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How Human Users Engage with Consumer Robots? A Dual Model of Psychological Ownership and Trust to Explain Post-adoption Behaviours

Abstract

Consumer robots are technically evolving and have a growing presence in our daily lives with enhanced interactive capabilities. While there is insightful literature on robot adoption, so far, research has done less to examine the post-adoption interaction of human-consumer robots. Drawing on trust in technology model and psychological ownership theory, this study proposes a conceptual dual model to explain robot users' post-adoption behaviours, while considers the moderating roles of anthropomorphism and social presence. We empirically corroborated our model by asking from 403 current robot owners to illustrate theoretical paths to their post-adoption behaviours including cognitive absorption and intention to explore. This study contributes to the extant literature of human-robot interaction by proposing a theoretically grounded and empirically tested framework that contextualizes psychological ownership theory, uncertainty reduction theory, and trust in technology model. We also highlight the implications for practitioners to leverage trust and psychological ownership mechanisms together for encouraging users to actively engage with robots.

Keywords: Consumer robots; Psychological ownership; Trust; Anthropomorphism; Social presence; cognitive absorption; Intention to explore

1. Introduction

What was considered as a revolution at the beginning of 21 century when the first generation of consumer robots like vacuum cleaners and lawnmowers was introduced, is now pretty common technology. The next generation of consumer robots is emerging which is going beyond home care robots typically taking on a specific chore (de Bellis & Johar, 2020) to interactive connected personally assistants or family companions (Lum, 2020). Consumer robots integrate information technology into physical embodiments to make everyday life easier. The recent development of artificial intelligence (AI) in understanding and producing natural language, learning from experience, and even understanding and mimicking human emotions has fuelled the rapid growth of robots. Further, the declining prices of robots and the growing demand for homecare due to increasing elderly population have also propelled consumer robots market growth (Businesswire, 2017). As reported by Market Watch (2020), approximately US$18 billion global market of consumer robot in 2020 is expected to reach more than US$76 billion by the end of 2026, outlining of 22.9% compound annual growth rate. Juniper Research (2019) has also projected that in 2024, the demand for consumer robots will reach to more than 74 million, up from approximately 28 million robot delivery in 2019. These numbers echo a promising market, such that more and more entrepreneurs are opting to enter this market to take advantage of its huge opportunities.

Although the human-robot interaction literature has generated rich findings on robot adoption (e.g., de Graaf et al., 2015; Latikka et al., 2019), but less is known about how users' post-adoption behaviours develop in association with robots. In this regard, Van Doorn et al. (2017) argue that the ability of robots to engage and interact with humans has important implications for shaping user' post-adoption experiences. Seeking to explicate how users might engage with consumer robots, this study develops and empirically tests a theoretically grounded dual model of psychological ownership (Pierce et al., 2001) and trust in technology (McKnight et al., 2011) that explains users' post-adoption behaviours in the context of consumer robots. In particular, our model predicts that users' post-adoption reactions (here intention to explore and cognitive absorption) to robots are driven mainly by two means: (1) psychologically feeling ownership of robots, (2) perceiving robots trustworthy and willingly depend on them. This dual model of psychological ownership-trust is in accordance with the commitment-trust theory which theorizes that the presence of commitment and trust are key factors that influence attitudes toward a relationship (Wang et al., 2016). In a similar vein, we use the psychological ownership theory as a new theoretical lens to understand the extent to which the sense of control in interactions with robots, obtaining intimate knowledge of them, and investing self into them signifies a strong psychological bond to robots, which in turn might lead to post-adoption behaviours. In addition, we draw on uncertainty reduction theory and McKnight et al.'s (2011) trust in technology model, to understand how perceived trustworthiness of consumer robots through the perception of normality of using robot conditions and the presence of protective structures would predict users' post-adoption behaviours. Thereby, our dual model proposes that psychological ownership and trust together generate a higher-level relationship with technology (here consumer robot) and make it more attractive relative to other technologies, which eventually lead to positive post-adoption behaviours such as intention to explore or cognitive absorption.

Furthermore, we incorporate anthropomorphism and social presence as moderators into our model. As Lee (2010) suggests human-likeness affects people's tendency to attribute social characteristics to artificial agents such as robots, which in turn may influence their psychological relationships with them. This is consistent with social response theory (Nass & Moon, 2000) which posits that the ability of nonhuman agents to foster a social connection would be stronger when the agent is anthropomorphized (Verhagen et al., 2014). Additionally, consumer robots' ability to socially interact with humans and resemble their behaviours and emotions differentiate them from many other objects in human livings. Gaudiello et al. (2016) assert that social presence has a salient effect on the reduction of uncertainties and fostering trust in human-robot interactions. Therefore, consumer robots' social presence not only may have a direct effect on trust, but the relationship of other means for generating trust may be contingent on this type of presence.

In sum, this study by proposing and empirically validating a dual model of psychological ownership-trust seeks to address the following backdrops: 1) few studies on human-robots interaction have considered consumers robots in general and their associated post-adoption behaviours in particular. Therefore, in this regard, the objective of the current work is to deepen our understanding of how human users engage with consumer robots and form stronger relationships with them. 2) While cost/benefit evaluations such as perceived usefulness have been indicated determinants in adoption stage, some researchers argue that in post-adoption phase they are not as influential as before (McKnight et al., 2011). Hence, this study intends to examine other variables to better understand users' post-adoption behaviours. 3) To our knowledge, there is no IS research that considers both psychological ownership and trust to examine the post-adoption behaviours, particularly in the context of human-robot interactions. Drawing on psychological ownership theory and trust in technology model, we aim to answer our research question: how human users' post-adoption behaviours in association with consumer robots are shaped?

The rest of the paper is organized as follows. We first review the theoretical background and propose the conceptual model and the hypotheses. We then present the empirical methodology for collecting the data and testing our research hypotheses. Thereafter, the paper continues with results and discussion sections. Finally, we present a summary of theoretical and practical implications of the study as well as and suggestions for future work.

2. Theoretical Background

2.1. Consumer Robotics

According to de Bellis and Johar (2020), the age of autonomy is emerging as autonomous technologies are coming to the scene to replace those that are merely automated. Franklin and Graesser (1996) characterize autonomous systems as agents that 'situated within and a part of an environment that senses that environment and acts on it' (p. 25). Based on this view, robots are autonomous systems that are designed and configured to function in a certain way to achieve utilitarian and instrumental objectives (Yogeeswaran et al. 2016). Typically, robots integrate physical embodiment with information technology, especially AI to work autonomously (Jörling et al., 2019). As AI and robotics technology continue to accelerate, convenient and cost-effective versions of robots are increasingly available in the market (Proia et al., 2015), so that it is more likely that robot-human interaction becomes more of an everyday occurrence (Silvia et al., 2010). Beside technology advancement, increased consumers' purchasing power and rising need for comfort and convenience are other key factors contributing to the growing consumer robot market. Ageing populations in advanced economies has also triggered consumer robots adoption that are gradually becoming part of people's life (de Graaf et al., 2015).

Consumer robots are a special category of robots that are mostly used in domestic or personal environments, for entertainment, housekeeping, and more recently for accompanying humans (Bertacchini et al., 2017; de Graaf et al., 2015), education (Serholt, 2018) and caring (Deutsch et al., 2019; Spekman et al., 2018). Consumer robots are not anymore limited to automatically carrying out our chores, but they are transforming into socially interactive and technically connected devices that offer attachment and intimacy (Birnbaum et al., 2016). Although domestic robots are improving lives by autonomously doing our chores and effectively free our time, robotic personal assistants or family companions with more social cognition and interaction are emerging ones. For example, Dogmy by ROOBO is the first '*intelligent*' and family-friendly pet robot that entertains children, understands emotions and gestures and even breaks into dance. By embedding AI systems like facial recognition, Dogmy identifies family members, greets and entertains them and follows their rules.

The transformation of consumer robots from automatic domestic tools into high-level autonomous partners (Piçarra & Giger, 2018) enables richer interactions with humans and stimulates considering them as social entities (Jörling et al., 2019). However, compared with the wealth of research on robot acceptance, there is still a paucity of knowledge about human-robot interactions after adoption. According to Schmitt (2019), as new technologies such as robots generate a new phase of digital revolution, combining bits and atoms; it is important to understand how people perceive and engage with these special technologies. Given this, we suggest a dual model of psychological ownership-trust to examine the relationship between users and consumer robots and advance our understanding of post-adoption behaviours in this context. Particularly, we examine two post-adoption outcomes: intention to explore as 'user's willingness and purpose to explore new technology and find potential use' (Nambisan et al. 1999, p. 371), and cognitive absorption as a state of deep involvement with the technology that all of the attentional resources of the user are focused on it (Agarwal and Karahanna, 2000).

