Customer's acceptance of humanoid robots in services: the moderating role of risk aversion

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Abstract. The emerging introduction of humanoid robots in service encounters is becoming a reality in the present and the short-term. Due to this unstoppable advance, there is a need to better understand customers' perceptions and reactions toward humanoid agents in service encounters. To shed some light on this under-explored phenomenon, this research investigates how the interaction between robot and customer's features may contribute to a successful introduction of this disruptive innovation. Results of an empirical study with a sample of 168 US customers reveal that customer's perceptions of robot's human-likeness increase use intentions to use humanoid service robots. Interestingly, customers risk aversion moderates this relationship. Specifically, the study found that highly risk-averse customers tend to avoid using humanoids when they are perceived as highly mechanical-like. The discussion highlights the main contributions of the research, which combine previous knowledge on human-robot interaction and risk aversion from a marketing approach. Managerial implications derived from the research findings and the avenues opened for further research are described at the end.

Keywords: Humanoid, Robot, Risk aversion.

1   Introduction

1.1   The rise of robots

Humanoid service robots are replacing human service providers in many sectors [1]. Among other benefits, automation increases productivity and reduces labor costs [2]. Indeed, robot prices are decreasing continually at rates of 10 percent annually [3]. Consequently, in 2017 and 2018, the average annual growth of sales was 20% for industrial robots, and 58,5% for professional services robots [4]. The theory of Artificial Intelligence job replacement [5], predicts that the robot infusion will be particularly intense

in the short term for jobs involving mechanical and analytical task, and would reach a broader scope by affecting intuitive and even empathetic skills in the next decades [5].

According to the Spanish Association of Hotel Managers [6], 96% of hotel receptionist will be replaced by autonomous devices by 2029, and 42% of food and drinks delivery in hotels will be performed by robots in 2023. Humanoid robots are already carrying out basic tasks in such as providing help in banks or transporting drugs in hospitals [3]. As well, more than 10,000 humanoid robots such as "Pepper" are already performing waiter tasks in many restaurants around the world [1].

Consequently, within the field of frontline service technology infusion, the introduction of humanoid automated social agents is becoming a particularly matter of interest [3, 7]. Indeed, the emergence of humanoid robots is becoming one of the most dramatic evolution in the service realm [1].

However, research on this disruptive innovation is still scare. Despite the emerging body of knowledge specifically focusing on service robots [3, 5, 7], previous research only present theoretical predictions about how service robot innovation may affect customers' experiences and organizations' service management, but empirical evidence to support these insights is still very exceptional [1].

To shed some light on this underexplored emerging field of research we investigate how customers' perceptions toward humanoid robots may affect their behavioral intentions to use such service innovation. In particular, following previous research on human-robot interaction [8], we hypothesize that customer's perceptions of human-likeness may contribute to increase humanoid use intention. We also propose that customer's personal characteristics in terms of risk aversion may play a relevant role in deciding whether to interact with a humanoid service robot. We predict that risk aversion have a direct negative influence of use intention. In addition, our research hypothesizes a moderating effect of risk aversion [9]; that is, the level of robot human-likeness may be relevant depending on user's risk aversion or risk seeking.

We test the proposed hypotheses by means of an empirical study presenting a human waiter scenario to a well-balanced sample of US customer in terms of age and gender. This research contributes to previous literature by extending previous knowledge on human-robot interaction and risk aversion to the marketing field. Specifically, our approach empirically assesses individuals' reactions toward robots from a marketing focus; that is, investigating how customers' perceptions and personal features may determine a successful introduction of humanoid robots in the service domain. The results and findings of the study are discussed together with the managerial implications derived from the research. The limitations and further research avenues are also commented at the end in order to inspire scholars to contribute to advance on this emerging field.

2 Hypotheses development

Like in human-human interaction, social perceptions of robots depend to a large extent on its appearance [10]. The Computers Are Social Actors (CASA) paradigm proposes that human-computer interaction follows the same rules of human-human interaction

[11], especially when machines have anthropomorphic cues that individuals recognize as social rules. The anthropomorphization of technical devices is a common phenomenon considered a "default schema" to be applied to non-social objects [12]. Using robots' physical appearance to infer human cues is a heuristic attribution difficult to avoid [10]. Thus, humanoid entities are perceived as having human identity to some extent.

