gravity of health-related decisions.

Competence Need Fulfillment

We hypothesized that the competence need fulfillment is higher in the tool and agency condition, as compared to experience condition. We observed the competence need fulfillment to be highest for AI as a tool, closely followed by AI as an agent, and lowest for AI as an experiencer. This trend partially aligns with our expectations, suggesting that users might feel more competent when interacting with AI systems perceived as tools or agents rather than as entities with the capacity to feel. The lack of statistical significance, however, indicates that these differences could be due to chance rather than a true effect in our sample. The potential factors could be sample size, effect size, and stimuli design as discussed before. Moreover, the nature of the tasks or interactions described in our stimuli might not have sufficiently differentiated the impact on perceived competence across conditions. Also, participants' varying levels of familiarity and competence with AI systems might have influenced their sense of competence regardless of the AI's perceived mind.

Relatedness Need Fulfillment

- **Relatedness to Others:** We hypothesized that the relatedness to others need fulfillment is higher in the tool condition as compared to agency condition. The experience condition has a variable effect. From the descriptive statistics, we observed that the relatedness to others was highest for AI perceived as a tool, followed by AI as an experiencer, and lowest for AI as an agent. This also aligns with our expectations, as AI perceived as an agent might be seen as potentially replacing human interactions, leading to lower relatedness scores. The lack of statistical significance, however, indicates that these differences could be due to chance rather than a true effect in our sample. The potential factors could be sample size, effect size, and stimuli design as discussed before. Moreover, we also observed that the reliability check of the scales by calculating Cronbach's alpha was below the threshold value of 0.7. This suggests we might not have been able to assess the relatedness to others need fulfillment in our context using the standard BPN-TU scale.

- **Relatedness to Technology:** We hypothesized that the relatedness to technology need fulfillment is higher in the experience condition, as compared to tool and agency condition. However, we observed that the relatedness to others need fulfillment was highest for AI as a tool, closely followed by AI as an experiencer, and lowest for AI as an agent. This does not fully align with our expectations, but the close gap between AI as a tool and AI as an experiencer suggest the predicted trend could happen with comprehensive study design. We did not get the statistically significant result, and the observation challenges our hypothesis as well. The potential factors could be sample size, effect size, and stimuli design as discussed before. Moreover, we can argue that users might feel more related to AI systems that they perceive as tools, possibly due to greater familiarity and comfort with this conceptualization. We observed this trend in the Attention check 1 question, where most participants selected tool, when asked how was the AI system presented. In addition, the relatedness to technology need fulfillment scale also showed lack of internal consistency, when calculating Cronbach's alpha for reliability check. This also suggests we might not have been able to assess the relatedness to technology need fulfillment in our context using the standard BPN-TU scale.

Additional Discussion

1. **Perceived Humanness:** We observed that the experiencer condition generally had higher perception of Maya to be humanlike and Maya's interaction resembling to a human caregiver. The higher perception of Maya and its interaction as humanlike in the experiencer condition aligns with the mind perception framework, where the capacity to experience is often seen as more human-like. However, the implications of

these perceptions in sensitive domain like healthcare need further explorations, especially considering mixed feelings of AI in caregiver roles (noble. dana, 2024).

2. **Gender Perception:** We observed the higher perception of Maya as feminine, and the perception of more femininity in the experience condition. This is in accordance with the work on user's interaction to artificial entities and the associated gender stereotypes for the application context (Bartneck et al., 2018). The design of human-centered AI systems need to consider these factors also, to have an optimal user experience.

3. **Context Sensitivity:** We observed most participants responded that they feel more comfortable when the domain is shifted from healthcare to entertainment sector(e.g. Online streaming services) in the tool condition. We did not dive deeper into the work context, as we just wanted to observe a general response. However, this also signifies the importance of considering domain-specific factors when designing advanced AI systems with perception of mind for effective AI interaction and acceptance, and could be incorporated in future researches.

In summary, our research adds to the literature on the effect of mind perception and uncanny valley effects, and fills the research gap on the effect of mind perception and basic psychological needs fulfillment in human-AI interactions within a healthcare context. Our results were not statistically significant; however, the trends observed are quite consistent with previous research and theoretical frameworks. This comparatively higher eeriness rating in the experience condition, coupled with varying patterns of BPN fulfillment across conditions, highlights how nuanced human responses to AI can be in healthcare settings. These findings suggest for careful regard towards perceived mind perception of AI systems in design and implementation, particularly within sensitive domains like healthcare, where user's trust, comfort, and autonomy are paramount. Additional dimensions of human likeness, perceived gender, context sensitivity, and other observations in our study further highlight the complexity of human-AI interaction, pointing to the need for domain-specific and tailor-made solutions.

Limitations and Future Directions

Our study, while providing valuable insights into the effect of mind perception on uncanny valley effects, and and basic psychological needs fulfillment in human-AI interactions within a healthcare context, has several limitations that should be addressed in future research.

