International Journal of Social Robotics
https://doi.org/10.1007/s12369-023-01024-x

Factors Affecting Acceptance of Social Robots Among Prospective Users

Prodromos D. Chatzoglou[1] · Vasiliki Lazaraki[1] · Savvas D. Apostolidis[1] · Antonios C. Gasteratos[1]

Accepted: 8 June 2023

Abstract

Rapid technological and scientific developments in the robotics field have led to the expansion of the use of service robots in domestic environments. The purpose of the study reported in this paper is to identify the factors that determine people's psychology, attitude, and intention to use a social robotic system. A new conceptual framework is developed and empirically tested, using data from 347 people, performing Structural Equation Modeling analysis. The proposed framework incorporates various factors related to hedonic attitudes, utilitarian attitudes, normative beliefs, control beliefs, and personality traits. The results reveal predominantly the positive impact of normative beliefs and utilitarian and hedonic attitudes but, also, the negative impact of control beliefs on people's intention to use social robot systems. Consequently, it is concluded that future clients are not only influenced by society's general attitudes, perceptions, and prejudices towards technology but, also, by the functional benefits of social robots.

Keywords Human–robot interaction · Intention to use social robots · Normative beliefs · Control beliefs · Utilitarian attitudes · Hedonic attitudes

1 Introduction

In recent years, robots have been integrated into users' environment, facilitating their everyday life by providing a plethora of services [52]. Therefore, it is critical to understand the way everyday people perceive them or respond to their use [5, 6, 13]. Social robots are designed for supporting human needs, as well as for their successful integration into people's personal life, in a socially interactive way [19, 25]. In addition, they have a major role in areas that require social interaction skills, such as domestic environments [55]. The social interaction between humans and robotic systems is a well-developed cooperation, in accordance with specific rules and human standards of behavior and communication [40]. This has been partly achieved by putting considerable effort to ensure safety in the human-robot interaction [98, 143]. However, safety is not the only requirement for a harmonious coexistence between people and robots. Robots will stop being perceived as any other artificial object and humans will be able to benefit from robot's advent in their households when they fill the gap between digital information space and humans [49], by not only utilizing their functional abilities but, also, exploiting social skills, thus creating a relationship of interdependence and trust.

Nonetheless, the utilitarian effects of social robotic systems on human life give rise to questions concerning the importance of the interaction between humans and technology. A common approach in human-robot interaction research is that such interactions accelerate the acceptance of new technology by humans [17]. The actual process of accepting a new technology is very important, as it helps humans to familiarize with its long-term use. Sociability, social skills, the technical nature of a robot, as well as the frequency of the human-robot interaction are some of the most critical factors affecting the acceptance of such technological systems [55].

✉ Prodromos D. Chatzoglou
pchatzog@pme.duth.gr

Vasiliki Lazaraki
lazaraki.vasiliki@gmail.com

Savvas D. Apostolidis
sapostol@ee.duth.gr

Antonios C. Gasteratos
agaster@pme.duth.gr

[1] School of Engineering, Democritus University of Thrace, Xanthi, Greece

Given that social robots, as innovative technology platforms, are expected to have significant presence in people's daily lives [14, 44, 101, 112], then, one may conclude that it is important to understand the specific parameters facilitating their acceptance. This is especially important considering that they have some characteristics (humanlike embodiment, perceived agency and experience, social capabilities and capacity for eliciting affective response) [28, 31, 64], which place them in a distinctly different class of product [41]. As such, it is argued that we should not uncritically accept even fundamental proposition of social sciences which apply to other classes of products [32, 44, 138]. The acceptance of robots should be examined from a multidisciplinary point of view, incorporating various theories from various disciplines, such as robotics, psychology, sociology, to name a few [8]. The main purpose of the present study is to identify and clarify the factors that determine people's intention to use social robots. More specifically, it aims to create a valid and reliable framework for measuring people's intention for future interaction with service robots in their living, working, and leisure environments. Its main contribution is the consideration of the combined effect of various theories (Utilitarian Attitudes, Hedonic Attitudes, Normative Beliefs, Control Beliefs, and Personality Traits) on the intention to use service robots in a country where the use of such systems is at an early stage.

2 Factors Affecting the Acceptance of Social Robots

The process of accepting a new technology is an intricate, thorough decision-making process, which has aroused widespread interest in the scientific community [33, 67, 128]. Specifically, it consists of a number of phases, each one reflecting individual decisions regarding the use of technology. These not always sequential phases are (a) the Expectation phase [121], (b) the Encounter phase (Use Intention) [129], (c) the Adoption phase [122], (d) the Adaption phase [47], (e) the Integration phase [121], and (f) the Identification phase [117]. It becomes evident, therefore, that it takes considerable time for an innovative technological instrument to be fully integrated into a user's life.

With regard to the reasons that lead people to purchase a new technology, it is commonly accepted that human intentions are a crucial part of various relevant theories, which attempt to analyze human behavior [3]. Since people's intention can be used to anticipate human attitude and actual behavior (in this case towards the acceptance of a new technological system), it has triggered the interest of the scientific community [88, 110, 135]. Acceptance could be interpreted as a combination of individuals' behavioral intentions and their voluntary behavior [33] and has been the focal point of several studies [37, 68, 133]. Moreover, as far as robotics is concerned, the intention to use a technological system indicates users' readiness to first accept and then, use it [99].

There are several theories which attempt to determine human intention and behavior. For instance, the Theory of Planned Behavior (TPB) [3, 53]; a guideline for a number of subsequent surveys, as it examines, explains, and predicts human behavior [123, 130] and contributes to the better understanding of such behaviors [41, 42]. Furthermore, the Technology Acceptance Model (TAM) [33], which is a development of TPB, is another similar approach, while the Unified Theory of Acceptance and Use of Technology (UTAUT) [131], an evolution of the TAM, is another important theory which has been used by a large number of researchers during the last 20 years.

Assessment of the new technology is paramount for its acceptance [105]. People's attitudes towards new technology influence their interaction with it, as well as its timely acceptance [37, 59, 70, 105, 141]. In 2004, a scale was developed to measure the psychological state and emotions of humans using social robots, according to twelve factors, which represent the twelve dimensions of views towards these technological tools [126]. By designing the proposed twelve-dimensional scale, the various aspects of human attitudes towards robots during their interaction have been studied in depth.

Focusing on the specific technology, i.e. social robots, a number of factors have been examined over the last few years in an attempt to identify those which mostly influence people's intention to use this technology. The present study incorporates into the conceptual framework a small number of factors, namely Utilitarian Attitudes, Hedonic Attitudes, Normative Beliefs, Control Beliefs, and Personality Traits, which have been examined separately by other researchers and found to affect intention to use. A detailed discussion of these factors follows in the next sections.

The contribution of this paper as far as the proposed theoretical framework is concerned is twofold. First, this combination of factors has not yet been examined as a set, whereas, second, it has not been used in this scientific field (social robots).

2.1 Utilitarian Attitudes

Utilitarian factors substantially influence people's consumer behavior and have a significant impact on shaping their attitudes towards technology. These factors may affect human behavior, as they are related to the practicality and usefulness of a technological tool. More specifically, they include perceived usefulness [33, 67, 95, 116], effort expectancy [38, 67, 116, 131], use [38, 67, 126], perceived adaptability [55, 67, 126], as well as intelligence [12, 30, 84] of a novel technology. In addition to the technological features, utilitarian factors also include facilitating conditions [90, 109], which refer to the available resources in users' domestic environment which facilitate acceptance of new technology.

Both TPB and TAM have verified that utilitarian factors affect people's intention to use a new technology tool. Venkatesh et al., [131] made a significant contribution, proposing the integration of some new factors (ease of use—effort expectancy, performance expectancy and facilitating conditions) in the existing theories and models, thus marking the development of the UTAUT.

Attempting to examine the factors influencing the acceptance of social robotic systems, several important research endeavors succeeded in validating the relevance between the utilitarian factors and the intention to use such systems. More precisely, Heerink [68] examined various utility factors, such as ease of system use (Effort Expectancy), perceived usefulness, use, perceived adaptability, and facilitating conditions, revealing that they affect people's intention to use social robots. Additionally, Heerink [68] confirmed the assumption that effort expectancy, in particular human expectation for effortless use of the technology system, affects its perceived usefulness. Furthermore, the same research verified the assumption that facilitating conditions have a significant impact on the use of the technology system. Similarly, De Graaf and Allouch [38] examined the relation between utility parameters, such as ease of use and usefulness of the technological system, confirmingHeerink's [68] assumption, and revealing that both ease of use and perceived usefulness influence people's intention to use the technology.In addition, the results from the study by Bartneck et al., [12] that examined a system's intelligence, showed that this utilitarian factor also influences people's intention to use a new technology. Lastly, there is also a wealth of literature reviews focusing on the relation between the utilitarian factors and the intention to use a system [2, 20, 27, 30, 45, 84, 116, 126, 137].

2.2 Hedonic Attitudes

Several research projects and theories have been developed and supported, verifying the fact that specific hedonic factors play a crucial role in shaping people's attitudes towards new technology systems [18, 21, 45, 67].

The hedonic criteria are related to the attractiveness of the system and the human feeling of enjoyment during the human-robot interaction. Attractiveness is associated with feelings of charm and allure, which are experienced during the human interaction with the new technology and may encourage users' positive attitude towards it [84, 114]. Moreover, enjoyment is related to the feelings of pleasure, which are experienced during the human-robot interaction [68, 116]. Attractiveness mainly depends on the appearance of the system. That is, the more attractive a robotic system is, the greater the level of pleasure during the human-robot interaction, as well as humans' intention to use it [46, 68, 116].

Additionally, there are several equally important hedonic variables, such as companionship [34, 40, 84, 89, 118], appearance [63, 68, 84, 92, 126, 136] and anthropomorphism [12, 49, 50, 68, 77, 84].

According to the scholarly literature, social robots can constitute social partners, contributing to satisfying human emotional needs [84]. Companionship is a significant factor influencing people's intentions, as well as their behavior towards the new technological tool [116]. Anthropomorphism is another crucial hedonic factor that contributes to shaping people's attitudes towards a social robotic system is [76]. In fact, this is probably one of the most essential factors for the acceptance of this new technology [84]. Anthropomorphism is defined as the tendency of humans to attribute human characteristics to objects [49]. Its meaning is related to the concept of "Animacy", which involves the extent to which users believe that social robots behave and respond realistically [12]. Anthropomorphism is related both to the robot's appearance characteristics and its behavior during the human-robot interaction. This factor has greatly triggered the interest of the scientific community, as it has a significant impact on people's attitudes towards the new technology [37, 49, 62, 84]. In 2009, a study [12] confirmed the assumption that the extent of human resemblance of a system is related to how realistic technology is and that it affects people's intentions and behavior. Furthermore, it is also argued that an intelligent robotic system possesses a greater degree of realism and plausibility. Consequently, anthropomorphism is also related to the intelligence of the system [12].

