Service Robots in Hospitality and Tourism: Investigating Anthropomorphism

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Abstract

This conceptual manuscript takes a small step in robotic service (rService) research, drawing on services marketing, Human Robot Interaction (HRI) and the Uncanny Valley Theory to explore the range, role and outcomes of anthropomorphic characteristics in service robots. The paper proposes six robot capabilities, three marketing outcomes of the Uncanny Valley, relevant theories for anthropomorphism and a rich future research stream. Throughout, the paper incorporates hospitality and tourism literature and examples.

Keywords: Robots, Robotics, Robotic Service (rService), Anthropomorphism, Human Robot Interaction, Hospitality and Tourism

Introduction

Robots

Perhaps the world's largest consumer electronics show (CES), the January 2017 CES in Las Vegas attracted 177,393 attendees from 180 countries. The attendees included 68,331 senior level executives, 200 government officials and 7,545 media representatives (ces.tech/Why-CES/CES-by-the-Numbers). One of those representatives, Jefferson Graham with USA Today noted that,

> "The one, coolest thing from this year's 2017 CES is an easy pick—those amazing robots.
>
> "We saw robots to make your morning coffee, pour candy, fold your clothes, turn on and off your lights, project a movie on the wall, handle your daily chores and most impressively, look just like a human, or in this case, legendary scientist Albert Einstein, with facial expressions and movement" (Graham, 2017).

Although the term robot originated in a 1921 Czech play, *Rossum's Universal Robots* (Čapek, 2001), the concept of humanoid machines goes "back at least to Homer, Plato, and Ovid's tales of statues coming to life" (Belk, 2016, p. 2). Robots, neither a new nor a narrow concept (Belk, 2016; Broadbent, 2017), are a "relatively autonomous physical device capable of motion and performing a service" (Murphy, Hofacker, & Gretzel, 2017, p. 106). Assuming Moore's Law remains in force, the capabilities in today's simple robots will double, and double again, while the costs will do just the opposite—comparable to microprocessors and computing three decades ago (Brynjolfsson, McAfee, & Cummings, 2014; Touretzky, 2010). Also, similar to microprocessors and computing, robots will impact markets and the workforce for decades (Broadbent, 2017; Brynjolfsson, McAfee, & Cummings, 2014; Frey & Osborne, 2017; van Doorn et al., 2017).

Robots generally fall into one of three categories—industrial, professional service and personal service (Thrun, 2004; Vaussard et al., 2014). The capabilities and design of personal service robots, also known as companion or social robots, generated the CES buzz (Graham, 2017; Ackerman, 2017). Personal service robots, which have the most autonomy and social interaction of the three robot categories, are the focus of this manuscript because they are particularly relevant for tourism and hospitality (Murphy, Hofacker, & Gretzel, 2017).

Emerging hospitality and tourism robotic applications include waiters in southeast Asia, a robot-staffed hotel in Japan, a bellboy in the USA and industrial robots that clean or make drinks (Belk, 2016; Collins, 2015; Pan, Okada, Uchiyama, & Suzuki, 2015; van Doorn, et al., 2017). Academic literature noting that robots have leapt from science fiction into hospitality and tourism is gaining traction and often mentions Human Robot Interaction (HRI) as a key area to investigate (Andrews, 1984; Belk, 2016; Fan, Wu & Mattila, 2016; Pan, et al., 2015; van Doorn et al., 2017). A recent hospitality and tourism article proposes six robotic research areas: customer acceptance of robots, robotic design and robots' impact on the work environment, management training, facility design and bottom line (Murphy, Hofacker, & Gretzel, 2017).