2.2.The Dual Model of Psychological Ownership-Trust

2.2.1. Psychological Ownership of Consumer Robots

Psychological ownership has evolved from the psychology of 'mine', proposing that people have an innate need to possess (Dittmar, 1992). Pierce et al. (2003) define psychological ownership as 'a state in which individuals feel as though the target of ownership (or a piece of that target) is theirs (i.e., it is 'MINE')' (p. 86). People experience psychological ownership over targets that are important to them, whether it is material or immaterial (Pierce et al., 2003), such as car, company, other people, song, or even social network. Psychology of possession argues that although psychological ownership and legal ownership may overlap, the latter does not necessarily result in feeling 'ownership'. Put differently, legal ownership is recognized by others and legal system, whereas psychological ownership is a self-derived perception and manifested *per se* (Dawkins et al., 2017). Hence, psychological ownership, as noted by others, reflects a relationship between a person and an object, wherein the person feels a close connection with the object as it is the extension of themselves (Jussila et al., 2015).

Pierce et al. (2001) posit that psychological ownership serves three basic psychological motives: (1) need for efficacy and effectance; (2) need for self-identity; and (3) need for belongingness (having affiliative attachments). They further suggest three major routes or mechanisms people experience whereby feeling ownership materialises: perceived control, intimate knowing, and self-investment (Pierce et al., 2001). More specifically, the state of psychological ownership of a target emerges when people profoundly have a sense of control or effectance over it, when they comprehensively know it, or when they considerably devote time and energy to it (Zheng et al., 2018).

Many researchers in various fields have studied psychological ownership and have shown its significant emotional, psychological and behavioural impacts. For example, in organizational behaviour, prior works indicate that psychological ownership has positive effects on desirable employee attitudes such as commitment (Liu et al, 2012), job satisfaction (Knapp et al., 2014), or work engagement (Ramos et al., 2014). In marketing, Harmeling et al. (2017) theorize that psychological ownership beside self-transformation lead to customer engagement, or Fuchs et al. (2010) contend that psychological ownership empowers customers. Likewise, psychological ownership has been investigated in several IS domains. Prior IS literature reveals that psychological ownership increases the likelihood of new system adoption (Barki et al., 2008), improves participation in the social media (Karahanna et al., 2018; Kwon, 2020), virtual worlds (Lee & Chen, 2011), and online communities (Lee & Suh, 2015), leads to the co-creation in crowdfunding projects (Zheng et al., 2018), or promotes players' commitment in online games (Moon et al., 2013). In addition, in the human-robot interaction context, Van Doorn et al. (2017), in their theoretical study, provide a high-level direction on mediating role of psychological ownership and social cognition between the social presence of industrial service robots and customer outcomes. They propose that customer sense of psychological ownership related to the service robots is formed through perceived receptiveness, attractiveness, and manipulability in the service encounter domain.

In sum, psychological ownership is instrumental to adoption and postadoption behaviour, because it (1) pursues users to consider attributes beyond the cost-benefit assessments such as ease of use or perceived usefulness, (2) preserves and enhances users' relationships with the target through satisfying three basic psychological needs (Karahanna et al., 2018). As per Belk (2013), feeling ownership is part of the human condition and plays a crucial role in the owner's identity that possessions become part of the extended self. Perceiving ownership encourages individuals to explore and exploit their possessions, because when they feel efficacy and control, when they obtain knowledge about something and become familiar, or when they can define themselves and express their self-identity to others objects, they sense effectance, belonging and find the reference points around them in which to dwell (Pierce et al., 2001). Thus, we postulate that when consumer robots have the essential attributes to fulfil the three basic needs of effectance, self-identity and belongingness, people can engage with them and develop post-adoption behaviours such as cognitive absorption or intention to explore.

H1a. Psychological ownership of a consumer robot is positively related to cognitive absorption of the robot in a postadoption context.

H1b. Psychological ownership of a consumer robot is positively related to individuals' intention to explore the robot in a postadoption context.

Psychological Ownership Mechanisms

Pierce et al. (2001) propose that psychological ownership may be developed through three major pathways or mechanisms: exercising control over the target, intimately knowing of the target, and investing the self in terms of time and energy in the target of ownership.

Controlling Consumer Robots

Controlling the use of an object is a key structural element contributing to the emerging of psychological ownership (Pierce et al., 2001). Rosenthal (2004) suggests that perceived control is the individual's perception about the availability of abilities, resources or opportunities to experience positive outcomes through their own actions. Perceived control is a cognitive-based appraisal (Moorman, 1993), thus the extent of control a person has over an object determines their experience as part of the self (Furby, 1978). As noted above psychological ownership differs from legal ownership, an object might be legally owned by someone, yet due to the lack of control over it, psychological ownership may not be developed, hence it does not become part of self. Previous studies highlight the role of perceived control in developing the feeling of possession. For example, Kirk et al. (2015) showed that perception of control over technology enhances psychological ownership, or Brasel and Gips (2014) found that increased sense of control as a result of using some interfaces led to the emergence of psychological ownership toward the product. Also, Kwon (2020) demonstrated that user opinion about having control over their experience on social media that resulted in psychological ownership eventually increases user participation. Accordingly, we suggest that when a person perceives that usage of a robot is under their control and they can adjust it based on their preferences, they are likely to experience psychological ownership.

H2a. Perceived control is positively related to user psychological ownership of a consumer robot.

Intimately knowing the Consumer Robot

Pierce et al. (2001) suggest that through the process of active association, a person become familiar with an object and consequently feel it as their possession. Association with the object is critical because it frames and justifies ownership (Beggan & Brown, 1994). Obtaining intimate knowledge of objects around us, rooted in our basic need to explore our environment and to affect it, thereby to feel competent (Pierce & Jussila, 2010). According to Beaglehole (1932), when a person acquires intimate knowledge of the target of ownership, a fusion of the self with the target occurs. Indeed, in the association with an object, 'the more information and the better the knowledge an individual has about [it], the deeper the relationship between the self and the object and, hence, the stronger the feeling of ownership toward it' (Pierce et al., 2001: 301). Providing capabilities and conditions that users gain knowledge through their association with robots helps to increase the sense of psychological ownership. Due to the increasing reliance of humans on autonomous systems such as AI or robots, scholars argue that providing information about functions of these systems improves the effectiveness of human-system interactions (Anjomshoae et al., 2019; Wortham & Theodorou, 2017). Prior studies on robots also show that enhanced transparency and self-disclosing of information increase human-robot interactivity (Edmonds et al., 2019; Nomura & Kawakami, 2011). Thereby providing users with opportunities for getting to know the robots would increase engaging behaviours. For example, designing simple interfaces or self-explanation features enable users to understand how to interact with robots and what functionality robots provide, hence users' cognitive awareness would be reinforced and as a result, their psychological ownership and engagement would increase. Thus, we hypothesise that:

H2b. Intimate knowing is positively related to user psychological ownership of a consumer robot.

Investing the Self into the Consumer Robot

The third route leading to psychological ownership of a target is through investing self into it. Csikszentmihalyi & Rochberg-Halton (1981) argue that when people invest physical, cognitive, and emotional energy into the targets of possession, they connect themselves with the objects. Investing self to a target reinforces the sense of belongingness to it and generates the feel of psychological ownership. This is consistent with Locke's (1690) view that we own our labour (energy), thus we feel ownership over what we create, share or produce. Pierce et al. (2001) speculate that investing efforts, time, skills, physical resources, or even values enable people to portray themselves in the targets and see their reflections in them which in turn nurtures the development of psychological ownership. For instance, when a person uses a new system and devote their time or energy to know and work with it closely, they have integrated some of their own characteristics with it; thereby the system might be a part of their extended self (Belk, 2013). In the IS context, technological systems like smartphones, virtual worlds, and social media usually provide their users with affordances to configure system features, customize them, create preferred lists or share contents with other users. Relatedly, if robots offer similar affordances to their users, such that they can invest their time and energy, the feel of psychological ownership would emerge. Personalizing or upgrading some features of the consumer robots, creating preferred lists and recalling them, recording and keeping valuable user resources such as information and photos, and finally providing emblems that users can signal their identity to others (Baxter et al., 2015) allow individuals to invest their own ideas, unique knowledge, and personal style into the robots. Accordingly, we propose that the more a user devotes her physical, cognitive, and emotional energy into a consumer robot, the stronger the sense of psychological ownership would be.

H2c. Self-investment is positively related to user psychological ownership of a consumer robot.

