Title: The Potential for Tourism and Hospitality Experience Research in Human–Robot Interactions

Purpose:

To review recent work in the robotics literature and identify future opportunities for consumer/tourist experience research in human-robot interactions (HRI).

Design/approach:

The paper begins by covering the framework of robotic agent presence and embodiment that is relevant for HRI. Next, the paper identifies future opportunities for hospitality and tourism scholars to undertake consumer/tourist experience research in HRI.

Findings:

Potential directions to advance theoretical, methodological, and managerial implications for tourism experience research in HRI.

Research limitations/implications:

Concepts from robotics research are diffusing into a range of disciplines, from engineering to social sciences. These advancements open many unique, yet urgent, opportunities for hospitality and tourism research.

Practical implications:

This study illustrates the speed by which robotics research is progressing. Moreover, the concepts reviewed in this research on robotic presence and embodiment are relevant for real-world applications in hospitality and tourism.

Social implications:

Developments in robotics research will transform hospitality and tourism experiences in the future.

Originality/value:
This research is one of the early studies in the field to review robotics research and provide innovative directions to broaden the interdisciplinary perspective for future hospitality and tourism research.

KEYWORDS: human robot interaction; tourism experience; service robot; presence; embodiment; morphology

1. Introduction

Research in robotics is advancing, creating new applications for everyday life and opening new research domains. Current possibilities transformed by robotics were unheard of even only a decade ago, with concepts and methods from this area diffusing into a broad range of disciplines from computer science and engineering to education and social sciences (Li, 2015). There are also an increasing number of real-world applications of robotics in hospitality and tourism settings; for example, Starwood's Aloft Hotel deployed Boltr, a robotic butler, to deliver amenities to hotel guests (Crook, 2014). Royal Caribbean's Quantum of the Seas installed robotic arms to act as bartenders in the Bionic Bar (Golden, 2014). Singapore tested SARA (Singapore's Automated Responsive Assistant), a robotic virtual agent, to offer information and assistance for tourists (Niculescu *et al*., 2014).

Within the robotics literature, there is a growing area of research interest in human–robot interactions (HRIs), which emphasizes human-centered experiences in which people are the core focus. However, most of the latest work that has been done in robotics originated from engineering research, despite using hospitality and tourism as their context. These studies typically focused on the technical aspects of robotic design, architecture, and performance rather than consumer/tourist experiences with robots (e.g., Kim and Banchs, 2014; Zalama *et al*., 2014). Yet, there could be distinct experiences arising from HRI that is highly relevant for advancing tourism experience research (Yeoman, 2012). In light of this research gap, this paper seeks to: (1) review what have been done in the robotics literature, covering the framework of robotic agent presence and embodiment that is relevant for HRI; and (2) identify future opportunities for hospitality and tourism scholars to undertake consumer/tourist experience research in HRI.

Many of the latest examples of robotics that are cited throughout this paper are reported from engineering as there are limited studies, particularly on the concepts of presence and embodiment in HRI, in mainstream hospitality and tourism research. In this regard, this paper contributes to hospitality and tourism research by uncovering what have been done outside of the field in order to suggest what more needs to be done within the field. The subject of this paper is also timely and informative for both researchers and practitioners considering many recent robotic deployments and launches by large hospitality and tourism enterprises.