In this line, the uncanny valley theory [13] proposes that people's affinity toward robots enhances as a consequence of human-likeness, that is of robot similarity with human features; however, robots with very developed human features (i.e. droids with skin, hair, teeth) may be perceived as unpleasant, eerie or uncanny. Nevertheless, empirical research carried out to prove the uncanny valley existence (i.e. perceptions of eeriness) has been inconclusive or against support [8]. Indeed, the uncanny valley effect is widely debated and considered controversial [10].

From a complementary approach, studies in other research fields also found that human decision making related to technology is influenced by the technology amount of anthropomorphism [12]; a finding that may be applied to humanoid service robots. Indeed, anthropomorphism has been already found to be the most relevant factor for robot acceptance by consumers in hotels [14]. Some evidence support that people systematically prefer robotic employees whose human-likeness matched the sociability required to carry out those jobs [15]; suggesting that humans judge humanoids favorably in terms of appearance and human similarity [8].

Therefore, our first hypothesis proposes:

H1. Customer's perception of robot's human-likeness increases customer's intention to use a humanoid service robot.

Risk aversion is a key variable in marketing and many other individual's economic decisions (e.g. finance, new product purchase) [16]. Hofstede and Bond ([17], p. 419), define risk aversion as "the extent to which people feel threatened by ambiguous situations, and have created beliefs and institutions that try to avoid these". Risk aversion belongs to the self (either individual or group) and has been described as a cultural value, a personality trait, or a consumer decision making style [18].

In general, it is assumed that humans are risk averse but this aversion may vary between people [19]. Risk aversion has been found critical in decisions involving uncertainty and it is closely linked to the concept of uncertainty avoidance [20]. Consumer with low risk aversion feel less threatened by uncertainty whereas those with high risk aversion feel more threatened [19].

In comparison to products, risk aversion is more salient for services due to its greater intangibility [21]. There is a long tradition suggesting that risk averse individuals are particularly reluctant to rely on technology driven services [22]. In this regard, previous research found that risk averse consumers avoid engaging in online shopping [23] or online banking [22], and are hesitant about using energy saving systems [24].

As past research has not explicitly analyzed the role of risk aversion on robot use, assuming that humanoid introduction represents a disruptive technology innovation, our second hypothesis is proposed:

H2. Customer's risk aversion reduces the intention to use a humanoid service robot.

Previous literature suggests that service managers should carefully deal with customer's risk perceptions. In particular, customers are often risk averse towards technology driven services offered by a company, which should offer employees based alternatives to those customers particularly fearful to technology [25]. In this regard, previous research indicate that risk averse individuals avoid to adopt self-managed technological systems in banking service encounters, but prefer personal treatment [26].

As a personal feature of customers, risk aversion is often proposed as a moderator variable in decision making [9]. Considering that humanoid robot systems may be perceived as more human-like or more mechanical-like, and based on the previous argumentations, we propose that risk aversion moderates the influence of human-likeness on customer's intention to use the humanoid service robot [8]. Specifically, we propose that as far as human-likeness tend to arise customer's perceptions of humanness and affinity [8, 13], high risk averse customers would avoid using less human-like robots, whereas low risk averse customers (i.e. risk seekers) would be more willing to use less human-like robots. Consequently, the last hypothesis is proposed:

H3. Customer's risk aversion moderates the influence of human-likeness perceptions on intention to use a humanoid service robot.

3 Method

3.1 Procedure

A study was designed to test the proposed influence of human-likeness and risk aversion on intentions to use services provided by a humanoid. Participants in the study were 168 US customers recruited by means of an online market research company in exchange for 1$ per participant. This procedure allowed us to obtain a balanced sample in terms of age (6.6% aged 18-24, 35.7% 25-34, 29.7% 35-44, 17.9% 45-54, 10.1% more than 64 years old) and gender (53.6% men, 46.4% women).

The study was presented as a research about innovation in services. The scenario presented the robot Casey (fictitious name specifically chosen to avoid gender or brand biases [27]) as a new humanoid waiter recently introduced in some restaurants and with equivalent performance skills to regular human waiters. Image 1 depicts the photographs that were presented together with the scenario description.

Image 1. Photographs included in the scenario description about the humanoid waiter.

The humanoid robot was actually HRP-4, which is a prototype robot developed by the National Institute of Advanced Industrial Science and Technology in Tokyo. This prototype was selected among five humanoids (including also RMC, Atlas, Robothesphian, HRP-4C) because of scoring an intermediate level of human likeness in a pretest previously conducted with a different sample of 91 participants.

After reading the scenario description and the pictures, participants of the main study were invited to answer to some questions related to the variables of our study. That is, they had to indicate their perceptions of the humanoid level of human likeness, their intention to use this humanoid provided service, their level or risk aversion and some sociodemographic information.