2.2.2. Trust in Consumer Robots

The crucial role of trust in relationships under uncertainty or risky situations has long been emphasized by academics and practitioners (e.g., McKnight et al., 2011; Pirson & Malhotra, 2011). Trust is defined as a willingness to be vulnerable to another party (Schoorman et al., 2007), based upon the positive characteristics of the other party (Rousseau et al., 1998). In their seminal paper, Mayer et al. (1995) suggest that a trustor evaluates the trustworthiness of a trustee in terms of three primary dimensions of *ability*, *benevolence*, and *integrity*. Ability is the belief that the trustee endowed with the required competence and skills to effectively accomplish the specific task at hand. Benevolence is the belief that the trustee cares enough and acts in accordance with trustor's interests. Integrity is the belief that the trustee consistently believes and follows an agreed set of principles. McKnight et al. (2011) argue that trustworthiness is not only attributable to humans, but also to technologies and suggest the concept of trust in technology. They define trust in technology as the extent to which a specific technology has the essential attributes to accomplish a required task, offer useful advice to perform a task, and work consistently and predictably (McKnight et al., 2011). They further propose a model based on technology attributes that predicts how trust in a specific technology could predict its post-adoption usage. Prior work reveals that in shaping post-adoption behaviours, trust resulted from knowledge of technology and experience are more determinants than constructs that are based on cost-benefit evaluations such as perceived ease of use or perceived usefulness (e.g., Kim& Malhotra, 2005; Srivastava & Chandra, 2018; Venkatesh et al., 2016; Wang et al., 2016).

Technically, characterized by high degrees of autonomy with intelligence and decision-making capabilities, it is likely that consumers perceive robots with scepticism that they might have unpredicted consequences or even behave intrusively and endanger their lives (Gaudiello et al., 2016). Because of unique characteristics of robots such as physical embodiments, intelligence, authority, making decisions and taking actions capabilities, researchers increasingly highlight the role of trust in human-robot interactions (e.g., Baker et al., 2018; Gaudiello et al., 2016; Natarajan et al., 2020; Salem et al., 2015). Baker et al. (2018) contend that whereas robots are more and more 'being deployed in environments and roles that require complex social interaction with humans', trust as an important aspect of such interactions must be more carefully considered (p. 30). Gaudiello and her colleagues (2016) investigated dynamics of human-robot interactions via an experimental study and demonstrated that users trust robots more in functional task relative to social tasks. In their longitudinal explorative study, de Graaf et al. (2015) report that trustworthiness of the robots is a serious issue and is largely reduced when the robots show some inconsistency in their behaviour or when provide incorrect information. Accordingly, we postulate that when consumer robots have the essential attributions to reliably and consistently deliver the promised functionalities and in the owners' best interest, users would be engaged with them and develop post-adoption behaviours such as cognitive absorption or intention to explore.

H3a. Perceived trustworthiness of a consumer robot is positively related to cognitive absorption of the robot in a postadoption context.

H3b. Perceived trustworthiness of a consumer robot is positively related to individuals' intention to explore the robot in a postadoption context.

Means of Consumer Robot Trustworthiness

Given the significance of the trustworthiness concept in the technology context, it is necessary and important to understand the key means of trustworthiness. According to the uncertainty reduction theory (URT), the primary concern of individuals during interactions is to alleviate uncertainty or improve the predictability of parties' behaviours (Berger & Calabrese, 1975). Typically, people seek relevant information in their interactions with others for mitigating risks and associated anxieties (Griffin, 2006). The central tenet of URT is that individuals use three information-seeking strategies to reduce uncertainty: active, passive, and interactive (Berger & Bradac, 1982). Employing passive strategy means observing the target unobtrusively without actually interacting with them. By using an active strategy, individuals obtain information from third parties or through manipulating and structuring other party's environment. Interaction strategy involves seeking information directly from the target by either asking questions or seeking reciprocity of self-disclosures (Venkatesh et al., 2016). Srivastava and Chandra (2018) suggest that these three strategies of URT are in accordance with McKnight et al.'s (2011) trust in technology model and in particular institutional trust-building mechanisms such as situational normality and structural assurance.

Situation Normality of Consumer Robots

McKnight et al. (2011) posit that situational normality refers to a belief that when people deem a situation is normal and well-ordered, they tend to extend trust to higher levels of interactions. In the context of technology, situational normality implies that the settings for using the technology is normal and favourable, facilitates a successful interaction with it (McKnight & Chervany, 2001). Srivastava and Chandra (2018) argue that situational normality corresponds to uncertainty reduction strategies of URT, such that during the interaction with the technology, users test and observe its functionalities, also they may obtain information clues from other users and the environment. When users find the technology is appropriate, safe, normal and favourable, they would generally tend to believe that the technology is trustworthy (McKnight et al., 2002). In contrast, users may be less likely to engage with a technology that is inappropriate, unsafe or disorder, thereby their trust beliefs are affected by unfavourable information they gather and the uncertainty associated with the lack of situational normality of the technology (Wingreen et al., 2019). Human-robot interaction is not a well-developed domain, still involves many uncertainties, and evidence to foster trusting beliefs are limited in comparison to other digital technologies (Park, 2020). In this regard, we propose users are able to notify the normality of a consumer robot setting in two ways. First, explicit interactions between users and robots increase information and familiarity, thus the sense of normalcy could gradually feed into the perceived trustworthiness. Second, previous favourable experiences with digital technologies especially automatic technologies could lead to the sense of situational normality. For example, the sense that a consumer robot is similar to that of other automatic technologies could point to benchmarking efforts and signal a certain level of trustworthiness in terms of ability, benevolence and integrity. Accordingly, we hypothesise that:

H4a. User perception of situational normality is positively related to the perceived trustworthiness of consumer robots.

Consumer Robots Structural Assurance

Rooted in socio-economical interactions (Shapiro, 1987), structural assurance refers to general passive beliefs that contextual conditions such as guarantees, regulations, safeguards, promises, and operational procedures are in place to assure success (Fang et al., 2014; McKnight et al. 2002). In the technology context, the existence of structural assurance implies that there are infrastructures that support continuous usage of technology. As McKnight et al. (2011) note, the technology structural assurance is a belief that 'adequate support exists (legal, contractual, or physical, such as replacing faulty equipment) to ensure successful use of an IT' (p. 12:9). Structural assurance is in accord with the active strategy of URT, wherein people use third-party information to form their trusting beliefs. For example, guarantees or external auditing mechanisms may lead to successfully implementing software. Structural assurance, as noted by McKnight et al. (1998) affect the perceived trustworthiness of technology in three ways. First, when individuals perceive that technology is bounded by some safeguards, they begin to believe its trustworthiness. Second, infrastructural support signals the quality of technology thereby assists in shaping the perceived trustworthiness of technology. Third, the existence of the structural assurances ensures the continuance of the technology performances and consistency of the outcomes. In the consumer robotic context, structural assurance belief implies that legal and technological safeguards are in place to make the robots usage safe and protect the users from potential risks. In 2017, Occupational Safety and Health Administration, National Institute for Occupational Safety and Health, and the Robotic Industries Association formed an alliance to improve awareness of robotics hazards in particular industrial robots in workplaces and develop robots' usage safety laws. Accordingly, we propose that by providing such regulations or other safety nets and generating structural assurance beliefs users would perceive robots trustworthy.

H4b. User perception of structural assurance is positively related to the perceived trustworthiness of consumer robots.

2.3.Moderating Role of Anthropomorphism

Many researchers suggest that anthropomorphism is a key construct in explaining human-robot interactions (e.g., Schmitt, 2019; Van Doorn et al., 2017). Anthropomorphism refers to the tendency to attribute human-like characteristics, behaviours, and feelings to non-human agents (Duffy, 2003). It thus goes beyond behavioural representations of imagined or observable actions (e.g., the dog is affectionate) to attributing mental capacities or physical features that are unique to human (e.g., the dog loves me; Epley et al., 2007; Kim et al., 2016). Damiano and Dumouchel (2018) assert that using visual and linguistic portrayals to anthropomorphize and inspire human schema, gives robots social cues that make them adequately credible for human users to engage in favourable and potentially enduring relations with them.

Epley et al. (2007) propose that anthropomorphism cognitive mechanism works in accordance with effectance mechanisms. Humans through anthropomorphism as a specialized process of induction, logically seek to understand and predict the complex world around them by applying their existing knowledge about human agents (Epley et al., 2007). By anthropomorphizing, indeed people seek to effectively interact with nonhuman agents, improve their ability to explain complicated notions around them and predict the behaviour of these complex things in the future.

Yang et al. (2020) suggest that knowledge about humans in general and the self in particular serves as an effective mean for gaining the sense of controllability over nonhuman agents. Ascribing human-like motivations and characteristics to nonhuman agents rises perceived control because knowledge about the self and about human improves people's ability to comprehend an agent's actions, reduces the uncertainty associated with the agent, and boosts assurance in predictions of it in the future (Waytz et al., 2010). Anthropomorphized reasoning about robots provides additional information about their intentions, emotional states, and underlying characteristics, thereby people can gain a sense of controllability and predictability. Thus, we postulate that the effect of perceived control should be strengthened in the presence of high anthropomorphism because attributing human-like characteristics to consumer robots increases feelings of predictability and controllability, which in turn enhance the state of psychological ownership.

H5a. Anthropomorphism positively moderates the relationship between perceived control of consumer robots and their psychological ownership such that the relationship would be strengthened for higher levels of anthropomorphism.

