MULTIFACETED TRUST IN TOURISM SERVICE ROBOTS

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Abstract

In recognizing the increase in the use of service robots by service industries, identifying the structure of trust in intelligent robots is crucial for tourism studies. This paper first proposes a model of multifaceted trust in service robots comprised of three constructs – performance, process, and purpose – and, second, tests the trust model that considers institution-based trust, trusting belief, and intention. As a result, this paper identified a higher-order formative construct of trust in service robots with the highest importance for a performance construct (Study 1). The antecedents of the multifaceted trust in tourism service robots are then identified (Study 2). This study provides important theoretical and methodological contributions to the fields of information technology and tourism.

Key words: artificial intelligence, autonomous robots, service robots, trust and service encounters

1. Introduction

The tourism industry has adapted to advancements in information technology, such as the Internet, mobile phones, and virtual and augmented reality. At present, the integration of artificial intelligence and robotics is ubiquitous, appearing in hospitality and tourism settings, including the accommodation, airline, and restaurant sectors. Starwood Aloft Hotels has deployed Boltr: a robotic butler that delivers amenities to guest rooms in lieu of staff (Crook, 2014). Hilton Worldwide provides a robot concierge employing Softbank’s NAO robot in collaboration with IBM. The humanoid NAO robot not only informs guests about hotel amenities, but also offers information about attractions and restaurants at the destination (Hilton, 2016). The Henna-na hotel in Japan was the first hotel to perform all its operations with autonomous robots. These developments imply that the adoption of artificial intelligence and service robots is shaping the nature of service experiences as, in fact, some service encounters have been fully redefined by human-robot interactions (Tussyadiah & Park, 2018). Recently, tourism scholars have identified appropriate places where service robots can be implemented (Ivanov & Webster, 2019a, 2019b).

An examination of the literature on robotics (Tung & Law, 2017) reveals that there is a growing research area in human-robot interaction emphasizing human- (or user-) centered experiences. In particular, trust, referring to the way people interact with new technology (Hoff & Bashir, 2015), is recognized as an essential element that affects the willingness of persons to adopt the autonomous technology, and as a result, to benefit from the advantages inherent in it (Kessler, Larios, Walker, Yerdon, & Hancock, 2017). Importantly, however, the academic attempt to understand consumers’ perceptions of trust in service robots is quite limited in the tourism field.

Artificial intelligence and robotics entail autonomy—a distinctive feature compared to other technologies. It refers to an agent's ability to handle variations in its environment (Thrun, 2004). In other words, these systems are designed to have increased levels of independent intelligence and decision-making authority—capacities that will be performed in uncertain, unplanned circumstances. This distinctive feature of artificial intelligence and robotics may produce adverse feelings, and such attitudes may consequently lead people to diminishing intentions to adopt the autonomous technology (Sanders et al., 2017). In this vein, creating the value of trust plays a key role in interventions designed to alleviate social and technical complexity—which ultimately helps to enhance users (or travelers') experiences (Gefen, 2000; Söllner & Pavlou, 2016). Thus, it is crucial to identify the formation of perceived trust in service robots and other psychological elements related to it.

Accordingly, the first aim of this study was to suggest a structure of trust principally associated with service robots, instead of employing a concept of trust in people or organizations, as has largely characterized previous tourism studies. Building on Mayer, Davis, and Schoorman (1995) definition of trust, Lee and See (2004) proposed three dimensions of trust in automation defined as "technology that actively selects data, transforms information, makes decisions, or controls processes" (pp. 50): (a) performance, (b) process, and (c) purpose. This research considers multidimensional trust in the context of service robots in tourism. The second aim of this paper was to test the trust model of service robots. Based upon the trust model of information technology proposed by McKnight, Choudhury, and Kacmar (2002), delineating institution-based trust, trusting beliefs and trusting intention, the relationships of the multidimensional trust of service robots is estimated to other trust constructs. In order to address the research aims, two separate studies with a pilot study have been conducted. The purpose of

Study 1 was to shed light on multifaceted trust in service robots by applying a number of validity estimations. Study 2 sought to test the trust model reflecting the linear process of trust formation derived from Study 1 (see Figure 1).