2. Robotics: Review of definitions and current research progress

2.1 Definition of service robots

Robotics has its roots in industrial automation. Industrial robots are focused on performing repetitive tasks at extraordinary speed with high precision and minimal downtime (Jordan *et al*., 2013). However, a paradigm-shift from rigid industrial models to more service-oriented and human-centered robots has emerged as research in mechanical engineering, electrical engineering, and computer science further developed. In 1994, the International Standardization Organization (ISO) 8373:1994 vocabulary only defined relevant terms for industrial robots that operated in a manufacturing setting (ISO, 2016). However, this area changed its definition in ISO 8373:2012 in 2012 to include robots and robotic devices that operate in industrial and non-industrial environments (ISO, 2016). In 2014, the first standards to address the safety requirements of HRI appeared for personal care robots in ISO 13482:2014. Currently, the International Federation of Robotics (IFR, 2016) defines a service robot as "a robot that performs useful tasks for humans or equipment excluding industrial automation application." Specifically, a personal service robot is used for a non-commercial task (e.g., domestic servant robot and personal mobility assistance robot), whereas a professional service robot is "used for a commercial task, usually operated by a properly trained operator…that is designated to start, monitor and stop the intended operation of a robot or a robot system" (e.g., cleaning robot for public places, and delivery robot in offices or hospitals). Robotics as a field has also developed significantly, and service robotics is becoming a leading area within this research (Jordan *et al*., 2013).

The term, social robot, has been used to describe service robots. The emphasis on the social aspect views robotic agents as a component of a heterogeneous society comprising robots and humans that are able to recognize each other and engage in social interactions (Dautenhahn, 1999). Social and practical objectives, such as serving people by providing information or assisting in hospitals and hotel environments, drive social robotics research to facilitate the gradual integration of robots into the real world (Zalama, 2014). HRI research with social robots emphasizes human-centered experiences meanwhile technological problems that require a variety of techniques are being solve (e.g., environment perception, visual and voice recognition, and psychological knowledge representations) (Zalama, 2014).

2.2 Human-centered experiences

Service robots in workspaces, such as hotels, private homes, hospitals, and other service areas, maintain frequent direct physical contact with humans in a shared, non-industrial environment. Consequently, service robots require more than an engineering solution because human-centered experiences entail a different set of conceptualizations compared with the traditional models of industrial robots in structured environments (Zinn *et al*., 2004). Although programming algorithms and software architectures are essential from an engineering perspective, the success of service robots depends on effective HRI. For example, human partners must have appropriate levels of training and skills to interface successfully with a robot (Johnson *et al*., 2015). From a robotics design perspective, service robots need to convey human-centered experiences, including gentleness, communication skills, and adaptability toward human partners, as well as ease of use and even humanoid appearance and behavior (Riener *et al*., 2006). These robots also strive to convey natural communication through language, gestures, and expressions (Kawarazaki *et al*., 2004). Currently, research in robotics is experimenting with service robots in different forms of presence and embodiment to understand these effects on human experiences.

2.2.1 Presence and embodiment

Service robots are differentiated based on two dimensions: presence and embodiment (Dautenhahn, 1999). These dimensions help to define three types of robots: copresent robots, telepresent robots, and robotic virtual agents (Li, 2015) (see Figure 1).

--- Insert Figure 1 here ---

Copresent robots are physically present and embodied in the user's space. For example, *Boltr* is a copresent robotic butler deployed at Starwood's Aloft Hotel in Cupertino to deliver amenities such as toothbrushes and towels to hotel guests (Crook, 2014). In Japan, Henn-na Hotel deployed a copresent, functional trolley robot to escort hotel guests and carry their suitcases (Lewis-Kraus, 2016).

By contrast, telepresent robots are physically embodied but displayed on a screen (e.g., as a live feed of a physical robot). The interaction of individuals with telepresent robots is mediated through a computer monitor, television, or projector screen. The virtual Sony Aibo is an example of a telepresent robot that is mediated through a screen to entertain individuals through singing and dancing (Lee *et al*., 2006).

Robotic virtual agents are not physically present and are only digitally embodied with a similar appearance of a robot (e.g., computer graphics model of a robot). An individual's interaction with a robotic virtual agent is mediated through a monitor or screen. For example, SARA is a robotic virtual agent that provides tourists in Singapore with information on local attractions, restaurants, sightseeing, direction, and transportation services (Niculescu *et al*., 2014). SARA detects the location of a tourist by using a GPS-integrated module and provides real time assistance and (re)orientation. CLARA is a robotic conversational agent and restaurant recommendation system that provides tourists with information about sightseeing, transportation, restaurants, and general information about Singapore (D'Haro *et al*., 2015).