We also expect that increasing anthropomorphism should elevate the impact of intimate knowledge on psychological ownership. That is when people anthropomorphize a nonhuman agent, it inspires the feeling of familiarity. This perceived familiarity alleviates uncertainties (Airenti, 2015), promote interactions (Damiano & Dumouchel, 2018), and generate shared meaning (Rogers et al., 2001). Epley et al. (2007) articulate that anthropomorphism reflects an inductive inference process including acquisition of knowledge, elicitation of stored knowledge, and applying elicited knowledge to a given target. Indeed, anthropomorphizing increases familiarity which in turn enhances 'intimate relationship or psychological proximity of the owner to the owned' (Pierce et al., 2003: 16). When people face uncertain or unpredictable situations, to reduce the anxiety they use their knowledge about humans and the self to make sense of the circumstances (Epley et al., 2007). Yang et al. (2020) suggest that anthropomorphism generates comprehension of the situation. They note that humans are acquainted with themselves and other humans, thereby anthropomorphizing unknown agents (here consumer robots) and leaning on human schemas to predict their future behaviours can provide a sense of understanding (Yang et al., 2020). Thus, we hypothesise that:

H5b. Anthropomorphism positively moderates the relationship between intimate knowing of consumer robots and their psychological ownership such that the relationship would be strengthened for higher levels of anthropomorphism.

Yang et al. (2020) suggest that when a person anthropomorphizes a nonhuman entity, it becomes an active source of belonging and social connection. In fact, as Chen et al. (2018) note, engaging with anthropomorphized agents assist people to satisfy their fundamental needs for relatedness. Anthropomorphism by changing the meaning of interactions with objects such as robots—from symbolic, utilitarian, or experiential relationship to a more interpersonal and social one—fosters the sense of belongingness. Epley et al. (2007) posit that anthropomorphized agents can establish social connections, and anthropomorphizing technological agents assist in effectively working and dealing with them. This sense of connection also prompts people to invest more energy to protect and care for anthropomorphized entities, thereby increases the sense of ownership (Yang et al., 2020). Therefore, we suggest that the effect of investing self should be enhanced when users anthropomorphize consumer robots because attributing human-likeness could address people needs for belonging as one of the innate motivations of psychological ownership. As a result, the effect of investing self on psychological ownership should be strengthened in the presence of higher levels of anthropomorphism. Accordingly, we hypothesise that:

H5c. Anthropomorphism positively moderates the relationship between self-investment in the consumer robots and their psychological ownership such that the relationship would be strengthened for higher levels of anthropomorphism.

2.4.Social Presence of Consumer Robots

Inciting social presence, or the feeling of being there with a real person (Oh et al., 2018) is one of the most significant implications of human-robot interactions and the ultimate goal of designing consumer robots (Kim et al., 2013). Lee et al. (2006) point out that 'without strong feelings of social presence during [human-robot interactions], the experience with robots will be nothing more than a physical experience of artificially embodied entities' (p. 759). In the context of human-robot interaction, social presence is defined as robots' capabilities to give users the 'sense of being with another' (Biocca et al., 2003), or the 'feeling of being in the company of someone' (Heerink et al., 2008).

Generally, studies about the impacts of technology on social presence can be categorized into two main research streams. In one stream, scholars have focused on interactions between humans through digital media such as teleconferencing, social networks, or virtual reality. In the other stream which is more recent, research has focused on human and machine interactions particularly because of increasingly engaging humans in 'quasi-social relationships with new forms of artificially intelligent beings … such as robots' (Biocca & Harms 2002:10). Typically, consumer robots involve a variety of communication cues such as speech, gaze, facial and gestural expressions, bodily movements, as well as intelligent adaptive behaviours (Willemse & van Erp, 2019) to enhance their social presence. Robotic scholars believe that social presence plays a crucial role in shaping human-robot interactions (e.g., Lee et al., 2006; Edwards et al., 2019).

In this respect, Van Doorn et al. (2017) introduced the concept of automated social presence as robots can replace humans in social interactions and execute some communication activities. Prior works indicate that communication cues of robots regulate the two core dimensions of social presence, i.e. intimacy and immediacy that people perceive in interaction with robots (Oh et al., 2018). According to Biocca et al. (2003), the social cues of social presence and cognitive states of immediacy and intimacy associated with it form mental models that can reduce the perceived relational risks. Also, social presence by establishing close interactions between humans and robots facilitates obtaining knowledge of robots, thereby increase their predictability and perceived trustworthiness. Similarly, in their empirical research, Kim et al. (2013) showed that when the social presence of robots is stronger, they are more likely to be perceived as genuine social actors, thus may increase their trustworthiness. Thus, we hypothesize:

H6a. The social presence of consumer robots is positively associated with their perceived trustworthiness.

As noted above, situational normality signals that exploring and exploiting technology is normal and convenience. Social presence provides additional information about how robots actually behave, allow individuals to experience interacting with robots and verify their relational attitudes. People through social presence can evaluate intimacy and immediacy of communication cues of robots (like vocal cues, gestures, and physical appearance) and link them to their previous assessments of situational normality. Matching social cues of social presence to users' prior experiences fosters the effects of situational normality and helps users to reduce uncertainty. Further, a wider capacity of conveying social presence effectively improves understanding the meanings attached to the robots' actions, reactions and emotions, which provides additional assessment information (Srivastava & Chandra, 2018). Accordingly, we postulate that social presence may have a synergistic relationship with situational normality in affecting perceived trustworthiness. Social presence delivers supplementary communication cues that boost the credibility of signs indicating the situation for using robots is normal and favourable.

H6b. Social presence positively moderates the relationship between situational normality and perceived trustworthiness of consumer robots such that the relationship would be strengthened for higher levels of social presence.

Structural assurance, as mentioned, signals users that adequate safeguards exist to support them. The objective of this institutional-based mechanism is to mitigate contextual risks in the interaction with robots and increase users' trusting beliefs. However, unlike the lacking of social presence situation that users must assess the situation based on third parties' information and/or visual cues (Fang et al., 2014), communicating with robots provides a unique approach to assessing their trustworthiness. More specifically, when users directly interact with robots, they obtain experience-based, first-hand knowledge to evaluate communication cues and mitigate uncertainties regarding using robots. Such experiential knowledge about the robot that gained via social presence is often strong enough to be a primary source of trust (Fang et al., 2014). Srivastava and Chandra (2018) argue that since 'social presence provides immersed experience, the need to verify the credentials of other [users] and the safety of the environment through third party sources may be mitigated' (p. 784). Thus, we suggest that higher levels of social presence can substitute the information and support obtained through third parties, which in turn attenuate the effect of structural assurance on the perceived trustworthiness of robots.

H6c. Social presence negatively moderates the relationship between structural assurance and robots perceived trustworthiness such that the relationship would be attenuated with higher levels of social presence.

Figure 1 presents the theoretical framework of this study with corresponding hypotheses.