[Please Insert Figure 1 about here]

The present research extends the literature on trust in tourism and information technology (Bauernfeind & Zins, 2005; Buhalis & Law, 2008; Chen, 2006). It considers the nature of trust toward autonomous technology—service robots—as the trustee itself and suggests three constructs to define trust beliefs pertaining to the technological artifacts. A series of estimations of reliability and validity not only shed light on multidimensional trust in tourism service robots (Lee & See, 2004), but also demonstrate the association of it with other psychographic variables and test the trust model.

2. Literature Review

2.1. Service Robots

Service robots can be descried as “systems that function as smart, programmable tools, that can sense, think, and act to benefit or enable humans or extend/enhance human productivity” (Engelhardt & Edwards, 1992, pp. 315-316). Service robots in tourism, in particular, refer to autonomous intelligence that assists travelers and service providers with their personal or professional goals. The service robots can be classified according to their levels of automation: quasi-automated and fully automated robots (Murphy, Gretzel, & Hofacker, 2017). Quasi-automated robot decisions involve either self-directed behavior stemming from their programming or from remote human input. On the other hand, fully automated robots are considered as agents that have the ability to react to environmental variations and communicate with others without external control (Li, 2015).

Autonomy in service robots is a key feature that differentiates them from other forms of technology. Autonomy, referring to a robot's ability to handle variations in its environment (Thrun, 2004), is a vital attribute that determines the levels and types of tasks a robot can perform, thus enriching its capability of functioning within complex environment (Beer, Fisk, & Rogers, 2012; Goodrich & Schultz, 2007). In this sense, the theme of human-robot interaction has been considered as the crucial research topic for understanding user experiences and adoption (Kiesler & Hinds, 2004; Thrun, 2004). Interaction, by definition, requires communication between a human and an object, in this study, a service robot (Goodrich & Schultz, 2007). Communication includes diverse forms that are constructed by the degree of proximity between a human and a robot, which develops remote and proximate interactions. Remote interactions denote moments wherein a user and a robot exist in a separate location and/or time. Proximate interactions describe settings where the human and robot are collocated. Considering the features of tourism and hospitality services, proximate interactions, where robots exist in the same place as humans (or consumers), are a more suitable approach than remote ones—for instance, the use of a robot concierge (Goodrich & Schultz, 2007).

From the perspective of human-robot interaction, a robot's morphology—the degree of human likeness—is a factor that influences users' perceptions. A well-known theory, the Uncanny Valley (Mori, 1970; Mori, MacDorman, & Kageki, 2012) suggests that a robot's degree of human likeness is related to people's comfort with it. Users' responses are not necessarily positive to the degree of the robot's resemblance to humans: subtle imperfections could make a robot seem strange. Along these lines, Goudey and Bonnin (2016) demonstrated that the anatomical anthropomorphism of the technological artifact partially affects experiences of the companion robot. People also perceive robotic agents as intermixed morphologies placed in the service environment; this, in turn, influences the perceived capabilities of the robots (Li, 2015; Tung & Law, 2017).

Several scholars in tourism have investigated consumer experiences in using service robots (Tung & Au, 2018; Yu & Ngan, 2019) and perceived appropriateness of automated robots in hotel services (Ivanov & Webster, 2019a). Specifically, the study conducted by Tung and Au (2018) analyzed consumer reviews sharing service experiences of robot hotels and identified five dimensions of user experiences including embodiment, emotion, human-oriented perceptions, feeling of security, and co-experience. Another research shows cultural and gender variations of customer service experiences between human-like robot and human staff according to the direction of head tilt as non-verbal cues (Yu & Ngan, 2019). It is identified that the different levels of power distance (cultural dimension) and gender are important factors to explain different consumer experiences between human-like robot and personal staff. Tussyadiah, Campus, Zach, and Wang (2019) have conducted a series of studies to identify factors that form trusting beliefs toward intelligent service robots, such as self-driving transportation and robot bartender. The study revealed a positive impact of propensity to trust technology and a negative influence of negative attitude on trusting beliefs in intelligent robots. Ivanov and Webster (2019a) found out appropriate places of robot application in hotel services. Indeed, the robots can be applicable to deliver services related to information provision, housekeeping, food, beverages and guidance, personal services, entertainment, bookings, payments and documentation.