3.2 Measures

Human-likeness was measured by two items obtained from Rosenthal-von der Püthen and Kramer [8]. Because of being a two-item scale, reliability was analyzed by means of the Spearman correlation (0.86). More precisely, customers assessed to what extent the humanoid was human-like, and mechanical-like (reversed question) in a 7-point scale ranging from 1 "not at all" to 5 "very much".

Risk aversion was measured by three items borrowed from Bao et al. [18]. Specifically, participants responded to the following 7-point Likert scale ranging from 1 "Strongly disagree" to 7 "Strongly agree". Subjects were asked to indicated their agreement with the following statements: "I am cautious in trying new or different services",

"I would rather stick with a service I usually use than try something I am not very sure of", and "I never use something I don't know about at the risks of making a mistake". Scale reliability was assessed by means of Cronbach's α, obtaining a value (α=0.87) higher than the indicated threshold of 0.65 [28].

Finally, intention to use the service provided by the humanoid was measured following the three-item scale proposed by Wu and Chen [29]. By means of this 7-point Likert scale, participants were asked to indicate their level of agreement with the following statements: "If I have access to the humanoid waiter, I intend to use it", "If I have the chance, I predict that I would use the humanoid waiter", "If I have access to the humanoid waiter, I want to use it as much as possible". Again, the construct presented a high level of reliability (α=0.95)

To evaluate the unidimensionality of the proposed scales, we conducted a principal components analysis, with a factor extraction on eigenvalues greater than one. Factor loadings on each scale were greater than 0.50 points with a significant total explained variance [28]. Only one factor was extracted from each scale: human-likeness, risk aversion, and behavioral intention to use.

4 Results

4.1 Test of the Hypotheses

A regression model was employed to test the proposed hypotheses. In every case, the variables introduced were calculated as the average of their respective measures. To evaluate the moderating effect, the interaction term of human-likeness and risk aversion was calculated (before conducting this analysis, constructs were mean-centered to avoid multicollinearity in the presence of interaction terms [30]).

Results indicate that perceptions of human-likeness increases customer intention to use the humanoid service robot ($\beta = 0.56$, $p < 0.01$), in support of the direct effect suggested in H1. As proposed in H2, customer's level of risk aversion reduces the intention to use the service robot, but this direct effect is only marginally significant ($\beta = -0.16$, $p < 0.10$). Interestingly, as hypothesized, risk aversion moderates the effect of human-likeness on intention to use ($\beta = 0.27$, $p < 0.01$), in support of the interaction effect proposed in H3.

Finally, the proposed influence of the two independent variables, as well as the interaction term, allows us to explain to a great extent the variance of the dependent variable. In particular, the intention to use explained variance ($R^2 = 0.47$) reached higher levels than those usually reported in behavioral intention literature [31].

4.2 Post-hoc analysis

In order to better understand the interaction effect of human-likeness and risk aversion on customer's intention to use humanoid service robots, we conducted an additional post-hoc ANOVA analysis.

Following the standardized procedures to compare between groups [32], participants were split up taking the average of the independent variable plus or minus one half of

the standard deviation. Despite the reduction of the sample size due to subsequent di-chotomizations, this method allowed us to compare between users with higher and lower levels of risk aversion and higher and lower levels of human-likeness percep-tions. Results of the ANOVA analysis reinforce the previous findings. As hypothesized, human-likeness exerts a positive influence on customers' intention to use the service robot ($F = 30.86$, $p < 0.01$), in support of H1. Nevertheless, the effect of risk aversion proposed in H2 turns non-significant when comparing high versus low risk averse cus-tomers ($F = 2.37$, $p > 0.10$). Again, as proposed in our moderating hypothesis, there is a significant interaction effect between human-likeness and risk aversion on humanoid use intention ($F = 4.99$, $p < 0.01$), in support of H3.