A sub-category of virtual agents with neither presence nor embodiment (i.e., lack of visually observable appearance) exists in other forms as text or voice only, such as Siri, and more recently from Siri's creators, Viv (Hardawar, 2016). For example, R-cube, an unembodied virtual agent that provides tourists in Singapore with restaurant recommendations, selections, and booking (Kim and Banchs, 2014).

2.2.1.1 Presence

Presence refers to the presentation of a robotic agent to others (Li, 2015). The three types of presence are self, social, and physical presence (Lee *et al*., 2006). Self-presence occurs when users perceive artificially constructed identities inside virtual worlds as real (Lee, 2004). Social presence is one's mental simulation of nonhuman intelligences, such that individuals may respond socially to avatars or robotic agents as if they were actual humans (Nass and Moon, 2000). Physical presence reflects the perception of objects within one's range of senses, whether objects are real or digitally presented (Lee *et al*., 2006). For example, users in virtual reality may feel a strong sense of physical presence and dodge simulated objects hurling towards them.

Within physical presence, the term copresence implies that the user and robotic agent are within physical proximity. This distance enables an individual to experience physical and reciprocal perceptions. The experience could range from touching and to being touched by a copresent robot in a human–robot shared environment.

Presence could also extend digitally if a robotic agent is presented in electronic proximity to the user. A telepresent robot can share the same real-world environment as a user via interactions through a computer monitor, television, or project screen. However, the robot itself is mediated electronically as a live video feed. Bainbridge *et al*. (2011) developed the robot Nico and explored how its physical presence could affect human judgments. In their experiment, participants collaborated on simple book-moving tasks with Nico when it was copresent or displayed via a live feed. The authors analyzed several aspects of HRI, including greetings, cooperation, trust, and personal space. The findings showed that participants readily greeted and cooperated with Nico when the robot was copresent and telepresent. However, participants were more likely to fulfill an unusual request (i.e., Nico asked participants to discard expensive textbooks) when it was physically present than when it was telepresent

Similar to telepresent robots, HRIs with robotic virtual agents are mediated through a monitor or screen in the real world. A robot may have physical embodiment but this trait may not be displayed in its physical form if shown digitally on a screen as a computer graphic (e.g., SARA) (Niculescu *et al*., 2014).

2.2.1.2 Embodiment

In robotics, the concept of embodiment is defined as the "dynamic coupling among brain (control), body, and environment" (Pfeifer *et al*., 2007, p. 1088). This definition suggests that abstract programming algorithms need to have physical instantiation or a body in the form of a physical robot or virtually simulated agent to have dynamic interactions with humans (Ziemke, 2003). Embodiment encompasses total body communication that involves verbal and non-verbal behaviors to create face-to-face experiences (Cassell, 2000).

Embodiment is affected by a robot's morphology, which represents a robot's form and structure, such as the shape of its body and limbs, as well as the type and placement of sensors (Pfeifer *et al*., 2007). Robot morphology is characterized into several groups: anthropomorphic,

zoomorphic, caricatured, and functional (Fong *et al*., 2003). Anthropomorphism refers to the tendency to attribute human characteristics to nonhuman objects, and anthropomorphic robots, or humanoid robots, seek to facilitate HRI by mimicking human-like forms (Duffy, 2003). Sacarino is a humanoid robot that accompanies and provides guests with information about hotel services (Zalama *et al*. (2014). Users may expect human-like experiences if a robot is inspired with anthropomorphic features and users may have higher expectations from highly anthropomorphic robots than those with lower anthropomorphism (Nowak and Biocca, 2003). However, the idea of the uncanny valley suggests that the response of an individual to a humanoid robot could abruptly shift from empathy to revulsion due to a not quite perfect lifelike appearance (Mori *et al*., 2012). These subtle imperfections could make a robot seem eerie.