A recent result of anthropomorphism is the "Uncanny Valley" phenomenon. This widespread theory aims to relate the human resemblance of a robot with the level of human familiarity with the system during their interaction [102]. Mori et al., [112] observed that anthropomorphic robots attract human beings to a certain extent, during their constant interaction. When the relationship between humans and technology has reached this point, the phenomenon of "Uncanny Valley"emerges, creating a feeling of anxiety and fear to the user towards the social robotic system [23]. Several studies have been conducted, examining ways to avoid the "Uncanny Valley" phenomenon when humans interact with the robotic system. For instance, one such study [48] concluded that the appearance of an anthropomorphic robot should not be repulsive, frightening and disturbing to users, during their interaction. In addition, the facial features of a social robot should neither reveal feelings of aggression towards the user, nor reach the limits of resemblance to living beings [93, 134]. Moreover, in order to avoid this phenomenon and achieve a positive interaction with the robotic system, there must be consistency regarding the models of social behavior and the limits set by humans [134].

2.3 Normative Beliefs

Normative beliefs include two essential and interrelated components, the personal normative component and the social normative component [97], which constitute a crucial factor influencing people's psychology, intentions, and behavior, encompassing values, ideals, beliefs, and experiences. The personal normative component includes the factor of trust towards the new technological tool, as well as people's attitude towards the system. Trust plays a crucial role in the acceptance of a new technology, specifically in the case of social robots [58, 68, 87, 140, 141]. There has been a large number of studies examining how normative beliefs and prejudices either facilitate or interfere people's intention to use new technology [37, 67, 84, 97, 141]. Significant studies and experiments have been conducted to examine the confidence factor during the process of technological acceptance [29, 63, 80, 87, 137]. For instance, in 2010, a noteworthy survey was carried out in order to clarify the role of trust in the human-robot interaction [140].

Additionally, the social normative component includes social effects, in particular, on the image of people, which refer to the consequences both on their hierarchical status in the society, as well as on the strengthening of their prestige. This factor has also a significant impact on the acceptance of new technologies [37, 79, 83, 129]. The integration of a new technological tool in people's daily life may lead to their prominence in society as a whole, to public recognition, as well as to the strengthening of their status and classification into higher social groups [54, 129]. The positive image of an individual in society as a whole could reduce the degree of his/her uncertainty towards this technology [111].

In their pursuit of obtaining an innovative product, consumers are usually expected to take into consideration the views of their social environment before making a purchase. Social norms are of paramount importance for people, and they are highly likely to bring about a particular behavior [79]. Thus, social influences form people's attitudes and expectations about a novel technology [37, 68, 79, 84, 111, 130, 137, 141]. In addition, social influences are also related to people's social environment, especially family and friends. Social standards and behaviors from an individual's social environment can greatly influence people's attitude [130]. More specifically, there are many people who trust and rely on the experiences of other users, in order to develop their own personal experience. The common sources of information about such technological systems are the mass media and social networks [81, 120, 141]. The influence of the mass media is particularly strong, especially for people who interact with a new technology for the first time [111]. Moreover, people sometimes even refer to movies and science fiction books to find answers to questions related to robots in order to describe this technological tool [81].

2.4 Control Beliefs

Control beliefs are associated with people's views regarding the availability and presence of resources which could help them improve their performance, as well as their tendency to fully control the technology, during their interaction with it [43]. These beliefs have a significant impact on people's psychology and behavior. Control factors may hinder or facilitate the acceptance of new technology systems. In general, control beliefs have been the main subject of several studies [3, 4, 41]. Ajzen's [4] theoretical model of programmed behavior confirms that control beliefs affect people's intentions to use a new technological tool. Furthermore, Brown and Venkatesh's [21] study validated the assumption that control beliefs have a significant impact on human intention to use new technology.

Some of the control factors that have a significant positive effect on the psychology and intention of people to use a social robotic system are the following: the safety level they wish to maintain while using the system [12, 113, 142], their level of anxiety towards using the system [22, 38, 43, 78, 92, 105, 127, 129], as well as the cost of this technology [21, 43, 126, 133].

Safety is a crucial factor influencing human behavior while interacting with a social robotic system [98, 143]. The concept of personal safety is particularly important for the acceptance and integration of technology into people's lives and is defined as users' sense of easily sharing their personal space with the robot [12]. Feelings of insecurity and uncertainty regarding technology could arise during human interaction with social robots, especially if it is to take place in users' domestic environment. Precisely, the autonomous behavior of the robot can lead to (perceived) loss of control as far the user is concerned, which is very likely to generate feelings, such as fear and anxiety that naturally impedes human's familiarization with the technological tool [142]. Ensuring comfort and safety while managing a system is an important prerequisite for the timely acceptance of technology [12, 131, 142].

In addition, users' emotional state is an essential prerequisite for shaping their attitudes towards the specific technology [9]. Thus, feelings of anxiety and restlessness regarding a social robot affect to a great extent people's intention to use it [21]. Several other studies have also validated this assumption [37, 68, 74, 78, 92, 105, 137]. Human restlessness during people's contact with a social robotic system, affects perceived usefulness, as well as ease of use of technology [129]. In addition, it has been found that there is a correlation between utilitarian and control factors regarding technological acceptance [68]. More specifically, it was found that anxiety towards a technological system had an impact on its usefulness and ease of use [68]. Further, Bartneck et al.,

[12] argued that anthropomorphism can also evoke feelings of anxiety and fear to humans during the use of a social robot.

Lastly, cost plays an important role in influencing consumers' intention to purchase new technology. Before purchasing it, people have to consider whether the cost is balanced with its overall (perceived) usefulness. As a result, perceived cost, as a control belief, is an obstacle to the timely acceptance of new technologies [21]. Moreover, another limitation for using a novel technological tool is the high cost of its maintenance and use. A large number of studies have been conducted examining cost as a factor influencing people's intentions and behavior [21, 133].

2.5 Demographic Characteristics and Personality Traits

Personal characteristics have also been found to affect the relationship between various factors and the acceptance of social robots [101, 119]. These characteristics include both human demographic [11, 119, 131] and personality traits [1, 106].

A wealth of studies have focused on identifying and clarifying human characteristics in order to contribute to the design of new social robotic systems capable of playing different roles in a variety of social contexts [38, 67, 73, 85, 126, 131, 132, 134]. These characteristics include (a) gender [7, 37, 57, 68, 73, 86, 96, 106, 108, 115, 119, 125, 128, 131, 132], (b) age [7, 37, 68, 82, 86, 89, 92, 115, 132, 133], (c) nationality and cultural background [12, 68, 72, 78, 87, 93, 96, 131] and (d) educational level of each user [12, 68, 73, 78, 93, 115].

Gender is one of the main factors affecting the psychology and behavior of new technology users. More specifically, it has been confirmed that due to the high percentage of female empathy, women accept the new technology easier and quicker than men [100]. Moreover, men perceive that robotic systems' usefulness is higher and show a greater intention to use them, inasmuch as they are attracted to their autonomy [86]. In a similar way, some surveys have indicated that women are influenced by emotional factors as they purchase new technology [125].

Age is also a critical parameter influencing human behavior towards the use of new technology and plays an important role in the technology users' psychology, in shaping their attitude and the demonstration of a particular behavior towards it [20, 24, 82, 86, 89]. According to various studies, human age and gender affect a system's (perceived) ease of use and, consequently, their intention to use it [132]. This has been validated by Graaf and Allouch [37], who found that human gender and age have a significant impact on systems' usefulness, ease of use, as well as on shaping people's attitudes towards social robots.

Another crucial parameter affecting human attitude and behavior towards social robots is the ethos and cultural background of each person [92]. This is due to the fact that each culture exhibits different behavioral patterns and stereotypes about particular types of technology [73].

People's educational level is another key parameter affecting human perception and behavior. Knowledge and technological expertise may influence people's attitude towards a novel technology, as well as their timely familiarization with it [92]. Various surveys have been carried out examining the importance of users' educational level and culture for handling new technology [12, 68, 73, 78].

Lastly, people's emotional state and personality traits are what differentiate each person as a unique entity and contribute greatly to their intention and behavior. Several studies have dealt with the measurement of human personality traits [60, 103]. This measurement was accomplished by grouping these characteristics into five key factors forming the "Big Five" personality model [10], which includes the following key factors: emotional stability, extroversion, agreeableness, conscientiousness and intellect [134]. Various research efforts confirmed that the five personality factors shape human attitude towards new technology [73, 134]. Umemuro et al., [126] presented a scale for measuring these factors, where they also included self-esteem, as a personality trait that has a considerable impact on people's behavior.

Despite all these important research attempts and findings, it is argued that further examination of the effect these individual differences play on Human Robot interaction is necessary [5, 28, 71, 94, 139].

Table 1 provides a brief definition of the main factors and the subfactors incorporated into the proposed theoretical framework, along with a number of relevant previous researches. The above theoretical and research background regarding the acceptance of social robotic systems led to the development of six main and five secondary hypotheses.

Main hypotheses.

H1 Utilitarian attitudes (intelligence, adaptability, usefulness, ease of use, facilitating conditions) affect people's intention to use a social robot.

H2 Hedonic attitudes (anthropomorphism, appearance, companionship) affect people's intention to use a social robot

H3 Normative beliefs (attitude, social influences, image, trust) affect people's intention to use a social robot

H4 Control beliefs (safety, anxiety, cost) affect people's intention to use a social robot

H5 Demographic characteristics (gender, age, education, occupation) influence the intention of humans to use a social robot.