HRI, a common theme across these six research areas and particularly with service robots, includes communication—e.g., voice, haptic, visual and programming—and anthropomorphic features (Belk, 2016). Anthropomorphism—how robots look, move and communicate similar to humans—helps "predict the degree of moral care and concern afforded to an agent, the amount of responsibility and trust placed on an agent, and the extent to which an agent serves as a source of social influence on the self" (Waytz, Cacioppo, & Epley, 2014, p. 1). Furthermore, the relationship between a robot's anthropomorphic features and emotional responses to that robot seem nonlinear (Belk, 2016; Broadbent, 2017; Mori, 1970). How anthropomorphic characteristics and communication relate to HRI and service robot success seems critical for tourism and hospitality enterprises and academics.

rService

Services marketing's concern with technology diffusion and technology's customer impacts (see Kim, Wang, & Malthouse, 2015; S. Y. Lam & Shankar, 2014 for two recent examples) helps bridge HRI and service robots research. Services scholars developed the eService paradigm—providing service over electronic networks (Rust & Kannan, 2003, p. 38)—and its impact on customers (e.g., Collier & Bienstock, 2006; Fassnacht & Koese, 2006; Parasuraman, Zeithaml, & Malhotra, 2005). Almost all e-service studies, whether looking at innovation adoption or implementation, focus on software that runs on an inert device such as a desktop computer or a mobile phone. To the authors' knowledge however, just two articles examine robotic service—rService—and both draw on HRI (Pan, et al., 2015; van Doorn et al., 2017).

An experimental study in Japan that tested hotel lobby robots as an alternative to information on digital signs found that robot head movement and direct greetings worked best (Pan et al., 2015). The second article, introduced the concept of automated social presence (ASP), developed a typology of different automated and human social presence with customers and conceptualised relationships between ASP and key service and customer outcomes (van Doorn et al., 2017). The authors noted that a major limitation of their study was ignoring the Uncanny Valley theory (Broadbent, 2017; Belk, 2016; Mori, 1970; Mori, MacDorman, & Kageki, 2012), which suggests a non-linear relationship between a robot's anthropomorphic features and emotional responses to that robot.

Literature Review

Robot Autonomy, Capabilities and Design

In determining which theories might suit anthropomorphism, it is appropriate to consider *autonomy*, *robot capabilities* and *robot design*. As these engineering achievements will condition the consumer or demand side

of the robot story, it makes sense to understand what the consumer will encounter. Autonomy, critical to the notion of a robot, helps distinguish among devices that make decisions with or without human input. Rather than a dichotomy, robot autonomy ranges from basic levels of manual teleoperation to full autonomy (Beer, Fisk, & Rogers, 2016).

In addition to considering autonomy, the key robot capabilities in Table 1 below have two interpretations. First, robots vary in their capabilities; there are and will be many specialised robot types with different capabilities. Second, with the addition of each row robots become more adept and more capable (Brynjolfsson et al., 2014; Touretzky, 2010).

Table 1. Proposed Robot Capabilities

Capability	**Examples**
General Mobility	Stationary, Mobile, Swimming, Flying
Task Mobility	Lifting, Carrying, Pushing, Opening
Communication: Robot-Robot	Swarming, Coordinating
Communication: Human-Robot	Voice, Gestures, Touch, Emotions, Remote Control, Sensors
Communication: Robot-Human	Voice, Gestures, Touch, Emotions, Display
Sociality: Human-Robot	Understanding, Empathising, Learning
Sociality: Robot-Human	Explaining, Advising, Conveying Affect
Memory	Storing, Retaining and Retrieving Information
Sensory Processing	Sensing, Perceiving, Identifying
Symbolic Processing	Understanding, Thinking, Reasoning

Design relates to how robots move and interact. For example, robots' arm/leg-like sub-systems vary in the degrees of freedom of translation and rotation (Kavic 2004), i.e. the degree of humanness. Robots also vary in their surface composition. Designers may use plastic or metal, or create a skin-like look. Robots may also be much smaller or larger than human-scale. Many CES 2017 service robots tended to be short, white, round and smooth, albeit one robot resembled Albert Einstein's head (Ackerman, 2017; Graham, 2017).