1. Sample Size and Statistical Power

Our study had relatively small sample size, although was determined by power analysis for medium effect size. This may have contributed to the lack of statistical significance in our findings. While we observed trends that aligned with our hypotheses and previous research, the limited sample size reduced our ability to detect potential effects.

For future research, we strongly recommend conducting larger-scale studies with increased sample sizes. This would enhance statistical power and improve the likelihood of detecting significant effects if they exist.

2. Stimuli Design

The use of text-based stimuli in our study, may have limited the strength of our experimental manipulation. The attention check results, which showed many participants perceiving the AI system as a "tool" regardless of the condition, suggest that our stimuli may not have been sufficiently strong to elicit distinct perceptions across conditions. This limitation aligns with findings from K. F. MacDorman (2024), where they demonstrated that the lack of visual stimuli often results in greater reported eeriness, and emphasizing the critical role of perceptual aspects. Thus, our text-based descriptive stimuli may have failed to engage participants fully, limiting their ability to differentiate between the AI's intended mind perception as tool, agent, or experiencer.

Future studies should consider more immersive and engaging stimuli designs, like video demonstrations, interactive scenarios, and virtual or augmented reality environments, showcasing the appearance and functionalities. This will allow the participants to get more comprehensive understanding and provide more nuanced insights of mind perception capabilities.

3. Measurement Scale

The reliability issues encountered with two of the Basic Psychological Needs for technology use (BPN-TU) scales, relatedness to others and relatedness to technology, suggest the need for more refined measurement in the context of human-AI interaction.

Future research should focus on developing and validating scales specifically designed to measure BPN fulfillment in Human-AI interactions.

4. Long-term effects

The cross-sectional nature of our study provides only a snapshot of user perceptions and experiences with AI systems. However, these perceptions and experiences are likely to evolve over time as users become more familiar with AI technologies.

To address the limitations, we propose longitudinal studies, that track changes in perceptions over time. The increased familiarity and interaction with AI systems could showcase how initial aversion could change to acceptance in the long run. This will also help in designing AI systems that will maintain positive user experiences over time.

5. Context Specificity

The aim of our research was to investigate the effect of mind perception in the healthcare context, which, while important, may limit the generalizability of our findings to other domains. The healthcare setting introduces unique factors such as the criticality of medical decisions and the importance of trust and empathy. This may influence perceptions and interactions with AI systems in ways that are not applicable to other contexts, like how we observed the comfort shifting while just presenting an alternative context as entertainment sector (e.g. Online streaming services).

The future research could investigate and compare studies across different domains, while also manipulating the stimuli. This will introduce domain-specific factors, and will provide more comprehensive understanding of how context influences human-AI interactions, and will in turn help build domain-specific design guidelines.

6. Cultural Factors

Our study did not explicitly account for cultural differences, which may have introduced biases in our results. Cultural backgrounds can significantly influence perceptions of technology , attitudes towards AI (Ge et al., 2024), and the interpretation of agency and experience in non-human entities.

Future research should conduct cross-cultural studies to investigate how cultural factors influence the perception of mind, interaction, and needs fulfillment. Understanding of these cultural dimensions would provide insights for design and development of AI systems, that are culturally sensitive and globally applicable.

Furthermore, the future studies could also achieve deeper insights from manipulating specific AI design features, that might manipulate the perception of mind in AI systems. This will help provide concrete design recommendations for the particular use cases. In addition, emotional and social dimensions of AI interaction, particularly in collaborative and care giving roles, could deepen our understanding of how these systems can be designed to align better with human psychological needs. Moreover, the use of AI in healthcare and other domains should focus on moral and ethical considerations of perceived agency and experience. By considering these factors, researchers should focus on developing trustworthy, ethical, and responsible AI systems, that cater to human needs and provide optimal user experience.

Conclusion

The present study investigated the effect of AI mind perception, across the dimensions of agency and experience, while tool being the no mind condition, on uncanny valley hypothesis and basic psychological needs (BPNs) fulfillment in a healthcare context. The research gap on the study of mind perception and BPNs fulfillment is filled by this research, although it needs further evidences. We manipulated the perceived mind dimension of an AI system named Maya, and examined how attributions of agency, experience, and tool (no mind condition) influence feelings of eeriness and satisfaction of autonomy, competence, and relatedness needs. Although our results did not reach statistical significance, the observed trends align with previous researches and theoretical frameworks. Future researches should build upon these findings and trends, while addressing the methodological limitations and the study design limitations presented in the paper. The research highlights the importance of interdisciplinary approaches in AI development, combining insights from psychology, cognitive science, and human-computer interaction. As AI systems become increasingly prevalent in healthcare and other critical domains, combining these psychological factors will be crucial for designing systems that not only perform tasks effectively but also support user well-being and foster positive human-AI interaction.

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Appendix

Survey Questionnaire

Please find the Survey questionnaire of our online experiment in the following GitHub Link. Survey Questionnaire

Data Availability

The dataset is available through the following GitHub Link. Data

Data Analysis

Please find the Python scripts and output of the analyses in the following GitHub Link. Data Analysis