Table 1 Brief definition of the factors and subfactors

Factor	Sub-factor	Definitions/operationalization	Relevant literature
Demographic characteristics	Gender		7, 37, 57, 68, 73, 86, 96, 106, 108, 115, 119, 125, 128,131, 132
	Age		7, 37, 68, 82, 86, 89, 92, 115, 132, 133
	Education		12, 68, 73, 78, 93, 115
	Occupation		
Personality characteristics (traits)	Emotional stability	Emotional stability is an individual's lack of susceptibility to experiencing negative emotional states (fear, anger, irritation, guilt)	73, 126, 134
		Self-esteem refers to varied & complex mental states pertaining to how one views oneself	
	Self-esteem	The extent to which someone is trusting and helpful. [136]	
	Trust	The degree to which a person's orientation is turned outward toward the external world. [136]	
	Extroversion		
Utilitarian factors	Intelligence	It is defined as users' evaluation of a robot's level of intelligence [12]	12, 30, 84
These factors relate to the practicality and usability of a robot. They are tied to utility and emphasize the extrinsic motivations to accept or use a technology	Use	The actual use of the system over a longer period in time [67]	38, 67, 126
[37]	Perceived usefulness	The degree to which a person believes that the system would be assistive [67]	33, 67, 95, 116
	Effort expectancy	It is defined as the degree of ease associated with the use of the system [131]	38, 67, 116, 131
	Perceived adaptability	The perceived ability of the system to adapt to users' changing needs [67]	55, 67, 126
	Facilitating conditions	Factors in the environment that facilitate use of the system [67]	90, 109
Hedonic factors	Companionship	It is defined as users' perceived possibility to build a relationship with a robot [84]	343, 40, 84, 89, 118
	Appearance/attractiveness	It is defined as the positive evaluation of the robot's physical appearance [83]	63, 68, 84, 92, 126, 136
These factors (or intrinsic motivation) refer to users' experience while using a robot and have no obvious relation to task-related goals [37]	Anthropomorphism	It refers to the attribution of a human form, characteristics, or behavior to nonhuman things such as robots [12]	12, 49, 50, 68, 77, 84

Table 1 (continued)

Factor	Sub-factor	Definitions/operationalization	Relevant literature
Normative beliefs	Trust	The belief that the system performs with personal integrity and reliability [67]	58, 68, 87, 140, 141
	Attitude towards robot	It is defined as the psychological states reflecting opinions people ordinarily have about robots [106]	70, 106
It includes both dispositions and rules that a group of people uses for appropriate and inappropriate values, beliefs, attitudes and behaviors. [37]	Social influences	Someone's perception that people who are important to him think he should or should not use a robot. [67]	37, 68, 79, 84, 111, 130, 137, 141
	Social impact on human image	The degree to which use of a social robot is perceived to enhance his status in his social system. [129]	40, 129
Control beliefs	Cost of robot	The actual cost of buying a robot	21, 43, 126, 133
	Safety	Perceived safety describes the user's perception of the level of danger when interacting with a robot, and the user's level of comfort during the interaction. [12]	12, 113, 142
Control beliefs consist of users' beliefs about salient control factors, that is their beliefs about the presence or absence of resources, opportunities and obstacles which may facilitate or impede behavior. [37]	Anxiety	It is defined as users' anxious or emotional reactions evoked when it comes to using robots. [67]	22, 38, 43, 78, 92, 105, 127, 129
Intention of use		The strength of one's willingness to use a robot. [99]	99

H6 Personality characteristics (emotional stability, self-esteem, trust, extroversion) affect people's intention to use a social robot.

Secondary hypotheses.

H7 Control beliefs (safety, anxiety) affect utilitarian attitudes (adaptability, usefulness, ease of use, facilitating conditions).

H8 Hedonic attitudes (anthropomorphism, appearance, companionship) affect control beliefs (safety, anxiety).

H9 Utilitarian attitudes (intelligence, adaptability, usefulness, ease of use, facilitating conditions) affect normative beliefs (attitude, trust).

H10 Personality traits (emotional stability, self-esteem, trust, extroversion) affect normative beliefs (attitude, social influences, image, trust).

H11 Ease of use of the system affects the perceived usefulness of the social robot.

3 Research Methodology

A structured questionnaire consisting of closed-ended questions (Likert scale, 1–5) was constructed for the collection of primary data. As it has already been discussed, the present survey examines 5 main factors along with 20 sub-factors in order to examine the factors that affect the dependent factor intention to use social robotic systems. To measure them, validated scales were used (a total of 88 closed-ended questions). These scales were adopted from other relevant studies (Table 2) and then they were adapted to the Greek language and context. The questionnaire consists of 7 parts, which correspond to the main factors of the framework, as well as four questions relating to the demographic characteristics of the sample (Appendix A). Before distributing the questionnaires, all necessary tests were carried out in order to eliminate expressive and other errors that could make the questions difficult to understand or that would require respondents to spend a lot of time in order to answer the questions. Among the steps taken was the pre-testing process which involved the participation of 10 people who were asked to read and comment on the questionnaire. Emphasis was also placed on

Table 2 Questionnaire structure and sources

Factor	Sub-factor	Items	References
Demographic characteristics	Gender, age, education, occupation	4	[67, 68, 132]
Personality characteristics	Emotional stability, Self-esteem, Trust,		
	Extroversion	8	[134]
Utilitarian factors	Intelligence	8	[12]
	Use	7	[67, 68]
	Perceived usefulness	3	[67, 68]
	Effort expectancy	3	[131]
	Perceived adaptability	4	[67, 68]
	Facilitating conditions	5	[67, 68]
Hedonic factors	Companionship	5	[37, 84]
	Appearance	6	[84]
	Anthropomorphism	5	[12, 37, 49, 67]
Normative beliefs	Trust	3	[67, 68]
	Attitude towards robot	8	[70, 106]
	Social influences	4	[37, 67, 68, 74, 79]
	Social impact on human image	4	[40, 129]
Control beliefs	Cost of robot	3	[74]
	Safety	4	[12, 40]
	Anxiety	5	[39, 67, 106]
Intention of use		3	[99]

the time needed to complete the questionnaire (around 15 minutes) in order to avoid participants suffering from fatigue or becoming bored.

The sample of this research includes the potential users of social robotic systems who live in Greece. More specifically, it is limited to individuals of Greek culture, with the ultimate aim of identifying the factors that accelerate their acceptance of social robots.

The questionnaire was distributed to 530 individuals, 347 answered and returned it (response rate 65,47%). The participants were selected using the Convenience and Snowball sampling approaches [61]. The sample involves people with various demographic and personal characteristics. It should be noted that the main demographic characteristics of the participants in the printed and electronic form do not significantly differ. In brief, participants are mainly women (59,9%), aged between 18 and 24 (57,9%) or 25 and 30 (19,3%), with an average age of 28 years (Std.Dev. 9,733) and well educated (74,7% have completed university level studies, while 15,6% hold a postgraduate degree). They are quite familiar with technology (μ = 3,95), but prefer not to feel uncertain about their choices (μ = 4,16) because they are very easily stressed (μ=3,36) and for this reason they are almost always well prepared and organized (μ = 3,46) when they have to take a decision. The above leads them to be rather cautious (μ = 3,10).

4 Results of Empirical Research

In order to test for the unidimensonality of the constructs, Exploratory Factor analysis was performed. Then, Analysis of Variance tests were carried out to find out whether various demographic characteristics of the participants differentiate the mean scores of the factors. Next, Correlation analysis was used to examine the relationship (in pairs) between the factors incorporated into the framework. Finally, Structural Equation Modeling was performed in order to test the proposed hypotheses. It should be emphasised that, before starting the analysis, specific pre-processing tests were performed (outliers, normality tests etc). All problems were eliminated, while it was found that all main factors incorporated into the framework were normally distributed. A detailed presentation of this statistical process follows in the next subsections.

4.1 Factor Analysis

Exploratory Factor Analysis using Principal Component Analysis was performed to test the unidimensionality of the items/questions that comprise each research factors. The reliability of each factor was then tested using Cronbach's alpha, while the appropriate indexes (Kaiser-Meyer-Olkin-KMO, Total Variance Explained-TVE, and Factor Loadings) were also examined [35, 51, 124].

Overall, the results of factor analysis (Table 3) confirmed the validity and relevance of the questionnaire structure. All factors and sub-factors are valid and reliable structures, while almost all variables are suitable items for measuring them, as for most sub-factors and factors (a) the value of the KMO index is greater than 0,600, (b) the value of the TVE index is greater than 60.000, (c) factor loadings are greater than 0,600 and (d) the Cronbach Alpha score is greater than 0,700. In addition, very few (only 6) items (questions) out of the 87 were removed, which indicates the appropriateness of the scales used for measuring the factors and sub-factors incorporated into the proposed framework.

Examining the mean scores of the factors (Table 3), it appears that the sample consists of people who focus mainly on utilitarian factors for purchasing and using new technology (μ = 3,67). In particular, if participants had the

Table 3 Results of 1st and 2nd order exploratory factor analysis

Factor	Variables	KMO	TVE	Factor loadings	Cronbach a	Mean	St. Dev
C1. Intelligence	3–8 [1, 2]	.804	55.412	.653–.759	.797	4.41	.562
C2. Use	1,2, 4–6 [3, 7]	.653	51.878	.589–.760	.710	3.48	.782
C3. Perceived Usefulness	1–3	.734	80.444	.874–.914	.878	3.66	.874
C4. Effort Expectancy	1–3	.667	62.501	.761–.815	.700	3.47	.730
C5. Perceived Adaptability	1–4	.781	63.878	.743–.838	.811	3.63	.750
C6. Facilitating Conditions	1–4 [5]	.807	70.884	.723–.890	.862	3.34	.943
D1. Companionship	2–5 [1]	.764	65.556	.746–.844	.814	2.12	.863
D2. Appearance	1–6	.830	54.953	.570–.803	.833	3.17	.884
D3. Anthropomorphism	1–5	.746	62.801	.679–.872	.847	3.02	.990
E1. Trust	1–3	.725	75.871	.855–.880	.840	2.71	.869
E2. Attitude towards robots	1–8	.881	52.031	.531–.808	.865	2.91	.795
E4. Social influences	1–4	.676	60.395	.743–.809	.779	2.86	.843
E5. Social impact on human image	1–4	.793	76.693	.778–.923	.894	2.12	.907
F1. Cost	1–3	.574	56.526	.601–.843	.594	3.74	.743
F2. Safety	1–4	.798	65.179	.760–.854	.820	3.54	.876
F3. Anxiety	1–5	.730	59.954	.646–.854	.830	3.27	.854
B. Personality characteristics	4–5 [1–3, 6, 7]	.500	81.758	.904–.904	.774	2.82	1.080
C. Utilitarian factors*	C1-C6	.778	54.689	.559–.805	.784	3.67	.542
D. Hedonic factors*	D1-D3	.619	66.858	.691–.889	.749	2.77	.746
E. Normative beliefs*	E1-E5	.786	64.204	.757–.861	.811	2.65	.683
F. Control beliefs*	F1,F3 [F2]	.500	69.098	.831–.831	.549	3.50	.664
G. Intention of use	1–3	.750	84.312	.907–.932	.907	2.58	1.027

*indicates second order factor analysis

opportunity to interact with a social robot, they would prefer a system with intelligent software ($\mu = 4{,}41$), which is really useful ($\mu = 3{,}66$) and usable, that is, to provide them with the opportunity to use it for different purposes ($\mu = 3{,}48$). Furthermore, they would like it to be convenient in its use ($\mu = 3{,}47$), as well as to easily adapt to their needs ($\mu = 3{,}63$).However, , in order for their possible interaction with the social robotic system to be facilitated, they consider that the available resources and conditions in the people's domestic environment are only relatively satisfactory and appropriate ($\mu = 3{,}34$).