The Uncanny Valley

Robot autonomy, capabilities and anthropomorphic differences, as well as the context and humans themselves, may lead to non-linear effects on human responses to robots. As Table 1 above illustrates, the ten robot capabilities imply many physical forms. Mobility, for example, can be life-like (legged robots) and thus imitate a biological organism. Robots can also be wheeled or spherical (rolling ball robots) and imitate machines like automobiles. This blurring of the living and the mechanical gives robots their dominant perceptual characteristics.

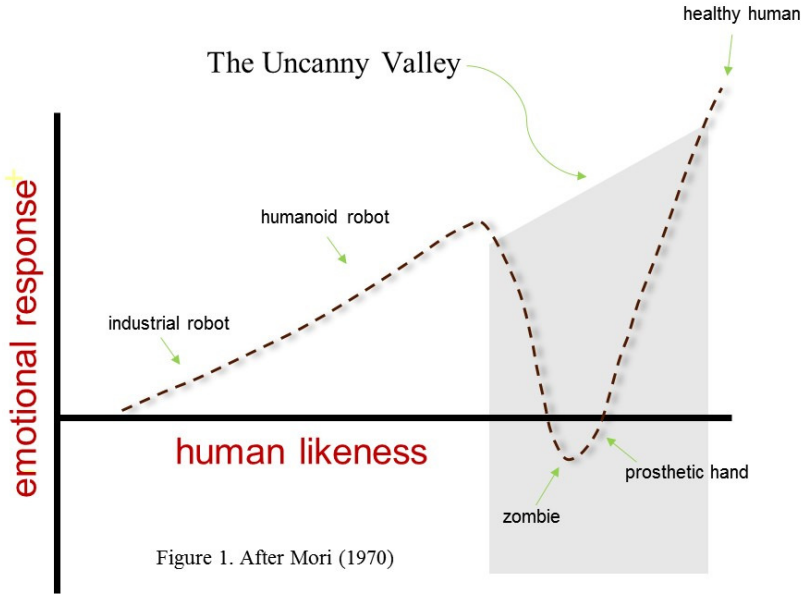

Figure 1. After Mori (1970)

Since many robot capabilities characterise

life, an important robot perception dimension is their degree of human likeness as in Figure 1, the Uncanny Valley (Broadbent, 2017; Belk, 2016; Mori, 1970; Mori, MacDorman, & Kageki, 2012). A popular theory, the Uncanny Valley suggests that a robot's degree of human likeness relates to feeling comfortable with the robot. Rather than a linear relationship, the feelings become eerie as the robots almost resemble humans—the Uncanny Valley. The relation again becomes positive as the likeness becomes even more human. At least one study extends this Uncanny Valley to monkeys' visual behaviour towards monkey faces (Steckenfinger, & Ghazanfar, 2009).

Uncanny valley research often draws on perceptual, cognitive, and social mechanisms and studies human faces. For example, manipulating computer generated human facial proportions, skin texture, and detail suggested complex factors and interactions varying the level of eeriness (MacDorman, Green, Ho, & Koch, 2009). As suggested in subjective ratings of robot video clips, there is no single Uncanny Valley for a particular range of human likeness; appearance is just one of many factors influencing perceptions of a robot as strange, familiar or eerie (MacDorman, 2006).

Other robotic factors include touch, movement, materials and speech (Mori, MacDorman, & Kageki, 2012; Pan, et al., 2015). For example, participants reacted favorably when a nursing robot touched them (Chen, King, Thomaz, & Kemp, 2014). The robot's perceived intent however, showed a more favourable response for cleaning participants' arms than for comforting participants. Furthermore, a verbal warning decreased the favourablity. And although not a robot per se, an experimental study tested the impact of a self-service technology (SST) machine's voice on consumer intentions to switch to traditional interpersonal customer service (Fan, Wu, & Mattila, 2016). A human-like rather than robotic voice led to lower switching intentions.