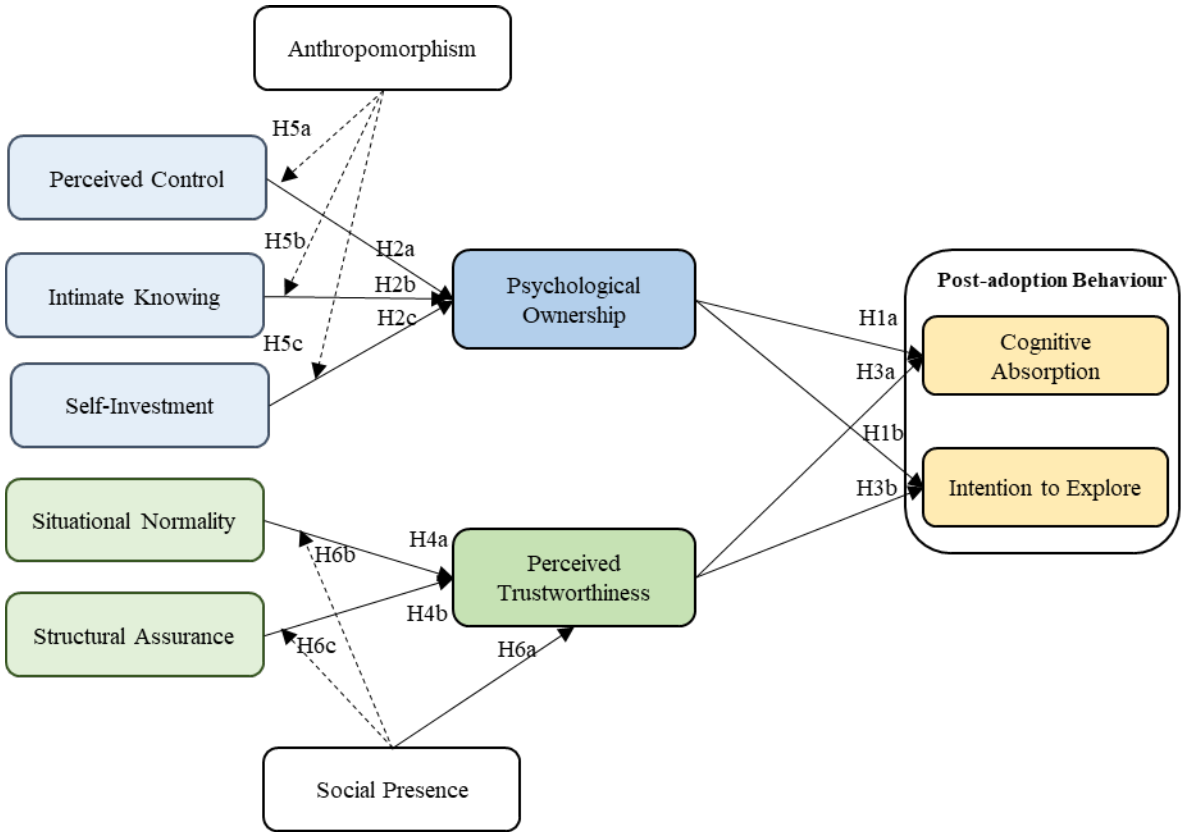

Figure 1. Theoretical Framework and Research Hypotheses

3. Research Methodology

3.1.Data Collection and Sample Characteristics

To empirically test our proposed theoretical framework, we developed a web-based survey. The questionnaire consisted of an introductory letter, highlighting the research purpose, a very concise description of what we mean by consumer robots in this study, measures for survey constructs, and questions on demographics (Olya et al., 2018). The Podsakoff et al.'s (2003) guidelines for procedural remedies to decrease potential common method bias were followed. For instance, on the questionnaire's cover page, we emphasized that data would remain confidential, the results of this survey were only for academic purposes, and the respondents' information would be anonymous (Taheri et al., 2020).

We approached four different robot owners' Facebook closed groups (including Vetor, Cozmo, and Jibo owners) with totally more than 23000 members to reach the customers with adequate insights and perception about robots. These groups are originally formed for sharing the members' thoughts, issues, and experience about possessing robots. We used the Facebook Message System to randomly send the questionnaire, along with a covering letter for describing the research purpose and information privacy. As this study intends to understand the cognition of users with relative experience in using robots, first we asked whether they had used robots and if so, they were eligible to participate in this survey by considering their personal experience. To incentivise the group members for participating, a £5 voucher was given for each correctly completed questionnaire.

Also, respondents would have a chance to win a voucher for buying a robot in a lucky draw if they responded to the questionnaire within 2 weeks. Totally, 4,000 members of robot owners' communities received our invitation and we collected 432 responses during a four-week online survey. Consequently, about one-tenth of persons contacted agreed to participate in this survey, out of which 29 responses were discarded due to at least one incorrect answer to the 'attention trap' questions. We finally analysed a total of 403 correctly completed questionnaires. We also compared the early and late respondents, which is, respondents who replied during the first week and those who replied during the last week to assess the nonresponse bias (Armstrong & Overton, 1977). A T-test was deployed on the two groups, and the results did not show any significant differences in terms of demographic specifications, experience with robots, self-efficacy, faith in technology and disposition to trust.

Table 1. Descriptive Statistics of Respondents

Age	***n***	***%***
Under 25	147	37%
25-35	114	28%
35-45	85	21%
45-55	53	13%
More than 55	3	1%
Gender		
Female	175	44%
Male	227	56%
Education		
No diploma	53	13%
College degree	88	22%
Undergraduate degree	157	39%
Postgraduate degree	104	26%
Experience in using robot	***in Month***	
	Mean= 11.3	SD= 5.67

3.2.Instrument Development

We adopted previously validated scales for all constructs and modified them to reflect the context of human-robot interaction (see Appendix 1). Psychological ownership was measured with four items adapted from Van Dyne and Pierce (2004). We adapted the five items for measuring perceived control from Zheng et al. (2018). Intimate knowing was measured with four items adapted from Brown et al. (2014). Four items for measuring self-investment were adapted from Kwon (2020). In line with McKnight et al. (2011), perceived trustworthiness of consumer robots is conceptualized as second-order constructs reflected by three dimensions: functionality, helpfulness, and reliability. Functionality refers to the robot's capacities and capabilities to accomplish the required tasks. Helpfulness refers to the robot's responsiveness and adequacy of its help function. Reliability refers to the robot's consistency and predictability. Together, these three perceived trustworthiness dimensions represent 'the essence of trust in a specific technology because they represent knowledge that users have cultivated by interacting with a technology in different contexts, gathering data on its available features, and noticing how it responds to different actions' (McKnight et al., 2011:129). Each of functionality, helpfulness and reliability was measured with three items adapted from McKnight et al. (2011). Both situational normality and structural assurance were measured with scales of four items adapted from McKnight et al. (2002). Social presence was measured with three items from Gefen and Straub (2004). We measured anthropomorphism with five items adapted from Epley et al. (2007). Four items adapted from Nambisan et al. (1999) were used to measure intention to explore. Cognitive absorption was measured with five items adapted from Burton-Jones and Straub (2006). All measurement items were anchored on a 7-point Likert scale ranging from *strongly disagree* (1) to *strongly agree* (7). Additionally, we included individual difference factors in our model to make sure that the empirical results are not due to covariance with other variables. Scholars propose incorporating gender, age, self-efficacy and experience with robots as control variables given their significant effects in post-adoption behaviours (Latikka et al., 2019; Wang et al., 2016). Further, we incorporated faith in general technology and disposition to trust as control variables for intermediate perceived trustworthiness construct given their salient impacts on user trust in technology (McKnight et al., 2011). Appendix 1 lists the questionnaire items used to measure each construct, along with descriptive statistics and loadings.

To validate our survey instrument, first three researchers reviewed measurement items along with the definitions of constructs. We then performed face and content validity via a sorting exercise with three senior PhD students. The three judges correctly placed the items onto the intended constructs with Cohen's Kappa scores averaged 0.79, the interjudge raw agreement scores averaged 0.84, and overall placement ratio of items within the targeted constructs averaged 0.81. Finally, we validated our instrument through a pilot study with 45 participants to assess the time required to complete the questionnaire, its ease of understanding, logical consistency, terminology, and its format suitability. The comments collected led to minor wording changes and pilot study results showed that the survey instrument was appropriate for use in a larger study.

4. Data Analysis, Results and Discussion

We used SmartPLS Version 3.2.8 (Ringle et al., 2015) to test both measurement and structural models. Partial least squares (PLS) is a suitable choice when we need to analyse various relationships between multiple independent and dependent variables simultaneously (Lowry & Gaskin, 2014) and also when we have second-order construct (i.e., perceived trustworthiness) in our model (Hair et al., 2019). Hair et al. (2016) recommend a two-step method for PLS analyses, wherein the first step analysing the measurement model and then the structural model.

4.1.Measurement Validity

We tested our measurement model in terms of convergent and discriminant validity. To examine convergent validity, three criteria of standardised path loading, reliability, and average variance extracted (AVE) of the constructs are used. As presented in Appendix 1, the standardised path loadings are all significant and greater than 0.7. Cronbach's alphas and composite reliabilities of all constructs are higher than accepting threshold of 0.70 (see Table 2). Also, each construct's AVE is greater than the cut-off value of 0.50, meaning that more than 50 percent of the variance observed in the items is explained by their latent constructs.

Table 2. Confirmatory Factor Analysis (CFA) Results

	CA	CR	AVE	1	2	3	4	5	6	7	8	9	10	11	12	13
Psychological ownership	0.81	0.86	0.8	**0.9**												
Perceived control	0.85	0.91	0.79	0.37	**0.81**											
Intimate knowing	0.77	0.84	0.74	0.6	0.44	**0.82**										
Self-investment	0.75	0.83	0.73	0.47	0.44	0.55	**0.85**									
Functionality	0.73	0.78	0.71	0.36	0.42	0.59	0.57	**0.84**								
Helpfulness	0.85	0.89	0.83	0.28	0.56	0.53	0.66	0.68	**0.85**							
Reliability	0.82	0.9	0.74	0.22	0.39	0.32	0.57	0.71	0.69	**0.91**						
Situational normality	0.78	0.86	0.8	0.6	0.32	0.31	0.37	0.57	0.49	0.45	**0.83**					
Structural assurance	0.79	0.87	0.82	0.22	0.25	0.28	0.32	0.43	0.56	0.61	0.45	**0.88**				
Anthropomorphism	0.82	0.88	0.84	0.58	0.31	0.46	0.43	0.32	0.28	0.21	0.27	0.19	**0.87**			
Social presence	0.83	0.89	0.79	0.58	0.54	0.45	0.49	0.56	0.42	0.59	0.52	0.48	0.61	**0.8**		
Cognitive absorption	0.87	0.91	0.79	0.55	0.44	0.58	0.64	0.45	0.41	0.51	0.39	0.5	0.47	0.55	**0.83**	
Intention to explore	0.89	0.93	0.75	0.61	0.58	0.51	0.46	0.54	0.66	0.49	0.58	0.46	0.64	0.48	0.65	**0.93**

Discriminant validity was established by the Fornell–Larcker (1981) test: the squared values of construct correlations were lower than the AVE value for each study construct (Table 2). Discriminant validity of our model is established because (1) items load higher on their related latent constructs than on other constructs and (2) the square root of each construct's AVE is higher than its correlations with other constructs (Fornell & Larcker, 1981). We also used the heterotrait-monotrait (HTMT) ratio of correlations to assess discriminant validity. The HTMT ratios are reported in Table 3 and all values are below the cut-off point of 0.90.