Zoomorphic robots are designed based on living creatures, such as cats or dogs (Pfeifer *et al*., 2007). Despite their form, these robots are often programmed to perform human tasks (Zanbaka *et al*., 2006). For example, Karotz is a rabbit-shaped robot that enables hotel guests to choose from different actions, such as receiving notification from the hotel and discovering nearby tourism activities. These actions are based on voice communication to make HRI as natural as possible (Nieto *et al*., 2014).

Caricatured agents are robots that do not resemble living things (Fong *et al*., 2003). A robotic virtual agent with caricature morphology could be in the form of a basketball to interact with humans. Finally, functional embodiment reflects the task to be performed (Fong *et al*., 2003). A service robot at a fitness center of a hotel may be in a form of a basket to collect used towels from guests.

Service robots could embody intermixed morphologies as well. The Philips iCat has zoomorphic qualities in which the robot has the head of a cat, humanoid torso, and facial expressions (Heerink *et al*., 2006). Functionally, the different morphologies in the torso and head could affect the degree of freedom and movement of the robot for carrying out the required tasks in a service context. In a HRI perspective, individuals may perceive robots with intermixed morphologies as expressive in its service environment and affect their perception of the robot's capabilities (Li, 2015).

In addition to morphology, the embodiment of a robotic agent could be physical, virtual, or a blend of both. A physical agent suggests that a robot has motors and actuators to interact autonomously or semi-autonomously with humans (Bartneck and Forlizzi, 2004). A digitally

embodied or virtual agent refers to an animated rendering of a character via computer graphics, although the character may not be anthropomorphic. Other terms that map robotic virtual agents in the current literature include embodied conversational agent (Cassell, 2000) and animated interface agent (Dehn and Van Mulken, 2000; Serenko *et al*., 2007). Robotic agents could consist of a blend of physical and digital components, such as robots having a physical torso but using a digital screen to display a face (Li, 2015).

3. Discussion, implications, and opportunities for consumer/tourist experience research in HRI

The next part of this paper is to identify opportunities for hospitality and tourism scholars to undertake consumer/tourist experience research in HRI. The approach taken in this part is thematic, and research opportunities are categorized based on the framework from Ritchie and Hudson (2009). This framework was developed based on an extensive review of the experience literature in hospitality and tourism, and is applicable to the present paper to categorize opportunities into main streams of conceptual thinking. This framework has also inspired a number of studies to explore management opportunities associated with facilitating tourism experiences (Ritchie *et al*., 2011), consider the dynamic nature of tourism experiences which are subject to constant evolvement and change (Neuhofer *et al*., 2014), and add to the tourism literature by considering perspectives from other fields (Jensen *et al*., 2015). In this regard, the following sections aim to: (1) explore the potential for new conceptualizations of tourism experiences in HRI based on the concepts of robotic presence and embodiment; (2) understand the influence of robotics on "the tourist", including their pre-trip decision-making process, onsite experiences, and post-trip evaluations and behaviour; (3) investigate the nature of specific types of tourist experiences that could be affected by robotics; (4) propose alternative methodologies that could be useful to investigate tourism experience research in HRI; and (5) focus on upcoming on research in robotics that may have particularly important managerial implications in hospitality and tourism. Streams (1) to (4) are more relevant to theoretical implications while stream (5) pertains to practical implications.

This paper first searched for relevant published articles on robotics in hospitality and tourism research in a wide range of hospitality and tourism journals as well as from large databases, including ScienceDirect and Google Scholar. These databases were selected because

they provided current research on this topic and presented relevant information at the top of search results (Law *et al*., 2016). Keywords such as "robotics", "human-robot interaction", "hospitality" and "tourism" were used to search for relevant articles. Nevertheless, previous studies on robotics that were published in hospitality and tourism outlets were limited, and as a result, research from other fields such as engineering and communication were also reviewed for inspirations that could potentially inform future opportunities in consumer/tourist experience research in HRI. In addition to reviewing full-length empirical and review articles, other forms of outputs, particularly conference papers, were considered as conference proceedings in engineering research can oftentimes reflect up-to-date and state-of-the-art research in innovation and technology (IEEE, 2017).