The above SST study highlights the consumer's role in HRI, as the consumer's sense of power and the presence of other customers attenuated the switching intentions for powerful customers (Fan, Wu, & Mattila, 2016). Similarly a type of technological readiness, using the Internet via a smartphone, showed a strong interaction effect on human likeness and service robot adoption (Goudey & Bonin, 2016). In addition to human likeness, which can vary from machine- to human-like, the study context and the study participants themselves can attenuate or amplify the effects of human likeness (Goudey & Bonin, 2016; Read & Belpaeme, 2014; Rosenthal-von der Pütten, et al., 2013). Teasing out the Uncanny Valley is a difficult, complicated and ongoing quest (Belk, 2016; Broadbent, 2017; van Doorn et al., 2017; Waytz, Cacioppo, & Epley, 2014).

Findings

The robotic continuum from machine- to human-like has marketing implications. As noted, anthropomorphism can predict care, concern, responsibility and trust afforded by a robot and the robot's social influence on the self (Waytz, Cacioppo, & Epley, 2014). Figure 2 illustrates how the Uncanny Valley may translate into two important marketing outcomes. One is acceptance or trial, a standard innovation adoption metric (Rogers, 2003). Human likeness would a priori be neutral with respect to robotic service delivery (van Doorn et al., 2017). Yet a robot falling into the Uncanny Valley may never be adopted.

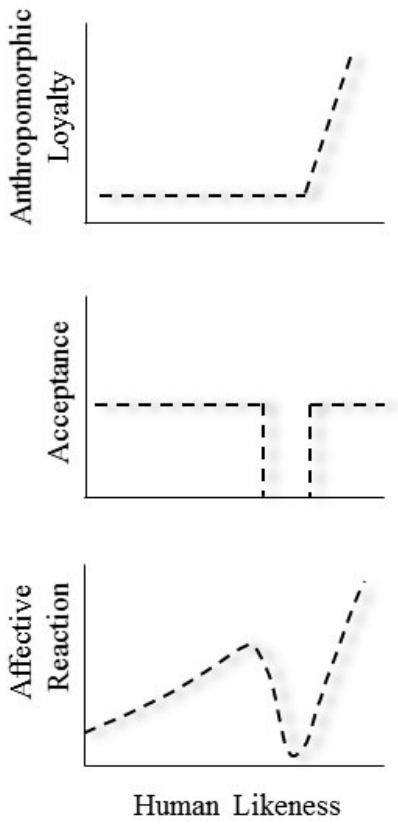

Figure 2. Marketing Outcome Implications of the Uncanny Valley

Anthropomorphic Loyalty
The top panel of Figure 2 shows the second outcome, a proposed new construct. *Anthropomorphic loyalty* merges consumer loyalty to an inanimate brand, and the loyalty traditionally reserved for a human companion. Anthropomorphic loyalty comes into play when the robot is sufficiently human like.

Such anthropomorphic loyalty seems a key outcome as service marketers have long shown various entities to which a relationship, and hence loyalty, can attach. As Reynolds and Beatty (1999) posit, customer-firm and customer-salesperson relationships differ. Similar to the e-commerce sphere, the customer may develop loyalty to the interface (Murry & Häubl, 2003). Finally, given the full force of anthropomorphism and how potent it can be in practice (e. g., Moon 2003), that loyalty could attach to robots in much stronger ways than to other sources of digital interaction.

Ownership Context
Numerous potential implementation issues revolve around robot ownership. Customer-owned robots that function in the house and yard are becoming commonplace (Murphy, Hofacker & Gretzel, 2017); personal service/companion/care/butler robots were popular at CES 2017 (Ackerman, 2017; Graham, 2017). Furthermore, robots could represent the customer to the firm, such as a physical rather than virtual shopbot (Kumar, Dixit, Javalgi, & Dass, 2016) or in a social role like chatbots. Firm-owned robots should surface in other contexts such as retailing, healthcare, hospitality, delivery and transport and manufacturing (B2B). Finally, psychological ownership helps consider the extent that "technology infusion provides customers with a sense of control in service experiences, an ability to understand and express their self-identity, and a sense of belongingness, resulting in a desire to revisit the service experience in the future" (van Doorn et al., 2017, p. 44).