Table 3. HTMT Ratios of the Constructs

	1	2	3	4	5	6	7	8	9	10	11	12
1. Psychological ownership												
2. Perceived control	0.62											
3. Intimate knowing	0.44	0.68										
4. Self-investment	0.71	0.73	0.73									
5. Functionality	0.57	0.57	0.58	0.56								
6. Helpfulness	0.49	0.55	0.48	0.63	0.75							
7. Reliability	0.72	0.63	0.57	0.73	0.58	0.66						
8. Situational normality	0.54	0.44	0.47	0.61	0.61	0.55	0.54					
9. Structural assurance	0.77	0.55	0.56	0.54	0.68	0.71	0.73	0.68				
10. Anthropomorphism	0.75	0.45	0.49	0.58	0.61	0.5	0.8	0.59	0.53			
11. Social presence	0.55	0.63	0.5	0.63	0.72	0.46	0.63	0.7	0.72	0.67		
12. Cognitive abortion	0.7	0.66	0.54	0.64	0.79	0.66	0.55	0.63	0.56	0.6	0.56	
13. Intention to explore	0.51	0.54	0.47	0.55	0.59	0.7	0.69	0.62	0.61	0.59	0.65	0.69

Furthermore, we tested the presence of common method variance (CMV) in our data by using Harman's single-factor test (Podsakoff et al., 2003) and marker-variable technique (Lindell et al., 2001). Unrotated factor analysis showed that the first factor accounted for 34% of the total variance. For the marker-variable technique, we used theoretically irrelevant construct (a marker variable) to check the correlation among the main constructs. The low correlation between the main constructs and the marker variable confirms that the common method is not an issue. In addition, the principal component analysis with oblique rotation showed that each emergent factor explained an almost equal amount of the total variance, ranging from 8.96% to 12.85%. Thus, common method bias is not a major concern in this study. Overall, the results of these tests indicate that our measurement model has good psychometric properties.

4.2.Results of Hypotheses Testing

After ensuring measurement validity, we also used SmartPLS Version 3.2.8 for bootstrapping re-sampling technique with 403 cases and 5,000 randomly generated to test our structural model. Path coefficients, R-squared values, and significance in the main effects of the structural model and summary of all results are shown in Figure 2 and Tables 4 and 5.

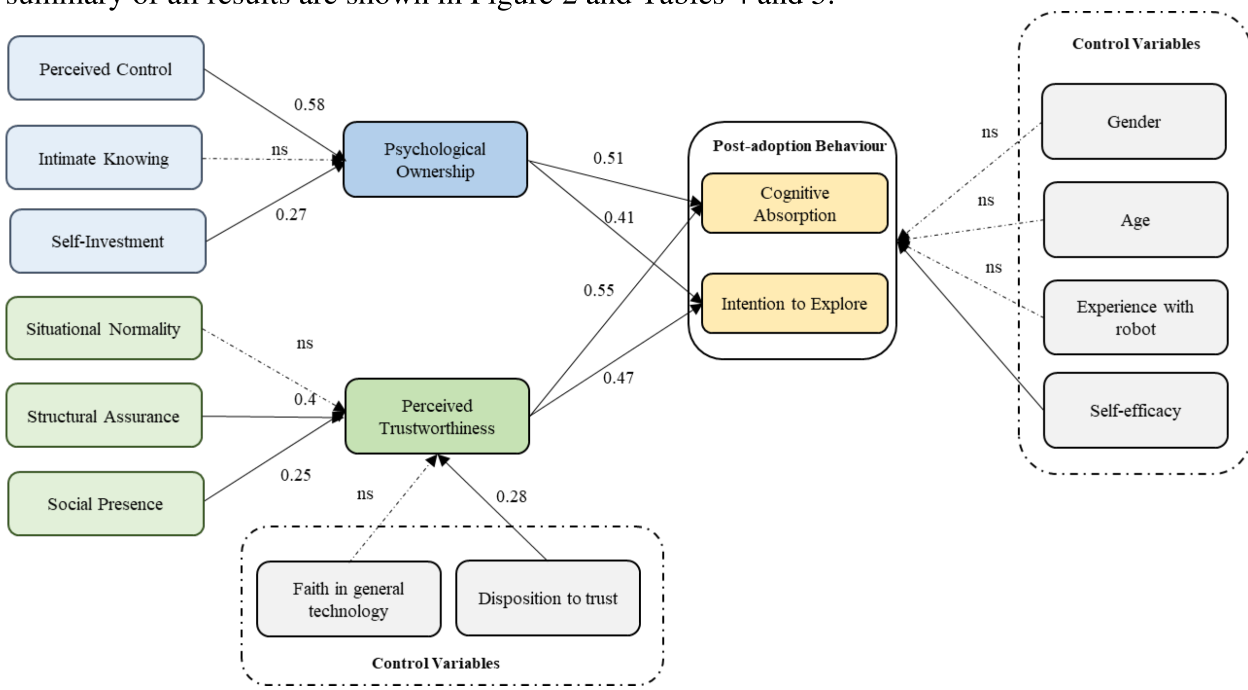

Figure 2. Results of Data Analysis

Table 4. Results of Main Path and Control Testing

Hypothesis/Path	***β***	**t-statistics**	**support**
Predictors → outcome			
H1a. Psychological ownership → Intention to explore	0.411	8.318***	Yes
H1b. Psychological ownership → Cognitive absorption	0.513	9.276***	Yes
H2a. Perceived control → Psychological ownership	0.583	10.913***	Yes
H2b. Intimate knowing → Psychological ownership	0.131	1.345 (n/s)	No
H2c. Self-investment → Psychological ownership	0.271	6.732***	Yes
H3a. Perceived trustworthiness → Intention to explore	0.545	10.489***	Yes
H3b. Perceived trustworthiness → Cognitive absorption	0.473	8.863***	Yes
H4a. Situational normality → Perceived trustworthiness	0.105	1.227 (n/s)	No
H4b. Structural assurance → Perceived trustworthiness	0.403	7.644***	Yes
H6a. Social presence → Perceived trustworthiness	0.247	6.259***	Yes
Controls → outcome			
Gender → Intention to explore	0.028	0.978 (n/s)	No
Gender → Cognitive absorption	-0.043	1.101 (n/s)	No
Age → Intention to explore	0.048	1.124 (n/s)	No
Age → Cognitive absorption	0.067	1.167 (n/s)	No
Experience with robots → Intention to explore	0.074	1.184 (n/s)	No
Experience with robots → Cognitive absorption	0.039	1.087 (n/s)	No
Self-efficacy → Intention to explore	0.225	5.684***	Yes
Self-efficacy → Cognitive absorption	0.175	3.432**	Yes

Faith in general technology → Perceived trustworthiness	0.147	1.639 (n/s)	No
Disposition to trust → Perceived trustworthiness	0.278	6.331***	Yes

Note: *p<.05; **p<.01; ***p<.001, n/s = not significant

Table 5. Bootstrapped confidence interval test for interaction effects

Interaction terms		**2.5% lower bound**	**97.5% upper bound**	**Zero included**	**support**
H5a. Anthropomorphism × Perceived control → Psychological ownership		-0.283	-0.022	No	Yes
H5c. Anthropomorphism × Self-investment → Psychological ownership		-0.210	0.042	Yes	No
H6c. Social Presence × Structural assurance → Perceived trustworthiness		0.036	0.009	No	Yes

Note: Moderation tests for the paths between intimate knowing and psychological ownership, as well as situational normality and perceived trustworthiness were not conducted because primary paths were not significant.

The results indicate that psychological ownership (H1a, H1b) and perceived trustworthiness (H3a, H3b) positively affect intention to explore and cognitive absorption. The results also show that perceived control (H2a) and self-investment (H2c) have salient effects on psychological ownership. However, we did not find an effect of intimate knowing on psychological ownership, thus H2b was not supported. Further, whereas results illustrate that structural assurance (H4b) and social presence (H6a) significantly impact perceived trustworthiness, situational normality has no substantial effects on it, hence H4a is supported.