Recently, several industry leaders in tourism and hospitality have employed robots in either humanoid or non-humanoid automated machines to play diverse roles in the process of service delivery. For example, Hilton Worldwide, collaborating with IBM to produce a Watson robot, employed a humanoid concierge robot to provide information about destinations and hotels to guests. Starwood introduced a robotic butler at Aloft Hotels that is able to deliver amenities to guest rooms in lieu of actual humans. Due to the technological gear of the robots, which combines sensors and WiFi/4G connectivity to communicate with the hotel and elevator systems, the mobility of such robots can be enhanced without the risk of breaking things or injuring people. The Sacarino robot, which serves as a hotel bellhop, can offer information about the hotel's facilities, events, and videoconference services. It can even call taxis and provide information from the Internet, as well as find its charging station at the lobby during its break and charge itself (Pinillos, Marcos, Feliz, Zalama, & Gómez-García-Bermejo, 2016).

In this new digital environment, the nature of interplay between consumers and service providers (e.g., destinations, hotels, airlines, etc.) might change substantially. Indeed, technology infusion—the integration by service providers of advanced technological systems into customers' frontline experiences—can be regarded as an essential attribute to enhance service experiences (Van Doorn et al., 2017). This is because technology infusion enables service providers to interact with customers efficiently and effectively and, ultimately, will foster the development of relationships between service robots and/or providers and customers (Marinova, de Ruyter, Huang, Meuter, & Challagalla, 2017). Specifically, the 24/7 availability of a robot would be able to cope with more diverse orders requested by consumers. Recognizing that tourism involves the mobility of international travelers, robots (e.g., artificial intelligence-enabled chatbots) offer the substantial potential benefit of alleviating language barriers in contrast to the limited language skills of staff (Ivanov & Webster, 2018). Besides the functional aspects of the robots, it is possible to provide additional fun and entertainment through various multimedia on the service robots during the service delivery process. These features of service robots are capable of addressing travelers' multi-information needs which, in turn, assists all stages of information-processing (Vogt & Fesenmaier, 1998). Indeed, interactive ways of service delivery, communication, and engagement with consumers, as provided by service robots, would ultimately enhance the perceived service quality (Kuo, Chen, & Tseng, 2017).

2.2. Trust in Human-Robot Interactions

Trust can be defined as "the attitude that an agent will help achieve an individual's goals in a situation characterized by uncertainty and vulnerability" (Lee & See, 2004, pp. 51). The foundation of trust can be regarded as a set of attributional abstractions (trust dimensions) that include the trustee's competence (i.e., service robots in this study) to achieve its intentions (Lewis, Sycara, & Walker, 2018).

There have been a number of tourism studies assessing the role of trust in various online platforms. For example, trust is an antecedent of e-loyalty and a consequence of navigational functionality, perceived security and satisfaction in online shopping for tourism products (Kim, Chung, & Lee, 2011). Filieri, Alguezaui, and McLeay (2015) investigated trust in consumer review websites (e.g., TripAdvisor) adopting the trust-building model developed by Beldad, De Jong, and Steehouder (2010) that suggests antecedents of trust including customer-based, website-based and organization/company-based antecedents. The importance of trust was discussed in the context of a peer-to-peer accommodation website. Ert, Fleischer, and Magen (2016) suggested the role of host's profile photos to generate trustworthiness in Airbnb. Built on technology adoption model, the study of Kaushik, Agrawal, and Rahman (2015) proposed a behavioral model to explain a self-service hotel technology adoption. They estimated a unidimensional construct of trust affecting attitude and intention toward adoption.