3.1 Theoretical implications

3.1.1 Conceptualization of experiences

The first research stream seeks to understand the essence of the tourism experience and studies often develop or use specific conceptual frameworks as their point of departure. There are a number of representative work in this stream; for example, the conceptualization of the optimal experience, authentic experience, extraordinary experience, and memorable experience (Arnould and Price, 1993; Csikszentmihalyi, 1975; Tung and Ritchie, 2011; Wang, 1999).

There are opportunities for hospitality and tourism scholars to extend the field's conceptualization of tourism experiences in HRI. Future research could benefit from the framework of presence-embodiment reviewed in this paper and use it as their point of departure; that is, how do robotic presence and embodiment affect tourists' conceptualizations of experiences? For example, there are different robots deployed at the reception of Henn-na Hotel in Japan: one is anthropomorphic (humanoid full body) and the other is zoomorphic (dinosaur) (Lewis-Kraus, 2016). Researchers in cognitive science are conducting experiments with different forms of embodiment as they could affect the expressive capabilities of the robot from a functional standpoint as well as how it engages with individuals from an experiential view (Dautenhahn *et al*., 2002). Future hospitality and tourism research could also examine how different morphologies engage tourists from an experiential perspective.

Future research could explore how robots mediate the touristic experience. For instance, the tour guide is a traditional example of a mediator in a tourism setting, but the development of technology (e.g., prevalence of smartphones) has enriched the meaning of mediation in tourism experiences by stimulating fantasies and by providing recommendations, directions, and guidance for tourists throughout the three stages of the travel process (Tussyadiah and Fesenmaier, 2009). Similarly, as the pervasiveness of robotics increase into people's everyday life, future research could explore how robotics agents, particularly robotic virtual agents, mediate tourists' experiences throughout the anticipatory, experiential, and reflective phases of the travel process.

The role of robots in mediating the tourist experience could also depend on the framework of presence-embodiment. For instance, Lee *et al*. (2006) compared participants' experiences and evaluations of an actual Sony Aibo (i.e., copresent robot) with a virtual Sony Aibo (i.e., telepresent). The authors found that the aspect of presence mediated participants' evaluations of the robot. Future research could explore how robotic agents with varying aspects of presence-embodiment could mediate touristic experiences, affecting tourists' pre-travel, onsite, and post-trip behaviours and emotional states.

3.1.2 The tourist

This stream of research seeks to understand the tourist, including his/her pre-trip decision-making process, onsite experiences, and post-trip evaluations and behaviours. Studies have focused on the impact of travel information and technology on pre-trip decision-making as well as the influence of past experiences on travel choice behaviour, satisfaction, willingness to recommend, and intention to revisit a destination (Nerhagen, 2003).

Robotics can have an impact on tourists' pre-trip processes. According to the Technology Acceptance Model (TAM), an individual's behavioral intention to use a system could be influenced by the perceived usefulness and perceived ease of use of the technology (Davis, 1989). Perceived usefulness represents the extent to which individuals believe the technology would enhance their task performance while perceived ease of use is the extent to which individuals believe that using the technology is free of effort. TAM2 further incorporates social influence and cognitive instrumental processes in the model (Venkatesh and Davis, 2000). Taken

together, tourists' prior cognitive beliefs, social influence, perceived ease of use, and the perceived usefulness of robotics could affect their acceptance of robots during their experiences. Future research could apply the lens of TAM to examine tourist pre-trip intentions to use or adopt robotic agents during their travel. For example, tourists may have strong prior beliefs of robots, particularly copresent humanoid agents, that have been shaped by media and popular culture despite relatively little personal experience with actual robots (Sundar et al, 2016). Future research could also provide theoretical contributions to the literature by considering the role of emotions such as fear and anxiety on technology acceptance (Venkatesh, 2000). These affective responses are highly important as robots and humans engage in direct contact with each other, especially in hospitality and tourism settings given the co-creation of experiences in shared environments (Liu and Tsaur, 2014).