To test the moderating roles of anthropomorphism and social presence, we followed James et al. (2019) description. For examining interaction terms, the path coefficients of the variables of interest are multiplied together and the outcome is sorted in descending order for each interaction. Next, the lower and upper bounds of the confidence interval are computed. As the results in Table 6 show, confidence intervals of the interaction terms of "anthropomorphism × intimate knowing" includes value zero, thereby we conclude that H5c is not supported. Conversely, results indicate moderating effects of anthropomorphism (H5a) on the relationship between perceived control and psychological ownership, and social presence (H6c) on the relationship between structural assurance and perceived trustworthiness.

In PLS, two measures in addition to the size and significance of the path coefficients are recommended to assess the predictive power of a model: coefficient of determination (R^2) as an indicator of predictive accuracy, and Stone–Geisser's Q^2 as an indicator of predictive relevance (Hair et al., 2016). Results of the structural model analysis indicated that the proposed model explained 32.7% of the variance (R^2) in intention to explore, 46.4% of the variance in cognitive absorption, 56.4% of the variance in psychological ownership, and 48.7% of the variance in perceived trustworthiness. Using blindfolding, Q^2 was 0.217 for intention to explore, 0.305 for cognitive absorption, 0.369 for psychological ownership, and 0.317 for perceived trustworthiness. Overall, all values were greater than the accepted threshold of zero (Hair et al., 2016).

As for the control variables, we did not find an effect of gender, age, and experience with robots, on the intention to explore and cognitive absorption, while self-efficacy had significant effects. Also, though results showed that faith in technology did not affect perceived trustworthiness, we found that disposition to trust had a significant relationship with it.

4.3.Discussion

The primary purpose of this empirical study was to examine the dual model of psychological ownership-trust that characterizes post-adoption behaviours in the context of consumer robots. Findings based on the data collected from the users that have already experienced interaction with robots highly support our proposed dual model. A notable result is that both psychological ownership and perceived trustworthiness are key determinants of post-adoption behaviours (here intention to explore and cognitive absorption). While many prior studies have focused on cost/benefit assessments such as perceived ease of use or usefulness (e.g., Ghazali et al., 2020; Latikka et al., 2019), some scholars argue that they have less predictive power in continued usage and highlight the role of trust in the post-adoptive context (e.g., Kim & Malhotra, 2005; McKnight et al., 2011). However, our findings indicate that in addition to trusting beliefs, psychological ownership plays a key role in engaging users with robots and shaping post-adoptive behaviours. In this respect, previous studies show that promoting psychological ownership is crucial in forming psychological bonds (Kwon, 2020) and enhanced type of relationships such as engagement (Harmeling et al., 2017) or commitment (Zheng et al., 2018) between a person and an object. This finding is also consistent with the commitment-trust theory that suggests commitment and trust together generate loyalty toward a target (Wang et al., 2016).

Specifically, our findings indicate that perceived control and self-investment affect the sense of ownership and fulfil the needs for effectance, self-identity and belongingness. According to Schmitt (2019) perceived autonomy of a system is inversely related to the perceived control over it and because of robots' autonomous nature, our results indicate that perceived control of robots has the biggest effect on the feeling of possession. This is in line with prior work in human-robot interaction that has profoundly demonstrated that perceived control is a significant factor in robot adoption and usage (e.g., Jörling et al., 2019). Also, we found that self-investment in robots in the form of time and energy leads to psychological ownership. However, contrary to our expectation findings show that the intimate knowing of robots does not influence ownership feeling. This could be because consumer robots are not yet transparent enough to explain their intention, performance, future plans, and reasoning process (Wright et al., 2019) or not capable enough to make complex interactions with humans.

In developing trusting beliefs in consumer robots, structural assurance and social presence are found to affect perceived trustworthiness. Since consumer robot technology is a relatively new context, the belief that safeguards exist to protect users and also perceived intimacy and immediacy of having close relationships with robots mitigate their uncertainties and ensure them to successfully use robots (Srivastava & Chandra, 2018). Yet, our findings reveal that situational normality does not have a significant effect on the perceived trustworthiness of robots. This could be because of the novelty of this technology that users do not still deem robot context normal and comfortable.

Other substantial findings are that anthropomorphism positively moderates the relationship between perceived control and psychological ownership, and social presence negatively moderates the relationship between structural assurance and perceived trustworthiness. Positive interaction of anthropomorphism implies that when human-likeness of a robot is high, perceiving its controllability and predictability increases, and consequently it plays a more significant role in predicting psychological ownership. In contrast, the negative interaction effect of social presence indicates that when users can have close relationships with robots and obtain experiential knowledge of them, their perceived trustworthiness of robots increases. Thus, the knowledge resulted from social presence may substitute for reliance on the third-party safeguards, alleviates the impacts of structural assurances on perceived trustworthiness of robots.

5. Conclusion and Implications

5.1. Implications for Research

This study contributes to the existing literature in several important ways. First, this paper addresses a gap in the extant literature on human-robot interaction where there is a lack of theoretically grounded and empirically tested models to understand users' post-adoption behaviours regarding robots. Currently, research on human-robot interaction is mainly focused on the factors influencing robot adoption with very little knowledge related to how users interact and engage with robots (e.g., de Graaf et al., 2015; Gaudiello et al., 2016; Latikka et al., 2019). Such research is important because there are several examples of robots that despite early success to create enthusiasm in the public and user acceptance, few if any of them to date have demonstrated an ability to connect with users in a deeply social manner. This research is among the first studies that theoretically and empirically examines how owners and robots could create deep interactions and engagement.

Second, prior work on post-adoption behaviours has widely focused on cost/benefit assessments like perceived usefulness, which has been argued that its influence is likely fragile across different context (Lewicki & Bunker 1995; McKnight et al., 2011). Thereby, some research on loyalty suggests using trusting beliefs to create commitment towards technology (Chow & Holden, 1997). Yet, in this study, we proposed a dual model of psychological ownership-trust to explicate users' post-adoption behaviours in association with consumer robots. We theorize that the presence of psychological ownership and trust is crucial to successfully engage users with consumer robots. Psychological ownership has been profoundly studied in various areas of organization behaviours (Knapp et al., 2014), marketing (Harmeling et al., 2017) and more recently in information systems (Kwon, 2020) and human-robot interactions. In these studies, it has been shown that feeling of ownership has a salient effect in developing deep social bonds and enduring desire to keep the relationship. However, few studies in the human-robot interaction discipline have examined psychological ownership and trust simultaneously. In this respect, the current study contributes to the literature by proposing a theoretically grounded and empirically validated model that explicates post-adoption behaviours toward a robot. Our suggested model sheds light on the human-robot engagement behaviours that psychological ownership and trust can jointly predict intention to explore and cognitive absorption.

Third, this study has implications for psychological ownership theory (Pierce et al., 2001, 2003) by examining three mechanisms through which feeling of ownership in association with consumers robots may emerge. Our results reveal that through two routes of perceived control and self-investment people can psychologically experience the state of possession. This finding has important implications for human-robot interaction research. Because, whereas much of the prior work has indicated the salient impacts of robot predictability and controllability in explaining human-robot interactions (e.g., Van Doorn et al., 2017), our study shows that in addition to perceived control, self-investment is important in developing psychological ownership. We found that the feeling of ownership is also driven by investing time and energy, for instance, the efforts spent in personalizing robots and relationships with them. Further, the finding of the non-significant route from intimate knowing to psychological ownership in human-robot interaction highlights the contingency impacts of the three main mechanisms on developing psychological ownership based upon the target and its related context (Zheng et al., 2017).

Fourth, current paper adds to the literature by contextualizing and extending uncertainty reduction theory and trust in technology (McKnight et al., 2011) to the human-robot interaction domain. Using URT strategies and matching them with McKnight et al.'s (2011) trust in technology model, we identified and examined the three means of mitigating uncertainties (i.e., situational normality, structural assurance, and social presence) regarding consumer robot usage. By introducing the social presence and examining its direct and interaction effects, this study reveals that working closely with and experiencing robots have important implications on building trust in human-robot interactions. In addition, our findings highlight the conditional effect of means for building trust and show the substitutional role of social presence in the relationship between structural assurance and perceived trustworthiness.

Fifth, we examined the moderating role of anthropomorphism on the routes to psychological ownership. Findings of this study show when users attribute human-likeness to robots, they feel a stronger connection with them and consider them more predictable. Anthropomorphizing increases the sense of efficacy of robots and competence in users, thus have a synergistic relationship with perceived control in affecting ownership feeling. Yet, insignificancy of the moderating role of anthropomorphism in the relationship between self-investment and psychological ownership implies humanization of robots does not influence investing time and energy in them.

Finally, a significant amount of IS studies on post-adoption behaviours has focused on and limited to *continued usage*. This study provides a more nuanced view of post-adoption behaviour and enhanced understanding about the relationship between usage and its antecedents in the context of human-robot interaction. Our model incorporates two specific post-adoption outcomes: intention to explore as a willingness to experiment with different features of a robot and cognitive absorption as the extent to which a user is absorbed when using the robot. To our knowledge, this is the first study in the context of human-robot interaction that examines these constructs as post-adoption behaviours.