A review of the theoretical foundations of trust in information technology artifacts reveals that there are apparently two main classes. On the one hand, one widely-applied definition of trust proposed by Mayer et al. (1995) considers it as an intention to act. The approach by these authors suggests three dimensions—ability, benevolence, and integrity—built on management discipline, which focuses on trust between individuals, groups of people, or organizations. It has been considered to be a suitable concept for coping with different kinds of information technology-mediated relationships between people, for instance, in the context of e-commerce (Kim, Ferrin, & Rao, 2008) and virtual communities (Lu, Zhao, & Wang, 2010). Importantly, however, the findings of this information system research suggest that information technology artifacts not only play a role in the communication methods mediating between people and organizations, but also act as tools offering recommendations with the increase of automation. This means that the information technology artifact (i.e., service robot) takes on the role of trustee itself in a relationship between a user and an information technology artifact, involving a direct interaction. This argument is associated with the notion of human-computer interactions, arguing that human treat computers as social actors (Limerick, Coyle, & Moore, 2014). Indeed, people join relationships with information technology artifacts and respond to them in a manner equivalent to their reactions to other people (Nass & Moon, 2000). According to human-robot interaction, robots installed in the transition from a simple tool to teammate as coworker require more interactions akin to human-human teamwork (Lewis et al., 2018). The human is the trustor, and the robot is the trustee. Along with Barber’s (1983) trust model, suggesting persistence, technical competency, and responsibility between human and machine, this notion has been convergent with three dimensions of trust: performance, process, and purpose (Lee & Moray, 1992; Lee & See, 2004). The advantage of the theoretical foundation of this trust concept is that it originated in the study of trust relationships between humans and automated systems (Söllner & Pavlou, 2016), which are based on two propositions: (a) the automated systems (or service robots) take the role of trustee in the trust relationship, and (b) the automated systems (or service robots) are a means to support users in achieving their goals (Söllner, Hoffmann, Hoffmann, Wacker, & Leimeister, 2012). A brief discussion on the three dimensions of trust follows (Lee & Moray, 1992; Lee & See, 2004).

Performance refers to the past and present operations of service robots, reflecting their characteristics, including reliability, predictability, and ability. Indeed, the performance dimension illustrates *what* the robots do, which refers to their capability or competency to achieve the user's goals. As their performance is associated with functional achievement, it is attributed to the task- and situation-dependent nature of trust. *Process* indicates the degree to which the robot's algorithms are proper for coping with certain situations. The process dimension hence depicts *how* the service robots operate. Linking to interpersonal relationships, this is compatible with the consistency of actions (Mayer et al., 1995). Indeed, the process focuses on trust toward the agent (or service robot itself) rather than certain actions of the agent. In this sense, process is comparable to integrity, confidentiality and sincerity (Butler Jr & Cantrell, 1984; Moorman, Deshpande, & Zaltman, 1993). *Purpose* refers to the degree to which the service robot is being used in the domain of the designer's intent (similar to benevolence and concern). The purpose dimension refers to *why* the service robot was developed, which is associated with faith and benevolence with regard to interpersonal trust.

2.3 Trust Model of Service Robots

According to an interdisciplinary model of trust in e-commerce proposed by McKnight and Chervany (2000), there are sequential constructs showing a linear relationship including institution-based trust, trusting beliefs, and trusting intention. Trusting beliefs refer to one believing that the other party has characteristics beneficial to him or herself (McKnight & Chervany, 2001). Indeed, trusting beliefs is not an expectation but rather a cognitive belief reflecting interactions between people and cognitive/affective components. This idea is salient to the trust of service robots discussed above. A traveler can form a cognitive belief from his/her interaction with service robots.

McKnight and Chervany (2001) argued that institutional trust focusing on situation or structures affects trusting beliefs. Institutional-based trust means that one believes that favorable conditions (e.g., legal, regulatory, business, and technical environment in e-commerce) are in place that are beneficial to situational success (e.g., successful online transaction). This construct comes from the tradition in sociology in which people can count on others because of structures, situations, or roles that ensure things will go well. Institutional trust consists of structural assurance and situational normality (Wingreen, Mazey, Baglione, & Storholm, 2018).