On the contrary, it is obvious that they are less interested in the various hedonic factors ($\mu = 2{,}77$), thus concluding that participants are more interested in the functional characteristics of a social robot than its technological characteristics that could make its use enjoyable. More specifically, participants do not appear to be in need of a social robotic partner in their life, since they do not look for companionship from a technological system ($\mu = 2{,}12$). However, they are slightly attracted by its appearance ($\mu = 3{,}17$), but they are indifferent (μ=3,02) to the anthropomorphism characteristics of the social robotic system.

Similarly, the mean of the normative beliefs factor is relatively low ($\mu = 2{,}65$). In particular, it is considered that the use of robots will not enhance their image in society ($\mu = 2{,}12$), while their influences from the social environment are also at a low level ($\mu = 2{,}86$). Additionally, their trust towards robots is slightly negative ($\mu = 2{,}71$), which reflect their neutral, at best, attitude towards the use of this type of technological tool ($\mu = 2{,}91$).

Lastly, examining the control beliefs related factors, it is concluded that participants are seriously concerned about the cost of purchasing and maintaining social robots ($\mu = 3{,}74$). Moreover, they do not feel safe enough during their possible interaction with a social robot ($\mu = 3{,}54$) and, as a result, they are restless and anxious regarding its use ($\mu = 3{,}27$). For all the above reasons, in general, most participants stated that they are greatly concerned about the possible future use (intention of use) of a social robotic system ($\mu = 2{,}58$).

Table 4 Correlations among the main factors

	Personality characteristics	Utilitarian factors	Hedonic factors	Normative beliefs	Control beliefs
Personality characteristics	1.000				
Utilitarian factors		1,000			
Hedonic factors		.356**	1.000		
Normative beliefs		.476**	.547**	1.000	
Control beliefs	−.239**	.108*	.293**	.160*	1.000
Intention of use	.116*	.392**	.184**	.593**	− .107*

*indicates significance at .05 level, **indicates significance at .01 level

4.2 Correlation Analysis and Analysis of Variance (ANOVA)

The results of the Correlation Analysis confirmed the existence of a weak or moderate statistically significant correlation (Spearman's rho) between almost all sub-factors, as well as between the sub-factors and the dependent variable (intention of use). More specifically, the sub-factors that seem to be highly correlated with the intention to use are attitude towards robots (rho = ,593), social influences (rho = ,539), safety (rho = ,484), impact on human image (rho = ,419) and perceived usefulness (rho = ,414). The fact that for most of these sub-factors the perception of participants is rather negative (Table 3), may partly explain why the intention to use social robots is low. Regarding the factors the general view remains the same (Table 4). While all factors have a statistically significant correlation with intention to use, normative beliefs (rho = ,593) and utilitarian factors (rho = ,392) have the strongest statistically significant correlation with it.

As far as the demographic characteristics of the sample (gender, age, education, occupation) are concerned, it is found that only age is not correlated with any of the sub-factors or factors. In contrast, the other three characteristics have a statistically significant (<,300) correlation with several sub-factors or factors, even with the dependent factor (intention to use).

Furthermore, ANOVA was also performed in an attempt to examine whether there are differences among the mean scores of the sub-factors and factors of the proposed framework of people with different demographic characteristics. The results indicate that the intention to use a social robotic system varies depending on the gender and educational level of people. More specifically, it seems that men exhibit higher intention to use (2,85 compared to 2,40 of women). Similarly, those with higher educational level have relatively higher intention to use, compared to high school graduates (2,91 and 2,62 respectively). Furthermore, there is statistically significant difference in the mean score of various control beliefs of people with specific demographic characteristics. In particular, women feel more insecure and stressed, but also place more emphasis on the high cost than men (3,65 and 3,29 respectively), whereas university graduates feel relatively less insecure and anxious than high school graduate (3,41 and 3,88 respectively). On the contrary, there is no statistically significant difference in the mean scores of the utilitarian factors, the hedonic factors, and the normative beliefs of people with different demographic characteristics.

Based on these findings, it is reasonable to conclude that demographic characteristics play a significant role on people's intention to use the specific technology and it is, therefore, necessary to take them into consideration and include them in the originally proposed framework.

4.3 Structural Equation Models

To test the research hypotheses, Structural Equation Modeling (SEM) was carried out. Two different frameworks were used to examine both the main and secondary hypotheses. These are illustrated in Figure 1 (incorporating only the main factors) and Figure 2 (examining only sub-factors). The data fit indices of these two frameworks are presented in Tables 5 and 6. The results demonstrate the satisfactory adjustment, validity and reliability of the two frameworks, as the scores of all the indicators are satisfactory (within the accepted range).

The independent factors of the first framework (Figure 1) can interpret 43% the variation of the dependent factor (intention to use a social robot), 45% of normative beliefs, 20% of control beliefs, and 15% of hedonic attitudes. When sub-factors are considered (Figure 2), the independent sub-factors of the framework can interpret 43% of the variation of the intention to use a social robot, 55% of the attitude towards robots, 38% of the impact on the human image, 23% of anxiety and 19% of social influences. Therefore, it is reasonable to claim that the predictive power of both frameworks is quite satisfactory.

Based on the above results, it is understood that some of the initial hypotheses are accepted, some others cannot be

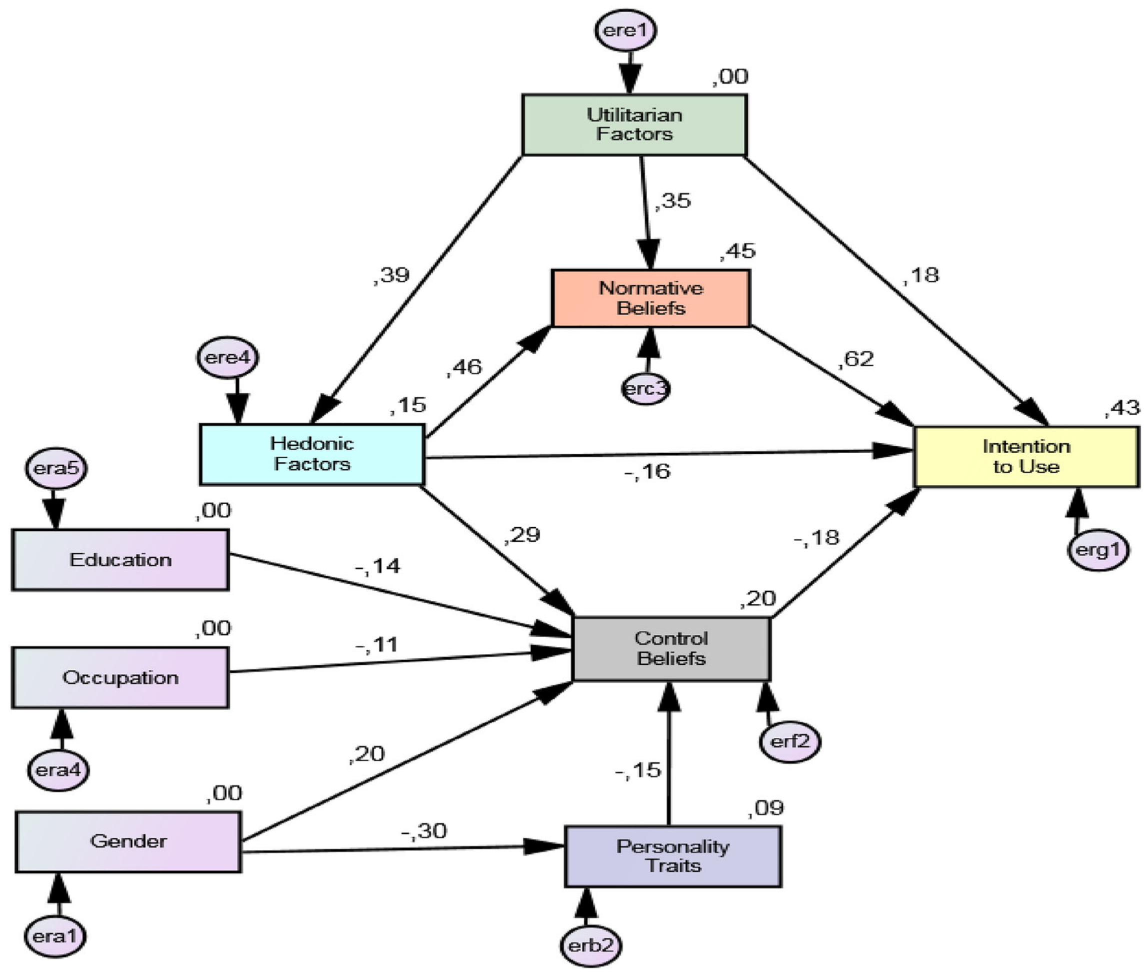

Fig. 1 Amended research framework using factors

accepted, while there are others that emerged after the completion of the statistical analysis (modifications based on the suggestions of SEM). More specifically, the main hypotheses H1, H2, H3 and H4 are accepted (Fig. 1), because there is a direct and statistically significant relationship between utilitarian factors, hedonic factors, normative beliefs, and control beliefs with the intention to use a social robotic system. As it turns out, in fact, normative beliefs have the greatest impact on intention to use (62). More specifically, two of the normative beliefs related subfactors (social influences and attitude towards robots) have the greatest direct impact on intention to use such systems (Fig. 2). Additionally, it is observed that Utilitarian Factors have a considerable total (direct and indirect) impact on intention to use social robots (0,422). This suggests that the functional characteristics, as well as the usefulness of the technological systems directly and indirectly affect the intention to use social robots. However, the results from Fig. 2 suggest that only perceived usefulness affect intention to use.

Furthermore, the results indicate that control beliefs negatively affect people's intention to use this technology (−0,179). More specifically, as shown in Fig. 2, the control beliefs related subfactors, anxiety and cost negatively affect intention to use, while safety/security positively.

On the contrary, although the initial results (Fig. 1) indicate that hedonic factors moderately influence Intention of Use (0,152), when the hedonic relate sub-factors were examined separately (Fig. 2) no statistically significant impact on the intention to use was observed. This fact indicates that participants of the current study do not pay too much attention to the features related to the appearance and attractiveness of a robot, but they rather focus on features related to its technical characteristics.

Regarding the secondary hypotheses (H7-H11), only H8 (relationship between hedonic and control beliefs) and H9 (relationship between utilitarian factors and normative beliefs) were validated from the findings (Figs. 1 and 2 respectively).