Figure 1 presents the level of intention to use the humanoid robot depending on the levels of human-likeness and risk aversion. More, precisely the post-hoc analysis re-veals that customers level of risk aversion is not relevant when facing a robot perceived as highly human-like ($t = 0.47$, $p > 0.10$). However, risk aversion is significantly influ-encing customers' intention to use the humanoid when it is perceived as lowly human-like ($t = -2.82$, $p < 0.01$). This means, that risk averse customers will be more reluctant to use mechanical-like humanoids, whereas risk seekers will be more prone to use a humanoid service robot, even when they perceive the robot as highly mechanical-like.
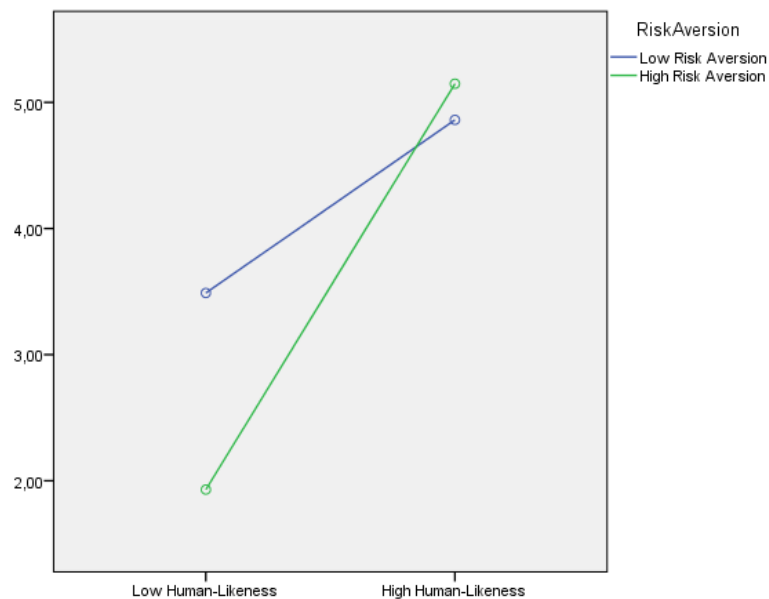

Fig. 2. Interaction effect of perceptions of robot human-likeness and customer's risk aversion on the intention to use the humanoid service robot.

5 Discussion

5.1 Conclusions

Robotics is a technology innovation that increases productivity and profitability in manufacture but also in service provision. Thus, scholars, practitioners, international organizations and the overall society identifies this phenomenon as having a relevant impact on economy and employment; and as an emerging field in frontline operations affecting customer choices that are crucial for the future of service encounters [1, 5, 7].

Assuming the emergence of humanoid service infusion in the frontline [1], our research analyzes to what extent perceptions of human-likeness and customer's risk aversion may determine a successful introduction of such a disruptive technology.

The results of our empirical study found that robot's human-likeness increases customer's intention to use the humanoid agent. This result agrees with previous findings in literature about human-robot interaction [8], and contributes to evaluate this influence from a marketing approach and in a service context. Our research also found that risk averse customers tend to be more reluctant to use humanoid service robots; however, this effect was only marginally significant, suggesting that the risk aversion may not play a direct influence but a moderating one.

The test of the moderation effect, further extended in a post-hoc analysis, revealed an interaction effect between human-likeness and risk aversion. In particular, risk aversion is found relevant when robots are less human-like (that is, more mechanical like), whereas is found irrelevant when dealing with highly human-like humanoid robots. Our findings suggest that highly risk averse customers tend to avoid mechanical like humanoids to a greater extent than lowly risk averse customers (i.e. risk seekers), who will be in turn more willing to use a mechanic-like humanoid in a service encounter. This finding is particularly noteworthy, because it links literature on both robot adoption and risk aversion to contribute to a better understanding of humanoid introduction from a marketing approach.

5.2 Managerial Implications

As a principal implication for management, this research indicates that the decision to introduce a humanoid service robot need to be analyzed not only from an internal perspective but from a customer oriented perspective. Indeed, our findings suggest that service managers should carry out customer segmentation strategies to better adapt the features of the robot (i.e. human-likeness) to the features of customers (i.e. risk aversion). Offering the traditional employee based service, or humanoids with human features would help to approach highly risk adverse customers. In turn, the identification of lowly risk averse customers could help to address them as a group of pioneers for using prototypes when launching humanoid service robots for the first time in the company.

5.3 Limitations and further research

The limitations of this work open avenues for further research. We rely on a single service scenario of a robot waiter. To confirm the generalizability of our findings, the empirical study should be replicated in different contexts and using different kinds of humanoid robots. The study should be also replicated in other countries, as far as cultural values may greatly impact the level of uncertainty avoidance (and risk aversion). Our research focuses on humanoid service robots because they are the most commonly used in service provision; however, some companies are designing droids (very human-like robots like Sophia, with human features such as skin, face, etc.). Further research is thus needed to explore whether the findings of this research could be applied not only to humanoids but to droids that could be potentially employed in service encounters.

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