The 'tourist' cannot be viewed homogenously as perceptions and salience of experiences could vary considerably among tourists in different segments (Prayag *et al*., 2015). Tourism experiences could be influenced by a number of factors, such as an individual's social and cultural background, and lifestyle (Wang and Morais, 2014). Tourism experiences are also multi-faceted, arising from the confluence of the physical environment and activities with one's social identity (Bond and Falk, 2012). Future research can investigate the factors that affect "the tourist" and his/her corresponding HRIs. For instance, how do personal factors influence tourists' interpretations of HRIs? Hospitality and tourism researchers can get inspirations for their research from studies in engineering and communication that have explored the impact of users' culture, age, gender, and education on HRI. Li *et al*. (2010) analyzed the effects of culture (i.e., Chinese, Korean, and German), robotic embodiment (i.e., anthropomorphic, zoomorphic, caricature) and task (e.g., teaching and entertaining) on user responsiveness, engagement, trust, and satisfaction with a robot. Their results suggest that cultural differences exist in user attitudes and engagement with the robot. Chinese and Korean participants experienced higher engagement with the robot and perceived it to be more trustworthy and satisfactory than their German counterparts. Haring *et al*. (2015) focused on the perception of morphology (e.g., humanoid) robot between Japanese and Australians. Compared to Australians, Japanese users provided higher ratings for a humanoid robot on elements of anthropomorphism, intelligence, and safety. Future research could also explore how culture affects tourists' experiences in the framework of robotic presence-embodiment.

In addition to culture, future hospitality and tourism research could investigate the influence of age, gender, and education on tourist experiences toward robotic agents. Drawing from a healthcare context, Heerink (2011) investigated the influence of these factors on users' acceptance of an assistive service robot. The author found that older individuals were less willing to use the robot than younger participants, and users with higher levels of education perceived higher levels of social presence from the robot.

3.1.3 Types of experiences

This stream of research seeks to explore the nature of specific types of tourism experiences, such as backpacking, rural, adventure, hiking, culture, and among many others (Cetin and Bilgihan, 2016; Cutler *et al*., 2014; Loureiro, 2014; Noy, 2004; Pomfret, 2012). There are renewed opportunities for hospitality and tourism researchers to re-explore potentially unseen HRIs in various types of experiences; that is, how can robotics influence tourists across different types of experiences? For example, studies in the tourism literature have explored tourist perceptions and willingness to travel with (real-life) pets, as well as the interaction between pets and their owners in co-creating tourism experiences (Bertella, 2014; Kirillova *et al*., 2015). Komppula and Gartner (2012, p. 173) reported in their auto-ethnographic study of a hunting experience that "the experience… often with just the dog (spiritual), remains one of the peak experiences of the year." Future research can extend this line of research and draw from the literature on anthropomorphism, representing the phenomenon in which enables individuals treat non-human objects as their friends or family members and give them meanings and personalities (Fournier, 1998). Today, zoomorphic robotic agents are being designed to mimic pets, accompanying and providing humans with educational, psychological, and lifestyle support. Although describing robotic agents and living animals in tourism experiences in the same breath may sound appalling, recent research in HRI points to the potential for humans to perceive an autonomous robot as a "buddy" or "being" that they enjoy interacting with (Lin and Schmidt, 2015). PARO is a zoomorphic robot seal designed to provide humans with psychophysiological effects, such as enjoyment and relaxation (Mitsui *et al*., 2001). PARO is equipped with tactile, vision, audition, and posture sensors that would act and react to inputs, and even includes soft white artificial fur. Mitsui *et al*. (2001) measured users' cerebral blood flow, skin temperature, blood pressure, respiratory wave, and mood states, and the findings from the physiological and

subjective measurements suggested that individuals were attentive and enjoyed the experience with PARO during their interactions. In this regard, future research could investigate tourists' psychophysiological effects with robotic "buddies" during their tourism experiences.