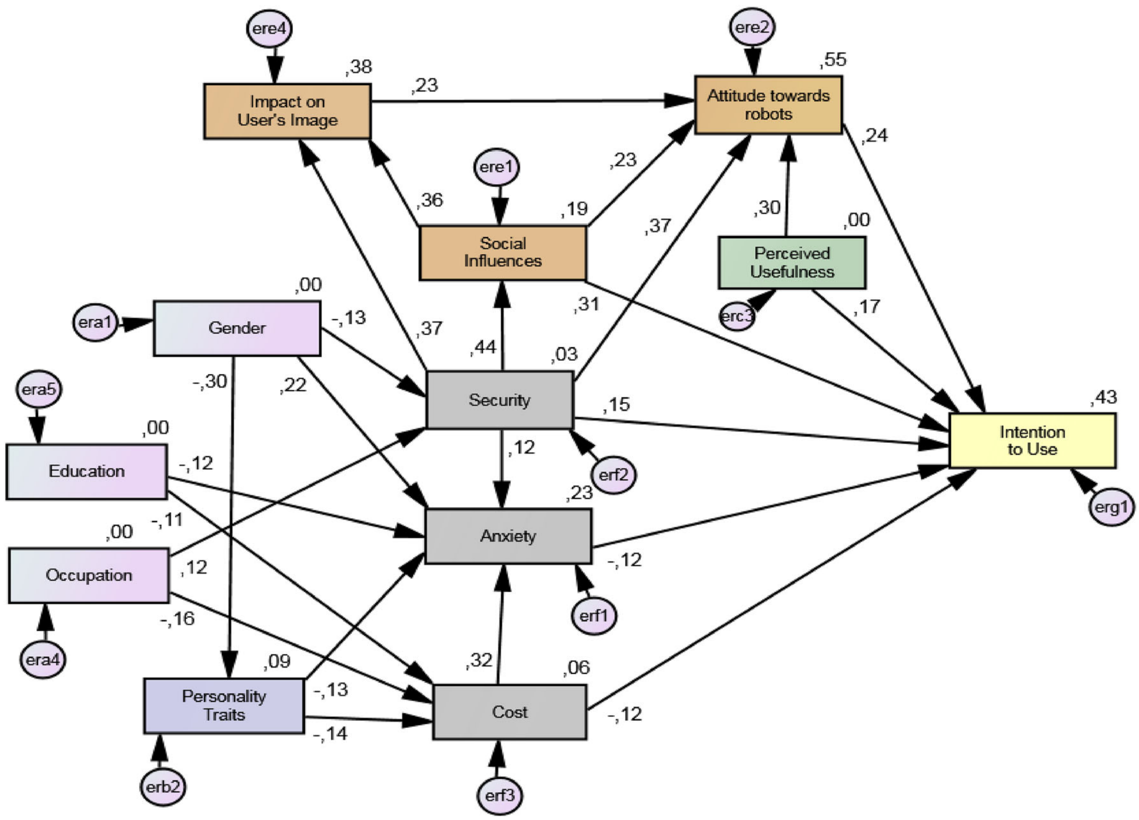

Fig. 2 Amended research framework using sub-factors

Table 5 Indicators of data adjustment of the factors research framework

Indices	Cmin/df	GFI	CFI	NFI	RMR	RMSEA
Acceptable scores	< 5	>.900	> .900	> .900	< .070	< .100
Actual scores	2 .210	.968	.952	.918	.074	.059

Table 6 Indicators of data adjustment of the sub-factor research framework

Indices	Cmin/df	GFI	CFI	NFI	RMR	RMSEA
Acceptable scores	< 5	> .900	> .900	> .900	< .070	< .100
Actual scores	2 .011	.962	.960	.925	.057	.054

It is also understood that specific characteristics (both demographic and personality ones) indirectly affect human intentions and their decisions regarding the future use of a social robot.

This positive overall effect suggests that the more efficient and functional the system is, the greater the degree of pleasure during the possible human interaction with a social robot. In addition, there is a strong positive correlation between utilitarian factors and normative beliefs. This indicates that the factors related to the usefulness of the system strongly influence the factors related to the beliefs, views, and mentalities of the society as a whole regarding this technology. Moreover, there is a direct impact of hedonic factors on both normative beliefs and control beliefs. Therefore, the factors which relate to the appearance of the specific technology determine the beliefs of society as a whole, shape people's attitudes, as well as their beliefs regarding the degree to which they feel secure and certain, while using a social robot.

In general, it becomes apparent that the impact of the normative beliefs and the utilitarian factors on the attitude of the research participants is quite powerful. Consequently, potential users are influenced not only by the general attitude of the society as a whole, or the mentality and prejudices concerning technology, but also by the functional benefits of the social robotic system.

Lastly, it should be stressed that following the adjustment of the research framework to the empirical data (based on the suggestions of SEM), new causal relationships among the variables emerged (Figs. 1 and 2). Specifically, it was found that utilitarian factors directly affect hedonic factors.

5 Discussion and Conclusions

The acceptance of a new technological system is a long and complicated process. This process begins with the acquaintance of a person with the system and results in its integration into his/her daily life. The current research examined the factors that accelerate or delay this process, investigating people's intention to use a social robot. The aim of the survey was to identify the factors that determine the psychology, attitude, and intentions of people to use a social robotic system. Its main contribution is twofold: first empirical, since it provides evidence about the magnitude of the effect various factors have on people's intention to use social robots in their everyday life, and at a practical level since these findings could potentially contribute towards the design and development of new, innovative, social robotic systems that exhibit a wider acceptance according to the requirements and needs of the people who might be using them. As far as the theoretical contribution, the study identified that utilitarian factors exhibit the strongest impact on people's intention to use a social robot, followed by normative beliefs, while hedonic factors have a relatively minor effect. Further, it is found that control beliefs have a negative effect since the cost of buying such systems is still relatively high. Analysis of the findings and the theoretical and practical contribution of this research are detailed in the next few paragraphs.

The role of utilitarian factors in shaping the intention of potential users of a social robot has been proved to be extremely important. These factors were found to have a positive effect on the intention of participants to use a social robot. Utilitarian factors are related to enhancing the efficiency of work and facilitating people's daily lives, through the functional characteristics of the technological system. More specifically, it seems that participants focus mainly on factors related to usefulness, and (less) to usability, ease of use, adaptability (to users' needs), as well as the facilitating conditions in their domestic environment. Several other studies have also validated the powerful impact of utilitarian factors on human decisions regarding the use of a social robot [12, 67, 68 131]. In addition, the theoretical and research results indicate that perceived usefulness of technology significantly influences the development of a positive attitude towards it. The scientific community has validated this assumption as well [79, 126, 131]. It is important to note that companies involved in the production of robotic systems have to focus on the operational characteristics of the system, in order to enhance their efficiency and productivity, and accommodate requests of their customers as well. The purpose of operating a robotic system should be clear and understandable to the general public, with the aim to increase its interest, to prompt its timely acceptance and, consequently, its continuous use. Thus, it becomes apparent that utilitarian factors contribute to urging the process of acceptance of social robotic systems.

Furthermore, the results of the current study show that hedonic factors have a relatively minor (but still statistically significant) effect on the intention of people to use social robotic system in the future. Hedonic factors are related to the feelings of pleasure during the potential use of the specific technology, to appearance features and anthropomorphic behavior of the system, and to satisfying the need for human companionship. It can easily be deducted that people usually focus on the functional benefits and not so much on the external features of the system. In the literature, one can find many studies showing that hedonic factors influence the acceptance of social robots [49, 67, 68, 84]. Nevertheless, this research shows that hedonic factors have a much lower (but still statistically significant) impact than utilitarian factors. This could urge designers of such systems to create attractive products with sophisticated functional features, aiming to stimulate human intention to use technology. It is worth mentioning that the results of the statistical analysis indicated that utilitarian factors affect hedonic factors. Therefore, social robot companies could combine the functionality and attractiveness of their products in order to create innovative technological systems that would stimulate human interest.

Moreover, it has been found that normative beliefs strongly affect people's intention to use a social robot. Normative beliefs relate to the rules and established standards of behavior, prevailing in a community, and this result suggests that people take into consideration these factors. Mentality, perceptions, and prejudices of society, shape people's attitude towards new technology, and influence their behavior towards it. A review of the literature confirms that normative beliefs significantly influence people's intentions to use the technological system [79, 105, 129]. This allows us to conclude that companies should design reliable systems, which can take initiatives whenever the user deems it to be necessary, so as to avoid uncertainty and insecurity during people's possible interaction with technology. Following the results of this study, both utilitarian and hedonic factors have a statistically significant effect on normative beliefs. In conclusion, social robot manufacturing companies should design intelligent, reliable, and useful systems, with attractive appearance features, in order to receive a positive evaluation from their customers.

In addition, the research results indicate that control beliefs negatively affect people's intention to use a social robot. More specifically, control beliefs relate to the human need to manipulate and control a technological system. Control beliefs include the cost factor of the system, as well as the anxiety and insecurity a person feels while using new technology. This is also supported by the existing literature, which verifies that control beliefs influence people's intention to use a social robot [104], as well as their behavior towards it [12, 67, 68]. Feelings of anxiety and uncertainty towards a social robotic system may delay its acceptance, resulting in its non-smooth integration into users' domestic environment. Thus, companies should design new, innovative systems that would eliminate the emergence of feelings of uncertainty, anxiety, and awkwardness, which are usually caused by the system's autonomous behavior. In addition, consumers focus on the cost of the new technology which concerns themgreatly. Therefore, companies should consider the cost factor as a significant barrier of delaying the acceptance of social robots.

It is important to note that intention to use is indirectly, but slightly, influenced by the demographic characteristics of each individual. In particular, it was observed that gender, educational level, occupation, as well as specific personality traits of the individuals (indirectly) influence their intention to use social robots. This result is consistent with the results of other similar studies, which examined the behavior of people towards a new technology and their intention to use it [16, 67, 104, 132, 134].

Finally, despite the significance of the results, it should be noted that the current study is restricted by certain limitations. First of all, the use of social robot systems in Greece is in its infancy and the impression the general public holds about such systems is probably blurred. It is very likely, thus, that this affects their attitudes towards the use of such systems. Therefore, it is reasonable to claim that the results would have been different in countries where the use of such systems is more widespread (e.g. in Japan). Further, the results reflect the perceptions, mentalities, prejudices, and the general attitude of Greek people. People from other countries possessing other cultural background, may have different attitudes and exhibit different behavioral patterns towards the use of similar systems. Another limitation concerns the sampling approach adopted to collect the necessary data (the random snowball sampling, a popular approach when internet and social media are used for collecting similar data). The adoption of a probabilistic hybrid approach (cluster, stratified and random approach) would produce a more representative sample. Finally, user beliefs and attitudes are treated in this study as antecedent to intention to use (pre-implementation stage), generally based on indirect experience and second-hand information [26]. However, it is also found that, at a post-usage stage, user beliefs, perceptions and attitudes can be changed as users gain personal experience with the system [15]. A study examining the changes in users' beliefs and attitudes (pre- and post-usage) could potentially offer a clearer picture of the way these factors are interrelated.