The intersection of psychological ownership and anthropomorphism provides an additional area of interest—potential consumer discomfort. While consumers have no problems owning objects, most individuals would reject the idea of owning people. Perhaps anthropomorphism relates positively with feelings of psychological ownership and responsibility for robot actions.

Anthropomorphism Dimensions
The literature review suggests that anthropomorphism goes beyond robot appearance and includes capabilities, autonomy and actions. An underexplored area is robot personality and interaction/communication modes normally ascribed to humans (being embarrassed, spontaneous, funny, moody, flirty, etc.). Anthropomorphic marketing literature (e.g. Veer, 2013) has shown that brands successfully use anthropomorphism to stimulate attachment. Current efforts to humanise brands via social media marketing could inform service robot design by identifying what makes interactions engaging. Applying human-human interaction principles to human-machine interactions (Reeves & Nass, 1996) seems applicable if the machines look, act and interact like humans. It is therefore essential to understand which dimensions and levels of anthropomorphism most likely trigger a human-interaction schema.

Conclusion

That robots will evolve and alter both the workforce and marketplace is clear; unclear is the extent of this evolution and alteration (Broadbent, 2017; Brynjolfsson, McAfee, & Cummings, 2014; Collins, 2015; Frey & Osborne, 2017; van Doorn et al., 2017). A central issue in this context is HRI. This paper conceptualised anthropomorphism and ownership as critical factors influencing customer-robot service interactions. While existing literature focuses on frequent/regular interactions, the tourism and hospitality field does usually not afford overcoming the Uncanny Valley through learning and habituation. It therefore is an important context in which to build knowledge on first impressions of robots and short-term interactions. To our knowledge, this is one of few studies that explores the intersection of robots with tourism and hospitality services.

Research Limits
Conceptualising HRI in tourism and hospitality settings is difficult; robots are a rare phenomenon in these environments and existing HRI research is in very different service contexts. Empirical research is clearly needed to better understand the peculiarities of tourism and hospitality HRI. For instance, an important tourism and hospitality aspect not considered in this conceptualisation is intercultural interactions.

Practical Implications
By definition of autonomy, managing robotic products will be unlike managing most tangible goods, which do not exhibit agency. How robots interact with and are treated by other staff, other robots and customers is an important area of consideration for future tourism and hospitality managers. Robot capabilities and appearance will both be critical on the consumer side due to problems stemming from the Uncanny Valley. Another aspect to consider is how robots design can fit into, and elevate, the service culture that forms the core of many tourism and hospitality brands.

Future Research
A burgeoning research stream this century has applied SERVQUAL to electronic service quality, or eService (e.g., Fassnacht & Koese, 2006). The automated nature of websites and many email replies, however, renders offline service quality measures inappropriate for measuring eService (Parasuraman, Zeithaml, & Malhotra, 2005), albeit studies extend SERVQUAL to websites and email (Murphy, Schegg & Olaru, 2007). Extending SERVQUAL to service robots merits research from two aspects, robots as an employee and as a self-service technology. An complementary approach to SERVQUAL could compare service robots and humans on two key dimensions—affect and cognition—that drive marketing outcomes (Cronin, Brady, & Hult, 2000).

Engagement, critical for HRI and ultimately customer service, is one of many dependent measures for future research. A recent experimental study confirmed and provided evidence that classic HRI engagement models should consider attitudes and personality traits (Ivaldi, et al., 2016). Extroversion related positively to talking with the robot and a negative attitude towards robots led to looking less at a robot's face and more at the robot's hands. Thus, future research needs to extend current customer engagement on social media literature to the HRI context, with emphasis not only on how to encourage/initiate and sustain engagement but also how to effectively measure engagement quality and outcomes.

At Uncanny Valley's far right, the android/gynoid (male/female) is a personal service robot that is anthropomorphic in both appearance and behaviour (Belk, 2016; Broadbent, 2017). Researching this end of the spectrum remains a challenge as the technological development has not advanced enough to create these kinds of robots. Future research could examine rService via androids, using scenarios and computer generated images.

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