Furthermore, many studies in HRI are focusing on the influence of robotics on children because today's children are exposed to unprecedented expansion of robotics during their growth and development. Okita and Schwartz (2006) investigated how young children between the ages of three and six evaluated the animate qualities of zoomorphic dogs to explore the degree to which they would consider intelligent, autonomous robotic dogs as living things. The results indicated that toddlers attributed animistic qualities to the robot while older children attributed a few animistic qualities but not others. From a hospitality and tourism perspective, future research could investigate how robots influence the travel experiences of children, particularly during the context of family travel. Future research could also explore how children engage with robots across different types of tourism experiences at various destinations.

3.1.4 Methodological approaches

The objective of this stream is to provide methodological contributions to tourism research by identifying possible approaches to investigate tourist experiences in HRI. This discussion seeks to answer: what methodological approaches are currently utilized in the literature in HRI? What methodological approaches could be relevant for the study of tourist experiences in HRI?

A large number of studies in the robotics literature are using interaction scenarios and experimental designs, and hospitality and tourism researchers could consider these approaches to study tourist experiences in HRI. Salem *et al*. (2015) analyzed the effects of error, task type, and personality on human–robot cooperation and trust. The authors conducted an experiment in which users interacted with a physically embodied caricature. Users interacted with Sunflower, a home companion mobile robot, in one of two conditions: correct mode or faulty performance. In the correct mode, Sunflower correctly translated user input into action and navigated the home in a smooth and goal-directed manner. In faulty performance mode, Sunflower showed cognitive and physical imperfections by incorrectly remembering the selection of the user and by navigating in an erratic manner, such as moving in the wrong direction and occasionally spinning. After the interaction, users completed self-reported measures to analyze the different

dimensions of HRI, including their perceptions of the interaction, involvement with the tasks, and trustworthiness of the robot. Pandey and Alami (2014) investigated basic human-centered object manipulation tasks, which required a robotic agent to perform a task (e.g., drop an item in a trash bin) for a human partner. The goal of this study was to refine robotic knowledge about various daily tasks as they evolve to co-exist in human-centered environments. Taken together, experimental designs with interactive scenarios in HRI could open a range of potential directions for hospitality and tourism research. Researchers could elicit different real-life scenarios to enable tourists to observe and even collaborate with robotic agents. In this sense, the robotic agent becomes a co-creator of the tourist experience. Researchers also could assess different types of tourist interactions with a robotic partner and measure tourists' subjective experiences as well as their acceptance and attitudes towards their robotic partners.

In addition to quantitative studies, future research could explore tourist experiences in HRI using qualitative methods. In communications research, Okita (2015) analyzed children's beliefs and preconceived notions about robots. In-depth interviews were conducted with children between the ages of four and seven, and the findings indicated that prior knowledge and beliefs, as well as age, influenced how children saw, interpreted, and interacted with robots. Further to interviews, tourism researchers can also use other techniques, such as focus groups, photo elicitation, and ethnography, including its extension into auto-ethnography, and more recently, netnography, to investigate tourist experiences in HRI. Hospitality and tourism research can benefit by embracing methods and approaches offered in other disciplines across the social sciences (Wilson and Hollinshead, 2015).

3.2 Practical implications

Throughout this paper, many examples of current robotic applications in the context of hospitality and tourism were provided (e.g., copresent robots such as Botlr and Karotz, and robotic virtual agents such as SARA and CLARA). Instead of revisiting these examples in this final stream, the purpose of this section is to focus on additional developments in robotics that may have particularly important managerial implications in hospitality and tourism. Tuominen and Ascencao (2016) described, interpreted, and anticipated changes in hotel management in the coming years. The authors synthesize three focus areas for future hotels: first, hotels have to respond to demographic trends by developing new offerings for the experienced consumer who

are more demanding of superior service and facilities. Second, hotels have to provide rapid individualization of product and service offerings. Third, hotels have to fully embrace emerging technologies from other industries. How would these trends affect robotics and HRI in hospitality and tourism experiences?