Funding Open access funding provided by HEAL-Link Greece.

Data Availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

Appendix A: Items used to measure the factors examined

Choose whether you agree or disagree with each of the following sentences on a scale of one (1) to five (5), with 1 indicating "strongly disagree" and 5 "strongly agree".

A. Personality characteristics

I think I'm a person who…

1. …. easily shows his confidence.
2. …. is familiar with technology.
3. …. can easily use a robot.
4. …. wishes not to be uncertain with his choices.
5. …. can be very stressed.
6. …. is relaxed most of the time and can control his anxiety.
7. …. is always well prepared and organized.
8. … wants a companion for most of the day.

B. Utilitarian Attitudes

Intelligence

If I owned a social robot, I would like it to …

1. …. give me good solutions and suggestions on the issues that concern me.
2. …. be able to adopt and apply new knowledge and functions.
3. …. always inform me with valid information.
4. …. handle the tasks I entrust it with flawlessly.
5. …. accurately perform all its functions.
6. …. not to delay during our interaction.
7. …. provide me with information faster than other means.
8. …. help me to do many things simultaneously.

use

If I came into contact with a social robot, I would use it to…

1. … help me with my chores.
2. … remind me of the work I must do.
3. … support me during the execution of my tasks.
4. … take care of me.
5. … protect me.
6. … keep me informed about various issues that concern me.
7. … amuse me (e.g. listening to music, playing games, etc.).

Perceived Usefulness

In general, I think that if I owned a social robot...

1. … it would be useful to me.
2. …. it would make my daily life easier.
3. …. it could help me with many things.

Effort Expectancy

I find that if I were to make contact with a social robot...

1 … our interaction would be clear and understandable.
2 … it would be easy for me to learn how to use it.
3 … it would not require much action on my part in order for it to start performing its functions.

Perceived Adaptability

I believe that if I were in possession of a social robot...

1 … it could be adaptive to what I need.
2 … it could do what I needed at that particular moment.
3 … it could help me when I consider it to be necessary.
4 … it could easily adapt to my space.

Facilitating Conditions

I believe that …

1. … I have everything I need to make good use of a robot.
2. … I could use a robot properly, as I have the necessary knowledge.
3. … I could use a robot easily, as I have the necessary knowledge (e.g. IT background).
4. .... I have the technological resources necessary to use home robots at my home (e.g. internet connection).
5. … my family would have no problem with having a robot in the house.

C. Hedonic Attitudes

Appearance of the Robot

I think my social robot should …

1. … be quite attractive.
2. … have the right size.
3. … have a voice like a living creature.
4. … look like a living creature.
5. … be designed with beautiful features.
6. … have many colors.

Companionship

If I owned a social robot, I would like …

1. … it to be friendly with me.
2. … to spend a lot of time with it.
3. … to spend a constructive time with it.
4. … to use it for companionship when I feel lonely.
5. … to have more social interaction with it rather than with people at certain time of the day.

Anthropomorphism

I I owned a social robot, I would prefer it to ...

1. … has anthropomorphic features.
2. … has human-like appearance and behavioral characteristics.
3. … move elegantly.
4. … has a conscience.

5. … give me the feeling that it is a living being.

D. Normativw Beliefs

Trust

If I made contact with a social robot…

1. … I would trust it to give me advice
2 ….. I would follow its advice
3. … I would trust it to take initiative

Attitude Towards Robots

I consider that…

1. …it's a good idea to use a social robot.
2. …the social robot makes my life more interesting.
3. …my social robot offers me a lot on a personal level.
4. …my social robot offers me a lot on a social level.
5. …social robots are effective in taking care of people.
6. …social robots are effective in entertaining people.
7. …social robots are effective for home use.
8. …it is good that robots in the future will increasingly appear in people's home environment.

Social Influence

1. I think that, the media has influenced my expectations of social robots.
2. I consider that, movies and science fiction series depicting social robots affect most people and me regarding the use of robots.
3. If my friends had a social robot in their home environment, it would have probably affected me and it is very likely that I would buy it as well.
4. My social environment would affect my decision to buy a social robot.

Image

Buying a social robot…

1. … would provide me with a favorable image in a tech-savvy social group.
2. … would enhance my image in the community.
3. … could give me more prestige.
4. …could have positive effects on my social well-being.

E: Control Beliefs

Cost

I have the impression that a social robot…

1. … is quite expensive.
2. … has a disproportionately high cost compared to the services it offers.
3. … takes a lot of money to maintain.

Safety

I think that, if I had a social robot…

1. …I would feel very safe because of its autonomous behavior.
2. …I would feel comfortable sharing my personal space with it.
3. …I would not feel any sense of danger because of its physical presence.
4. …I would feel safe to trust my personal information with it.

Anxiety

If I were in contact with a social robot...

1 .... I would be afraid to make mistakes with it.
2 .... I would afraid to break something.
3 .... I would find the social robot scary.
4 .... I would find the social robot intimidating.
5 .... I would be very careful about what functions I would ask it to perform.

F. Intention to use

1 I think I would use a social robot in the near future.
2 I am planning to use a social robot in the near future.
3 I am sure I will use a social robot in the near future.

References

1. Agarwal R, Karahanna E (2000) Time flies when you're having fun: cognitive absorption and beliefs about IT usage. MIS Q 24(4):665–694
2. Ahn T, Ryu S, Han I (2007) The impact of Web quality and playfulness on user acceptance of online retailing. Inf Manag 44:263–275

3. Ajzen I, Fishbein M (1980) Understanding attitudes and predicting social behavior. Prentice-Hall, Englewood Cliffs, NJ
4. Ajzen I (1991) The theory of planned behavior. Organ Behav Hum Decis Process 50(2):179–221
5. Allan DD, Vonasch AJ, Bartneck C (2021) The doors of social robot perception: the influence of implicit self-theories. Int J Soc Robot 13:58. https://doi.org/10.1007/s12369-021-00767-9
6. Appel M, Izydorczyk D, Weber S, Mara M, Lischetzke T (2020) The uncanny of mind in a machine: humanoid robots as tools, agents, and experiencers. Comput Human Behav 102:274–286. https://doi.org/10.1016/j.chb.2019.07.031
7. Arras KO, Cerqui D (2005) Do we want to share our lives and bodies with robots? Lausanne, Switzerland: Swiss Federal Institute of Technology Lausanne, EPFL.
8. Avelino J, Garcia-Marques L, Ventura R, Bernardino A (2021) Break the ice: a syrvey on socially aware engagement for human-robot first encounters. Int J Soc Robot 13:1851–1877. https://doi.org/10.1007/s12369-020-00720-2
9. Bandura A (1977) Self-efficacy: toward a unified theory of behavioral change. Psychol Rev 84(2):191–215
10. Barrick MR, Mount MK (1991) The big five personality dimensions and job performance: a meta-analysis. Pers Psychol 44(1):1–26
11. Benedict T, Jung Y, Park T (2014) When stereotypes meet robots: the double-edge sword of robot gender and personality in human-robot interaction. Comput Hum Behav 38:75–84
12. Bartneck C, Kulic D, Croft E, Zoghbi S (2009) Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots. Springer J Int J Soc Robot 1:71–81. https://doi.org/10.1007/s12369-008-0001-3
13. Bartneck C, Belpaeme T, Eyssel F, Kanda T, Keijsers M, Abanovi S (2020) Human-Robot interaction: an introduction. Cambridge University Press, Cambridge
14. Beraldo G, Di Battista S, Badaloni S, Menegatti E, Pivetti M (2019) Sex differences in expectations and perception of a social robot. In: 2018 IEEE workshop on advanced robotics and its social impacts (ARSO), IEEE, 38–43
15. Bhattacherjee A, Premkumar G (2004) Understanding changes in belief and attitude toward information technology usage: a theoretical model and longitudinal test. MIS Q 28:229–254
16. Bishop L, van Maris A, Dogramadzi S, Zook N (2019) Social robots: the influence of human and robot characteristics on acceptance. Paladyn J Behav Robot 10(1):346–358. https://doi.org/10.1515/pjbr-2019-0028
17. Breazeal CL (2002) Designing sociable machines. In: Dautenhahn K, Bond A, Canamero L, Edmonds B (eds) Socially intelligent agents: creating relationships with computers and robots. Kluwer, Norwell, Massachusetts, USA, pp 149–156
18. Breazeal CL (2003) Towards sociable robots. Robot Autom Syst Elsevier 42(3–4):167–175
19. Breazeal CL (2004) Social interactions in HRI: the robot view. In: IEEE transactions on systems, man, and cybernetics, Part C (Applications and Reviews), 34 (2): 181–186
20. Broadbent E, Stafford R, MacDonald B (2009) Acceptance of healthcare robots for the older population: review and future directions. Int J Soc Robot, Springer Link, Article number: 319
21. Brown SA, Venkatesh V (2005) Model of adoption of technology in households: a baseline model test and extension incorporating household life cycle. MIS Q 29(3):399–426
22. Bruckenberger U, Weiss A, Mirnig N, Strasser E, Stadler S, and Tscheligi M, (2013) The good, the bad, the weird: audience evaluation of a "real" robot in relation to science fiction and mass media. In: Advance trends in soft computing: proceedings of the world conference on soft computing - WCSC '13, ed. M. Jamshidi (Cham: Springer), 301–310
23. Caballar RD (2019) What is the Uncanny Valley? https://spectrum.ieee.org/automaton/robotics/humanoids/what-is-the-uncanny-valley
24. Čaić M, Avelino J, Mahr D, Odekerken-Shroder G, Bernardino A (2020) Robotic versus human coaches for active aging: an automated social presence perspective. Int J Soc Robot 12:867–882. https://doi.org/10.1007/s12369-018-0507-2
25. Charalampous K, Kostavelis I, Gasteratos A (2017) Recent trends in social aware robot navigation: a survey. Robot Auton Syst 93:85–104. https://doi.org/10.1016/j.robot.2017.03.002
26. Chen K, Lou VW, Tan KC, Wai MY, Chan LL (2020) Changes in technology acceptance among older people with dementia: the role of social robot engagement. Int J Med Inf 141:104241. https://doi.org/10.1016/j.ijmedinf.2020.104241
27. Chesney T (2006) An acceptance model for useful and fun information systems. Hum Technol 2(2):225–235
28. Collins EC (2019) Drawing parallels in human other interactions: a trans-disciplinary approach to developing human robot interaction methodologies. Philos Trans Royal Soc Biol Sci 374(1771):20180433. https://doi.org/10.1098/rstb.2018.0433
29. Cramer H, Evers V, Ramlal S, van Someren M, Rutledge L, Stash N, Aroyo L, Wielinga B (2008) The effects of transparency on trust in and acceptance of a content-based art recommender. User Model User-Adapt Interact 18(5):455–496
30. Cuijpers RH, Bruna MT, Ham JRC, Torta E (2011) Attitude towards robots depends on interaction but not on anticipatory behavior. In: Paper presented at the international conference on social robotics, Amsterdam, The Netherlands
31. Damiano L, Dumouchel P (2018) Anthropomorphism in human robot co-evolution. Front Psychol. https://doi.org/10.3389/fpsyg.2018.00468
32. Damholdt MF, Vestergaard C, Nrskov M, Hakli R, Larsen S, Seibt J (2020) Towards a new scale for assessing attitudes towards social robots: the attitudes towards social robots scale. Interact Stud 21(1):24–56
33. Davis FD (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q 13(3):319–340
34. Dautenhahn K, Woods S, Kaouri C, Walters ML, Koay KL, Werry I (2005) What is a robot companion: Friend, assistant, or butler?. In: Paper presented at the international conference on intelligent robots and systems (IROS 2005), Edmonton, Alberta, Canada
35. Dimitriadis E (2016) Business Statistics with applications in SPSS and Lisrel, 2nd edn. Kritiki Publishing, Greece
36. De Graaf MA, Ben Allouch S (2012) Harvey's last appearance: long-term use and acceptance of social robots. In: Paper presented at the International communication association conference 2012: Phoenix, AZ, USA. 21
37. De Graaf MA, Allouch SB (2013) Exploring influencing variables for the acceptance of social robots. Elsevier B.V., Robot Autonom Syst 61(12):1476–1486
38. De Graaf MA, Allouch SB (2013b) The relation between people's attitude and anxiety towards robots in human-robot interaction. In: Paper presented at the 22nd IEEE international symposium on robot and human interactive communication (ROMAN 2013): Gyeongju, Korea
39. De Graaf MA, Allouch BS (2014) Users' preferences of robots for domestic use. In: Proceedings of the 2014 ACM/IEEE international conference on Human-Robot interaction, pp 146–147
40. De Graaf MA, Allouch SB, Klamer T (2015) Sharing a life with Harvey: exploring the acceptance of and relationship-building with a social robot. Elsevier Ltd. Comput Hum Behav 43:1–14
41. De Graaf MA, Allouch SB, Dijk JAGM (2016) Long-term acceptance of social robots in domestic environments: in-sights from a user's perspective. In: AAAI 2016 Spring symposium on "enabling computing research in socially intelligent human-robot