Structural assurance refers to one's belief that structures such as guarantees, regulations, legal sources, or other procedures engender perceived trust toward an object, which ultimately anticipates a successful result (McKnight et al., 2002). Structural assurance in this study indicates the extent to which one believes legal and technological safeguards protect one from privacy loss and make it safe to use autonomous technology (McKnight & Chervany, 2001). Autonomous intelligence is part of self-service technologies that embody advanced analytical computation. Hence, one who has a high level of structural assurance in tourism technology would be more likely to rely on service robots due to the secure feeling structural assurance engenders (Wang, Ngamsiriudom, & Hsieh, 2015).

Hypothesis 1: Structural assurance positively affects trust beliefs consisting of performance, process and purpose.

Situational normality refers to the certain environment in which users perceive the situation approaching a new technology as normal and favorable (Lewis & Weigert, 1985; Wingreen et al., 2018). Service robots in tourism is still an uncertain context, in which evidence to reinforce trusting beliefs is limited. In this line, familiarity and previous experience in adapting to automatic technology generates an environment in which interacting with service robots is appropriate, well-observed, and favorable for tourism services.

Hypothesis 2: Situational normality positively affects trust beliefs consisting of performance, process and purpose.

Trusting beliefs, reflecting trust in service robots, leads to trusting intention, as trust can decrease the transaction cost in the interactions between autonomous technology and users (McKnight & Chervany, 2001). Consistently, the theory of planned action (Madden, Ellen, & Ajzen, 1992) supports the idea that beliefs are directly associated with corresponding intentions. Thus, it can be proposed that a perception of travelers' trust in service robots will bring about the intention to purchase the travel products associated with the autonomous robots.

Hypothesis 3: Trust beliefs positively affects a behavioral intention to purchase tourism products served by service robots.

In summary, based on reviewing literature on trust in information technology and tourism, it is found that scholars have mainly discussed trust in online shopping, social media and peer-to-peer accommodation websites. However, the research to understand trust in service robots is still limited. Taking into account features of service robots comparing to other information technology artifacts – autonomy, this study adopts a notion of human-robot interaction to propose trust in service robots. Indeed, service robots take on the role of trustee itself in a relationship between a user and the robot. Accordingly, according to trust in automation (Lee & See, 2004), this study proposes the multidimensional trust in tourism service robots consisting of performance, process, and purpose (i.e., Study 1). In addition to understanding the structure of multifaceted trust in service robots, this study tests a trust model that assesses the relationship of trust beliefs to structural assurance and situational normality as well as a behavioral intention (i.e., Study 2) (McKnight & Chervany, 2001).

3. Study 1: Service Robots in the Restaurant Context

The purpose of Study 1 is to test a second-order formative construct of trust in service robots, comprising three sub-constructs such as performance, process and purpose. A number of validity estimations including nomological validity with other psychographic variables are conducted to assess the structure of a trust construct.

3.1 Method of Study 1

Following the study of MacKenzie, Podsakoff, and Podsakoff (2011), which presents a comprehensive approach to conceptualization, measurement development, and validation estimation, this study synthesized the literature on measurement development for the trust construct in information technology and tourism and integrated a set of methodological strategies to validate the construct; essentially, a three-step validation procedure including construct definition, initial measurement development, and refinement/validation of the measurement (see alsoHoehle & Venkatesh, 2015). First, the researcher systematically reviewed and analyzed the trust construct for autonomous intelligence and service robots, as well as human-robot interactions (e.g., Hancock, Billings, & Schaefer, 2011). Once a definition of trust was formulated, the items were created (MacKenzie et al., 2011). Building on trust beliefs that comprise three dimensions, performance, process, and purpose (Lee & See, 2004), the researcher searched the extant literature to identify items that may be related to this research. As a result, a set of multiple survey questions representing performance, process, and purpose, was developed (Lee & See, 2004; Söllner et al., 2012; Söllner & Pavlou, 2016). Next, the face validity of the items was checked, mainly to assess their simplicity and wording. Total four participants including academic experts and doctoral students in the area of information technology and tourism were asked to examine the items and provide their comments on the clarity of the measurements. As a result, revisions of questionnaire statements have been revised.