5.2. Implications for Practice

Apart from the theoretical value of our study, our findings offer several pragmatic insights for practitioners in the consumer robot industry. First, the results of this study indicate that practitioners should leverage trust and psychological ownership mechanisms together to encourage users to actively use robots and engage with them. In particular, we suggest practitioners consider features and facilities such as customization, user friendliness, or increasing security and privacy that users can perceive both ownership and trust in their interaction with consumer robots.

Second, to develop a feeling of ownership, robots should have features that enable users to invest themselves and experience competence in controlling robots. An important practical implication of this study is that practitioners should encourage users to personalize their interactions with the robots because these interactions eventually would increase the sense of psychological ownership.

For example, robot designers need to improvise features that actively stimulate users to customize them. On the flip side, in a research project at MIT University, scholars found that if robots learn their users' personalities and provide customized services, they can keep users engaged (Park, 2019). Also, due to the autonomy of robots, users may feel less psychological ownership, we thus recommend practitioners provide features that increase the sense that robots are under control. For example, companies can provide facilities through which users can manipulate some of the functions of robot and receive feedback from them based on the changes users made. Further, our findings show that anthropomorphizing of robots increases the sense of control, which in turn, enhances the feeling of ownership. Thereby, we recommend practitioners engineer robots in a way that activate anthropomorphic projections in users.

Third, our findings indicate the importance of structural assurance and social presence as two effective means of uncertainty reduction for developing trusting beliefs in robots, thereby facilitating engaging with them. We suggest practitioners and policymakers provide more effective institutional infrastructure and safeguards such as guarantees or legal contracts that ensure users that they can successfully user robots. The significant interaction effect of social presence suggests that when social presence is high, users are more likely to engage with robots. Therefore, practitioners should design features that foster the social presence of robots for instance by increasing communication cues of robot either verbal or non-verbal to increase user trust and facilitate engagement with them.

5.3.Limitations and Future Research

Although our work contributes to the human-robot interaction literature, its findings should be interpreted in light of some limitations. First, we considered consumer robots as the selected type to be surveyed, due to its importance in today and future human livings. Investigating other types of robots such as service robots or industrial robots to check the generalisability of our results or to identify contextual differences are worthy to be studied in future research. Moreover, although we considered 'Anthropomorphism' as a moderator variable in our proposed model, considering the increasing progress in robotics, we expect more active role-playing from robots in future. Therefore, future studies might examine the partnership level between human and robots, wherein robots play active role in the interaction with humans. Alternatively, scholars might be interested in studying the perception of robots in the relationships with the human users. Second, we proposed a dual model of psychological ownership-trust to predict post-adoption behaviours in human-robot interactions. We cannot rule out the possibility that post-adoption behaviours in the consumer robot context are a function of other variables that our research model did not consider. For example, future research can consider other models such as the IS success model (DeLone & McLean, 2003) and examine the effect of their variables on post-adoption behaviours. Third, this study used survey data that does not enable causal inferences. Future research could utilize experimental design to obtain knowledge of causal relationships between dependent variables (here psychological ownership, perceived trustworthiness, intention to explore, and cognitive absorption) and their antecedents. Another option for modelling and simulating the interaction between human and robots can be deploying simulation models such as system dynamics, which facilitate understanding the multiple interaction loops (Hajiheydari &Zarei, 2013). Finally, we used an online survey to collect the data which may be subject to sampling bias. The participants of this study were relatively young users active in social media with relatively high computer self-efficacy. Hence, our sample may not be representative of the all consumer robot user population, still, our study participants are very likely representing the target population. Future research could examine senior users or users with low computer self-efficacy.

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Appendix 1. The Survey Questionnaire Items

Construct/ Items	Mean	SD	Factor Loading
Psychological Ownership			
This is my robot	5.78	1.22	0.76
I feel a very high degree of personal ownership for this robot	5.45	1.25	0.74
I sense that I own this robot.	5.23	1.35	0.81
Robot incorporates a part of myself.	4.32	1.56	0.75
Perceived Control			
I feel I have control over my robot.	5.26	1.22	0.77
When I consider my robot, I feel in control.	5.17	1.24	0.86
I feel that I have no control over my robot.	5.18	1.18	0.79
I feel in control in my robot.	5.07	1.07	0.81
In general, to what extent do you have control over your robot?	4.85	1.13	0.85
Intimate Knowing			
I am intimately familiar with what is going on with regard to my robot.	3.92	1.28	0.8
I have a depth of knowledge as it relates to my robot.	3.95	1.23	0.75
I have a comprehensive understanding of my robot.	3.87	1.36	0.81
I have a broad understanding of my robot.	4.07	1.35	0.78
Self-investment			
I feel very involved in my relationship with my robot – like I have put a great deal into it.	4.43	1.37	0.81
I have invested a great deal in my relationship with my robot.	4.25	1.25	0.83

Construct/ Items	Mean	SD	Factor Loading
The time I have spent on my robot is significant.	4.05	1.18	0.78
Compared to other things, I have spent a lot of effort using my robot.	4.12	1.43	0.76
Functionality			
My robot has the functionality I need.	4.21	1.48	0.82
My robot has the required features for my tasks.	4.12	1.36	0.77
My robot has the ability to do what I want it to do.	4.16	1.54	0.73
Helpfulness			
My robot supplies my need for help through a help function.	4.83	1.32	0.72
My robot provides competent guidance (as needed) through a help function.	4.37	1.56	0.77
My robot provides very sensible and effective advice, if needed.	4.55	1.45	0.75
Reliability			
My robot is a very reliable technology.	4.52	1.25	0.82
My robot does not fail me.	4.45	1.17	0.79
My robot is extremely dependable.	4.47	1.26	0.73
Situational Normality			
I am totally comfortable working with robots.	3.62	1.37	0.81
I feel very good about how things go when I use robots.	3.65	1.24	0.77
I always feel confident that the right things will happen when I use robots.	3.77	1.07	0.83
It appears that things will be fine when I utilize robots.	3.43	1.32	0.74
Structural Assurance			
I feel okay using robots because they are backed by vendor protections.	5.05	1.8	0.72
Product guarantees make it feel all right to use robots.	5.23	1.65	0.87
Favourable-to-consumer legal structures help me feel safe working with robots.	4.97	2.02	0.75
Having the backing of legal statutes and processes makes me feel secure in using robots.	4.85	1.88	0.73
Social Presence			
I believe there is a sense of human contact in using my robot for interactions.	5.57	1.07	0.93
I believe there is a sense of personalness in using my robot for interactions.	4.56	1.45	0.85
I believe there is a sense of human warmth in using my robot for interactions.	5.13	1.75	0.78
Anthropomorphism			
My robot has intentions.	4.35	1.13	0.81
My robot experiences emotions.	4.26	1.57	0.85
My robot has free will.	4.58	1.32	0.87
My robot has consciousness.	4.47	1.45	0.83
My robot has a mind of its own.	4.15	1.52	0.78
Intention to Explore			
I intend to experiment with new robot features for potential ways of using it.	4.08	1.25	0.81
I intend to investigate new robot functions for enhancing my ability to work with it.	4.36	1.27	0.78
I intend to spend considerable time in exploring new robot features to better interact with it.	4.45	1.35	0.75
I intend to invest substantial effort in exploring new robot functions.	3.85	1.17	0.76
Cognitive Absorption			
When I use my robot, I am able to block out all other distractions.	4.72	1.07	0.83
When I use my robot, I feel totally immersed in what I do.	4.67	1.16	0.75
When I use my robot, I got distracted very easily. ®	4.56	1.25	0.77
When I use my robot, I feel completely absorbed in what I do.	4.13	1.32	0.8
When I use my robot, my attention does not get diverted very easily.	3.85	1.43	0.78
Faith in General Technology			
I believe that most technologies are effective at what they are designed to do.	4.16	1.02	0.83
A large majority of technologies are excellent.	4.37	1.14	0.86
Most technologies have the features needed for their domain.	4.25	1.21	0.89
I think most technologies enable me to do what I need to do.	4.75	1.28	0.85
Disposition to Trust			

Construct/ Items	Mean	SD	Factor Loading
My typical approach is to trust new technologies until they prove to me that I shouldn't trust them.	5.33	1.27	0.75
I usually trust a technology until it gives me a reason not to trust it.	5.45	1.35	0.77
I generally give a technology the benefit of the doubt when I first use it.	5.07	1.22	0.81
Self-Efficacy			
I believe that I can use robot even if there is no one around to tell me what to do as I go.	5.23	1.05	0.85
I believe that I can use robot if I have a lot of time to interact with.	5.46	1.12	0.82
I believe that I can use robots if I have the built-in help facility for assistance.	5.13	1.15	0.79