interaction: a community-driven modular research platform": Palo Alto, CA, USA
42. De Graaf MA, Ben Allouch S (2016) Anticipating our future robot society: the evaluation of future robot applications from a user's perspective. In: Proceedings of the ROMAN 2016 international symposium on robot and human interactive communication. New York, NY: IEEE
43. De Graaf M, Allouch SB, Dijk J (2018) A phased framework for long-term user acceptance of interactive technology in domestic environments. New Media Soc 20(7):2582–2603. https://doi.org/10.1177/1461444817727264
44. De Graaf MA, Allouch S, B., Dijk J.A.G.M. (2019) Why would i use this in my home? A model of domestic social robot acceptance. Human-Comput Interact 34(2):115–171. https://doi.org/10.1080/07370024.2017.1312406
45. De Ruyter B, Saini P, Markopoulos P, Breemen A (2005) Assessing the effects of building social intelligence on a robotic interface for the home. Interact Comput 17(5):522–541. https://doi.org/10.1016/j.intcom.2005.03.003
46. van der Heijden, (2003) Factors influencing the use of websites: the case of a generic portal in The Netherlands. Inf Manag 40:541–549
47. Demiris G, Parker OD, Dickey G, Skubic M, Rantz M (2008) Findings from a participatory evaluation of a smart home application for older adults. Technol Health Care 16(2):111–118
48. DiSalvo C, Gemperle F, Forlizzi J, Montgomery E, Yonkers W, Divine J (2003) The hug: an exploration of robotic form for intimate communication. In: RO-MAN 03
49. Duffy BR (2003) Anthropomorphism and the social robot. Robot Auton Syst 42(3–4):177–190
50. Epley N, Waytz A, Akalis S, Cacioppo JT (2008) When we need a human: motivational determinants of anthropomorphism. Soc Cogn 26:143–155
51. Fabrigar L, Wegener D (2011) Exploratory Factor Analysis. UK, Oxford
52. Fernaeus Y, Håkansson M, Jacobsson M, Ljungblad S (2010) How do you play with a robotic toy animal? A long-term study of pleo. In: Paper presented at the international conference on interaction design and children (IDC 2010): Barcelona, Spain.
53. Fishbein M, Ajzen I (1975) Beliefs, attitude, intention and behavior: an introduction to theory and research. Addison-Wesley, Reading, MA
54. Fisher RJ, Price LL (1992) An investigation into the social context of early adoption behavior. J Consumer Res 19(3):477–486
55. Fong T, Nourbakhsh I, Dautenhahn K (2003) A survey of socially interactive robots. Robot Auton Syst 42(3–4):143–166
56. Forlizzi J, DiSalvo C (2006) Service robots in the domestic environment: a study of the Roomba vacuum in the home. In: Proceedings of the ACM/IEEE conference on human-robot interaction 2006: Salt Lake City, Utah, USA, 265–285.
57. Forlizzi J (2007) The product ecology: understanding social product use and supporting design culture. Int J Des 2(1):11–20
58. Frennert S, Eftring H, Ostlund B, (2013) What older people expect of robots: a mixed methods approach. In: International Conference on Social Robotics, Social Robotics, 19–29.
59. Fujita A, Ninomiya T, Suzuki D, Umemuro H (2015) Development of the multi-dimensional robot attitude scale: constructs of people's attitudes towards domestic robots. Springer, Berlin, pp 482–491
60. Goldberg LR (1990) An alternative 'description of personality': the big-five factor structure. J Pers Soc Psychol 59(6):1216–1229
61. Gray ED (2021) Doing research in the real world, 5th edn. Sage, USA
62. Groom V, Nass C, Chen T, Nielsen A, Scarborough JK, Robles E (2009) Evaluating the effects of behavioral realism in embodied agents. Int J Hum Comput Stud 67(10):842–849
63. Hancock PA, Billings DR, Schaefer KE, Chen JYC, de Visser EJ, Parasuraman R (2011) A meta-analysis of factors affecting trust in human-robot interaction. J Human Factors Ergon 53(5):517–527
64. Haring KS, Watanabe K, Velonaki M, Tossell CC, Finomore V (2018) FFAB–the form function attribution bias in humanrobot interaction. IEEE Trans Cogn Dev Syst 10(4):843–851
65. Heerink M, Krose B, Wielinga B, Evers V (2008) Enjoyment, Intention to use and actual use of a conversational robot by elderly people. In: Proceedings of the third ACM/ieee international conference on human-robot interaction. pp 113–119. https://doi.org/10.1145/1349822.1349838
66. Heerink M, Krose B, Wielinga B, Evers V (2009) Influence of social presence on acceptance of an assistive social robot and screen agent by elderly users. Adv Robot 23(14):1909–1923
67. Heerink M, Krose B, Evers V, Wielinga B (2010) Assessing acceptance of assistive social agent technology by older adults: the almere model. Int J Soc Robot 2:361–375
68. Heerink M, Krose B, Evers V, Wielinga B (2010) Relating conversational expressiveness to social presence and acceptance of an assistive social robot. Virtual Reality 14:78–84. https://doi.org/10.1007/s10055-009-0142-1
69. Heerink M (2011) Exploring the influence of age, gender, education, and computer experience on robot acceptance by older adults. In: Paper presented at the international conference on human-robot interaction (HRI 2011): Lausanne, Switzerland
70. Hendriks B, Meerbeek B, Boess S, Pauws S, Sonneveld M (2011) Robot Vacuum Cleaner Personality and Behavior. Int J Soc Robot 3:188–195. https://doi.org/10.1007/s12369-010-0084-5
71. Hinks T (2021) Fear of robots and life satisfaction. Int J Soc Robot 13:327–340. https://doi.org/10.1007/s12369-020-00640-1
72. Hofstede, (2003) Culture's consequences: comparing values, behaviors, institutions and organizations across nations, vol 2. Sage Publications, USA
73. Homburg N, Merkle M (2019) A cross-country comparison of attitudes toward humanoid robots in Germany, the US, and India. In: Hawaii international conference on system sciences, pp 4773–4782
74. Horstmann AC, Kramer NC (2019) Great expectations? relation of previous experiences with social robots in real life or in the media and expectancies based on qualitative and quantitative assessment. Front Psychol 10(April):939. https://doi.org/10.3389/fpsyg.2019.00939
75. Jung Y, Lee KM (2004) Effects of physical embodiment on social presence of social robots. In: Proceedings of presence, Valencia, Spain, pp 80–87
76. Kahn PH, Friedman B, Perez-Granados DR, Freier NG (2006) Robotic pets in the lives of preschool children. Interact Stud 7(3):405–436
77. Kanda T, Sato R, Saiwaki N, Ishiguro H (2007) A two-month field trial in an elementary school for long-term human–robot interaction. IEEE Trans Rob 23(5):962–971
78. Kaplan F (2004) Who is afraid of the humanoid? Investigating cultural differences in the acceptance of robots. World scientific publishing company. Int J Humanoid Rob 1(3):465–480
79. Karahanna E, Limayem M (2000) E-mail and V-mail usage: generalizing across technologies. J Organ Comput Electron Commer 10(1):49–66
80. Klamer T, Allouch SB (2010) Zoomorphic robots used by elderly people at home. In: Proceedings 27th International conference on human factors in computing systems, pp 1–18
81. Kriz S, Ferro TD, Damera P and Porter JR (2010) Fictional robots as a data source in HRI research: exploring the link between science fiction and interactional expectations. In: Proceedings of the 19th IEEE international symposium on robot and human interactive communication - RO-MAN '10 (Piscataway, NJ: IEEE), pp 458–463