The next step was to specify the measurement model, assessing how the indicators were associated with the corresponding constructs and exploring the relationships between relevant and higher-order constructs. In addition to measurement of the trust construct, the psychometric properties of the scales, including their convergent, discriminant, and nomological validity, were determined. The online questionnaire was then distributed via Amazon Mechanical Turk, targeting travelers residing in the United States. The respondents were presented with two images of the service robots and a video depicting a robot at work: Pepper serving a female guest for ordering and payment at a restaurant (see Figure 2). There were a total of 202 valid responses to the inquiry.

[Please insert Figure 2 about here]

The respondents were then asked to complete the questionnaire regarding trust in service robots (Lee & See, 2004; Söllner et al., 2012), measured by a 5-point Likert scale. Subsequently, three psychometric constructs, including perceived risk (Pavlou & Gefen, 2004) as well as a behavioral intention to use the service robots were collected to test the nomological network. Specifically, perceived risk can be defined as "the expectation of losses associated with purchase and acts as an inhibitor to purchase behavior" (Peter & Ryan, 1976, p. 185), associated with the evaluation of the products/services along with the cost-benefit relationships. In the service environment, consumers would be hesitant to adopt a new service technology when risk is involved. Accordingly, the negative relationship between perceived risk and trust has been confirmed in online shopping and mobile services in tourism (Park & Tussyadiah, 2017). Built on the study by Gefen (2002b), it can be expected that a traveler who has high trust in a service robot is easily engaged with the technology and are willing to adopt it. Thus, the two items reflecting a behavioral intention have been assessed to test the nomological validity of the proposed multidimensional trust in service robots.

3.2. Result of Study 1

Profiles of the respondents show approximately 64% of male, 77% of ages below 35 years, 40% of bachelor degree and approximately 70% of annual income less than US$60,000. When estimating normality of the data distribution, a tolerable concern was observed based upon threshold of skewness and kurtosis tests as ± 2 (Gravetter & Wallnau, 2016). A series of partial least square analyses was used to test a higher-order formative models of trust comprising three first-order reflective constructs, such as performance, process, and purpose. Dealing with a multidimensional latent construct, it is suggested to distinguish between two stages of analysis; one stage relating manifest indicators to first-order dimensions, and a second stage associating the individual dimensions to the second-order latent construct (Hoehle & Venkatesh, 2015). In validating measurement of first-order constructs by confirmatory factor analysis, it is shown that all of loading are greater than 0.60.

The values are then compared with other constructs to assess discriminant validity. The results show that average variances extracted (the mean-squared loading for each construct) are larger than the cross-correlations of other constructs, which suggests that the individual reflective construct is distinct from other constructs in the measurement model. The squared average variances extracted of each trust construct are also over 0.75, demonstrating that the latent variables explain its indicators more than the error variance, confirming convergent validity (see Table 1).

[Please insert Table 1 about here]

The correlation result was checked and that there was limited concern on collinearity between constructs. Composite reliability presents acceptable values: performance (0.87), process (0.81), and purpose (0.82) (see Table 1). These results confirm adequate convergent and discriminant validity of the first-order constructs. The second-order formative models were, then, built upon multidimensional constructs because first-order factors represent theoretically different aspects of the second-order construct (see Figure 3). Based upon Lee and See (2004)'s suggestion, each dimension reflects different functions of the service robots (Söllner et al., 2012). Hypothetically, a construct of the trust does not necessarily interrelate to another construct among three dimensions, which signifies the foundation of formative model.

To verify the validity of the formative constructs, the multicollinearity issue was first considered by checking correlations and variance inflation factors with threshold as 3.0. The statistical results of variance inflation factors for individual constructs are below 3.0, such as performance (1.83), process (1.92), and purpose (2.09). Additionally, this study performed a multitrait-multimethod analysis that assesses whether the items utilized to measure each latent construct are more highly correlated with their own second-order construct than all other variables (see Appendix 1). Based on the study of Henseler, Ringle, and Sarstedt (2015), this research tested heterotrait-monotrait ratio of correlations that assesses the average of monotrait-heteromethod correlations (i.e., the correlations of indicators within the corresponding constructs) relative to the average of heterotrait-heteromethod correlations (i.e., the correlations of indicators across constructs reflecting other constructs). The results present that all of the values are below cut-off, 0.90 (see Appendix 2).