The development of cloud robotics, for example, is an upcoming area that could address the consumer trend for more demanding services as well as the rapid customization of tourist experiences using real-time consumer insight. Cloud robotics or cloud-enabled robotics combines the potential of information networks with robotics to enhance agent capabilities (Hu *et al*., 2012). Cloud robotics merges cloud technology-based computing or cloud computing in information-communication technology (ICT) with service robotics. For example, Google Docs is a cloud-based software based on the idea of software as a service (SaaS). An extension of this idea is robots as a service (RaaS), which aims to dynamically link robots so that they are "connected to modern cloud-computing infrastructure for access to distributed computing resources and datasets, and [have] the ability to share training and labeling data for robot learning" (Jordan, 2013, p. 238). Cloud robots could acquire information and knowledge through networked databases to execute tasks because they could access vast amount of data (Hu *et al*., 2012). This potentially leads to a new form of collective robotic intelligence through learning and sharing (Goldberg and Kehoe, 2013).

Future research in hospitality and tourism could investigate how cloud robotics affect tourist experiences as experiences extend beyond human-to-human interactions to include robot-to-robot interactions that could then influence subsequent human-to-robot experiences. Cloud robots can access a database of tourist preferences and profiles, as well as a library of skills or behaviors, that map different task requirements to facilitate customized experiences during HRI. After an initial tourist-to-robot experience, the learnings from that individual robot could be shared through the cloud with other agents (i.e., robot-to-robot) on the network. When a tourist visits another destination or hotel, these learnings could be transferred to a subsequent robotic agent that could further tailor a co-created experience for the tourist.

Hospitality and tourism practitioners could also embrace emerging technologies, such as robotic navigation, allowing them to recommend better long-range navigation for tourists in urban, and in particular, rural destinations. The integration of cloud computing with robotics provides individual robotic agents with the ability to retrieve, store, and process large amount of

map data via commercially available maps (e.g., Google Maps). Cloud robotics, combined with advances in robotic navigation (e.g., in the form of virtual agents or copresent autonomous drones), allows a robot to determine its own position and plan a path to reach a desired location (Hu *et al*., 2012). Future research could explore how robotic navigation features (e.g., localization and path planning) transforms the tourist experience in different contexts, such as backpacking and hiking experiences, which commonly rely on mapping and positioning solutions (Floreano and Wood, 2015).

3.3 Conclusion and limitations

Research in robotics is developing rapidly and uncovering previously unseen possibilities across different industries and everyday life. Researchers from diverse fields, ranging from engineering to education and the social sciences, are collaborating to understand new concepts that are applicable to human-centered experiences in human–robot interactions. Towards this end, the current paper reviewed what have been done in the robotics literature, covering the concepts of presence and embodiment as well as the different types of robotic agents (i.e., copresent, telepresent, and virtual agents), and identified future opportunities for hospitality and tourism scholars to undertake consumer/tourist experience research in HRI.

The concepts covered in this review are considered relevant but certainly not exhaustive. For example, a robot in a virtual world could be considered as copresent if users perceive it in the same virtual space (Schuemie *et al*., 2001). A human operator could be telepresent on screen from a copresent robot in a virtual world. In this sense, definitions applicable to robotic agents could immediately become unclear because of the possible ambiguities of physical presentation in virtual environments (Li, 2015). This example demonstrates the speed in which research is progressing as unseen concepts could be possible in physical and virtual worlds. Nevertheless, for the purpose of this review paper, the literature on presence and embodiment that applies to the physical world is considered relevant for real-world environments in tourism and hospitality.

Finally, advancements in robotics represent a unique, yet urgent, window of opportunity where managerial insights could inspire new directions in hospitality and tourism research. For example, researchers could conduct interviews with managers in hospitality and tourism industries to explore practitioners' views towards robotics. Researchers could also gather both

positive and negative comments from tourists' experiences to investigate the extent to which the impact of robotics exists and are consistent with practical evidence. By combining the depth and breadth of knowledge in tourism experiences with HRI, insights from future research programs could benefit practitioners in this fast-growing area.

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