82. Kuo IH, Rabindran JM, Broadbent E, Lee YI, Kerse N, Stafford RMQ, et al. (2009) Age and gender factors in user acceptance of healthcare robots. In: Proceeding of the 18th IEEE international symposium on robot and human interactive communication, 2009, ROMAN 2009 (IEEE), pp 214–219
83. Lee Y, Kozar KA, Larsen KRT (2003) The technology acceptance model: past, present, and future. Commun Assoc Inf Syst 12(1):752–780
84. Lee KM, Jung Y, Kim J, Kim SR (2006) Are physically embodied social agents better than disembodied social agents? The effects of physical embodiment, tactile interaction, and people's loneliness in human-robot interaction. Int J Hum Comput Stud 64(10):962–973
85. Lee K, Kaloutsakis G, Couch J (2009) Towards social therapeutic robots: How to strategically implement a robot for social group therapy?. In: Paper presented at the international symposium on computational intelligence in robotics and automation (CIRA), Daejeon, South Korea
86. Lessiter J, Freeman J, Keogh E, Davidoff J (2001) A cross-media presence questionnaire: the ITC-Sense of presence inventory. Presence-Teleoperators Virtual Environ 10(3):282–297
87. Li D, Rau PLP, Li Y (2010) A cross-cultural study: effect of robot appearance and task. Int J Soc Robot 2(2):175–186
88. Liao C, Chen JL, Yen DC (2007) Theory of planned behavior (TPB) and customer satisfaction in the continued use of e-service: an integrated model. Comput Hum Behav 23:2804–2822
89. Libin AV, Libin EV (2004) Person-robot interactions from the robopsychologists' point of view: the robotic psychology and robotherapy approach. Proc IEEE 92(11):1789–1803
90. Liem GAD, McInerney DM (eds) (2018) Big theories revisited 2. Information Age Publishing, Charlotte, NC
91. Lu J, Yao JE, Yu C (2005) Personal innovativeness, social influences, and adoption of wireless Internet services via mobile technology. J Strateg Inf Syst 14(3):245–268. https://doi.org/10.1016/j.jsis.2005.07.003
92. MacDorman KF, Vasudevan SK, Ho C (2009) Does Japan really have robot mania? Comparing attitudes by implicit and explicit measures. AI & Soc 23(4):485–510. https://doi.org/10.1007/s00146-008-0181-2
93. MacDorman KF, Ishiguro H (2006) The uncanny advantage of using androids in social and cognitive science research. Interact Stud 7(3):297–337
94. Matthews G, Hancock PA, Lin J, Panganiban AR, Reinerman-Jones LE, Szalma JL, Wohleber RW (2021) Evolution and revolution: personality research for the coming world of robots, artificial intelligence, and autonomous systems. Personal Individual Diff 169:109969. https://doi.org/10.1016/j.paid.2020.109969
95. McFarland D, Hamilton D (2006) Adding contextual specificity to the technology acceptance model. Comput Human Behav 22(3):427–447
96. Merkle M, Homburg N (2019) A Cross-Country Comparison of Attitudes toward Humanoid Robots in Germany, The US, and India. In: Proceedings of the 52nd Hawaii international conference on system sciences
97. Miniard PW (1981) Examining the diagnostic utility of the Fishbein behavioral intention model. Adv Consum Res 8:42–47
98. Mitka E, Gasteratos A, Kyriakoulis N, Mouroutsos SG (2012) Safety certification requirements for domestic robots. Saf Sci 50(10):1888–1897. https://doi.org/10.1016/j.ssci.2012.05.009
99. Moon W, Kim JG (2001) Extending the TAM for a world-wide-web context. Inf Manag 38:217–230
100. Moore C (2015) Moral disengagement. Curr Opinion Psychol 6:199–204. https://doi.org/10.1016/j.copsyc.2015.07.018
101. Morsunbul U (2019) Human-Robot interaction: how do personality traits affect attitudes towards robot? J Human Sci 16(2):499–504
102. Mori M, MacDorman KF, Kageki N (2012) The uncanny valley. Robot Autom Magazine 19(2):98–100
103. Mount MK, Barrick MR (1999) Strauss PJ (1999) The joint relationship of conscientiousness and ability with performance: test of the interaction hypothesis. J Manag 25(5):707–721
104. Niemelä M, Heikkilä P, Lammi H, Oksman V (2019) A social robot in a shopping mall: studies on acceptance and stakeholder expectations. In: Korn O (ed) Social robots: technological, societal and ethical aspects of human-robot interaction, human-computer interaction series. Springer, Berlin, pp 119–143. https://doi.org/10.1007/978-3-030-17107-0_7
105. Nomura T, Syrdal DS, Dautenhahn K (2015) Differences on social acceptance of humanoids robots between Japan and the UK. In: Proceedings 4th international symposium on new frontiers in human-robot interaction
106. Nomura T, Suzuki T, Kanda T, Han J, Shin N, Burke J, Kato K (2008) What people assume about humanoid and animal-type robots: cross-cultural analysis between Japan, Korea, and the United States. Int J Humanoid Rob 5(1):25–46
107. Nomura T, Tasaki T, Kanda T, Shiomi M, Ishiguro H, Hagita N (2007) Questionnaire-based social research on opinions of Japanese visitors for communication robots at an exhibition. AI Soc 21(1):167–183
108. Norman DA (2004) Emotional design: why we love (or hate) everyday things. Basic Books, New York
109. Onaolapo S, Oyewole O (2018) Performance expectancy, effort expectancy, and facilitating conditions as factors influencing smart phones use for mobile learning by postgraduate students of the University of Ibadan, Nigeria. Interdis J e-Skills Lifelong Learn 14:95–115
110. Perugini M, Bagozzi RP (2001) The role of desires and anticipated emotions in goal-directed behaviors: broadening and deepening the theory of planned behavior. Br J Soc Psychol 40(1):79–98
111. Roggers EM (2003) Difussion of innovations, 5th edn. Free Press, N.Y.
112. Robb DA, Ahmad MI, Tiseo C, Aracri S, McConnell AC, Page V, Dondrup C, Chiyah Garcia FJ, Nguyen HN, Pairet E (2020) Robots in the danger zone: exploring public perception through engagement. In: Proceedings of the 2020 ACM/IEEE International conference on human–robot interaction, 93–102
113. Sarkar N, Rani P, Smith CA, Kirby LD (2004) Anxiety detecting robotic system-towards implicit human-robot collaboration. Robotica 22:85–95
114. Schenkman BN, Jönsson FU (2000) Aesthetics and preferences of webpages. Behav Inf Technol 19(5):567–377
115. Scopelliti M, Giuliani MV, Fornara F (2005) Robots in a domestic setting: a psychological approach. Univ Access Inf Soc 4(2):146–155
116. Shin DH, Choo H (2011) Modeling the acceptance of socially interactive robotics: social presence in human-robot interaction. Interact Stud 12(3):430–460
117. Silverstone R, Haddon L (1996) Design and the domestication of ICTs: technical change and everyday life. Communication by design. The politics of information and communication technologies, 44–74, Oxford: Oxford press
118. Sims VK, Chin MG, Ellis LU, Pepe AA, Sinatra AM, Finkelstein N, (2008) Robot features are examined as artifacts, not as "Faces". In: Proceedings of the human factors and ergonomics society annual meeting (HFES), Sage Journals 52: 1384–1388
119. Sun HS, Zhang P (2006) The role of moderating factors in user technology acceptance. Int J Hum Comput Stud 64(2):53–78
120. Sundar SS, Waddell TF, and Jung EH (2016) The Hollywood robot syndrome: media effects on older adults' attitudes toward robots and adoption intentions. In: Proceedings of the 11th ACM/IEEE international conference on human robot interaction - HRI, pp. 343–350.

121. Sung JY, Christensen HI, Grinter RE (2009) Robots in the wild: Understanding long-term use. Paper presented at the International Conference on Human Robot Interaction (HRI 2009). La Jolla, California, USA
122. Sung JY, Grinter RE, Christensen HI (2010) Domestic robot ecology: an initial framework to unpack long-term acceptance of robots at home. Int J Soc Robot 2(4):417–429
123. Taylor S, Todd PA (1995) Understanding information technology usage: a test of competing models. Inf Syst Res 6(2):144–176
124. Thompson B (2004) Exploratory and confirmatory factor analysis: understanding concepts and applications. American Psychological Association, Washington, DC
125. Turkle S (2011) Alone together: why we expect more from technology and less from each other. Basic Books, New York, NJ
126. Umemuro H, Ninomiya T, Fujita A, Suzuki D (2015) Development of the multidimensional robot attitude scale: constructs of people's attitudes towards domestic robots. In: International conference on social robotics, Paris, France, 482–491
127. Venkatesh V (2000) Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. Inf Syst Res 11(4):342–365
128. Venkatesh V, Morris MG (2000) Why don't men ever stop to ask for directions? Gender, social influence and their role in technology acceptance and usage behavior. MIS Q 24(1):115–139
129. Venkatesh V, Davis FD (2000) A theoretical extension of the technology acceptance model: four longitudinal field studies. Manage Sci 46(2):186–204
130. Venkatesh V, Brown SA (2001) A longitudinal investigation of personal computers in homes: adoption determinants and emerging challenges. MIS Quaterly 25:71–102
131. Venkatesh V, Morris MG, Davis GB, Davis FD (2003) User acceptance of information technology: toward a unified view. MIS Q 27(3):425–478
132. Venkatesh V, Brown SA, Maruping LM, Bala H (2008) Predicting different conceptualizations of system use: the computing roles of behavioral intention, facilitating condition, and behavioral expectations. MIS Q 32(3):483–502
133. Venkatesh V, Thong JYL, Xu X (2012) Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. MIS Q 36(1):157–178
134. Walters ML, Syrdal DS, Dautenhahn K, Boekhorst R, Lee K (2007) Avoiding the uncanny valley: the robot appearance, personality, and consistency of behavior in an attention-seeking home scenario for a robot companion. Auton Robot 24(2):159–178
135. Wand X (2011) The role of anticipated negative emotions and past behavior in individuals' physical activity intentions and behaviors. Psychol Sport Exerc 12(3):300–305
136. Weibel D, Wissmath B, Mast FW (2010) Immersion in mediated environments: the role of personality traits. Cyberpsychol Behav Soc Netw 13(3):251–257
137. Whelan S, Murphy K, Barrett E, Krusche C, Santorelli A, Casey D (2018) Factors affecting the acceptability of social robots by older adults including people with dementia or cognitive impairment: a literature review. Int J Soc Robot 10:645–668
138. Wullenkord R, Eyssel F (2020) The influence of robot number on robot group perceptiona call for action. ACM THRI 9(4):1–14
139. Xu K (2019) First encounter with robot alpha: how individual ifferences interact with vocal and kinetic cues in users social responses. New Media Soc 21(11–12):2522–2547. https://doi.org/10.1177/1461444819851479
140. Yagoda RE, Gillan DJ (2012) You want me to trust a roBOT? The development of a human-robot interaction trust scale. Int J Soc Robot 4:235–248. https://doi.org/10.1007/s12369-012-0144-0
141. Young JE, Hawkins R, Sharlin E, Igarashi T (2009) Toward acceptable domestic robots: applying insights from social psychology. Int J Soc Robot 1(1):95–108
142. Young JE, Hawkins R, Sharlin E, Igarashi T (2007) Towards acceptable domestic robots: applying insights from social psychology. Int J Soc Robot 1(1):95–108
143. Zacharaki A, Kostavelis I, Gasteratos A, Dokas I (2020) Safety bounds in human robot interaction: a survey. Safety Sci. https://doi.org/10.1016/j.ssci.2020.104667

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.