As a result, the performance construct (b = 0.44, $p < 0.001$) shows the most critical dimension to define trust in service robots, followed by purpose (b = 0.41, $p < 0.001$) and process (b = 0.35, $p < 0.001$). Last, a redundancy analysis was used to assess the quality of the formative measurement model of trust in service robots (Cenfetelli & Bassellier, 2009) by estimating a correlation value with a unidimensional trust with a reflective model (Gefen, 2002a). As shown at Figure 2, a newly proposed formative model of trust in service robots is highly correlated to a reflectively measured operationalization of service robots (r = 0.75, $p < 0.001$).

[Please insert Figure 3 about here]

In order to test nomological validity, this research examined whether trust is a predictor of travelers' willingness to use the service robots at restaurants as well as relates to another individual factor (i.e., perceived risk) (McKnight et al., 2002). The structural model revealed that perceived risk marginally relates with trust in a negative way (b = -0.13, $p < 0.10$) As expected, the trust of service robots has a positive influence on a behavioral intention (b = 0.61, $p < 0.001$, $R^2 = 0.37$) (see Figure 4).

[Please insert Figure 4 about here]

Podsakoff, MacKenzie, Lee, and Podsakoff (2003) suggest that common method bias tends to be more evident in studies where data for exogenous and endogenous variables are collected from the same respondents using the same items with similar characteristics of instruments. Hence, this research performed two steps to test the potential errors in the model. First, Harman's single-factor test was employed by emerging single factors from exploratory factor analysis. The unrotated principal components analysis (considering the structural model used for the test of a nomogical validity) including eleven factors counts for 28.48% of the total variance, below the cut-off value of 50%. Second, looking at the correlation matrix (see Table 1), there was no extremely high value: r > 0.90. Therefore, the results of two different estimations to test common method bias reveal limited common method errors in the analytical model.

4. Study 2: Service Robots in the Accommodation Context

The main purpose of Study 2 is to assess the trust model reflecting a sequential process of trust formation considering institution-based trust, trust beliefs and trusting intention by testing the three proposed hypotheses. Besides, the multifaceted trust in service robots derived from Study 1 is verified in a different tourism context.

4.1 Method of Study 2

Once the measurements of trust in service robots were pretested and refined, additional data from a new group of participants were obtained to reexamine the derived scales as well as to verify the findings of Study 1—and thus enhance generalizability of the results (MacKenzie et al., 2011). This step is crucial for evaluating the extent to which psychometric properties of the scale have been derived from idiosyncrasies in the sample of data and certifying the statistics test of the proposed model. The second purpose of Study 2 was to estimate the proposed relationships of the trust model, including institution-based trust, trusting beliefs, and a behavioral intention. To address this objective, scales in the survey describing the service setting of accommodations were reworded. As well, the stimuli incorporated newly designed images and videos portraying the humanoid robot at work, for example, an NAO robot serving a female guest checking in at the front desk (EARS, 2015; see Figure 5).

[Please insert Figure 5 about here]

The instruments of institution-based trust, including structural assurance (e.g., “I feel okay using self-service or automated technologies because they are backed by vendor protections”) and situational normality (e.g., “It appears that things will be fine when I utilize self-service or automated technologies”) were adopted from Gefen, Karahanna, and Straub (2003), Mcknight, Carter, Thatcher, and Clay (2011) and See-To and Ho (2014). In the methodology of both sets of authors, after participants were exposed to images and a video of hotel service robots, four items of a behavioral intention were presented for them to answer (e.g., "how likely is it that you will recommend these hotels to someone who seeks your advice?" and "how likely is it that you will encourage friends and relatives to book these hotels?") (McKnight et al., 2002).

The online survey was then distributed to American travelers via Amazon Mechanical Turk; a total of 406 valid responses to the data were obtained. With regard to data analysis, the approaches employed in Study 1 (e.g., a series of partial least square analysis for testing first and second-order measurement models) were employed at first. Then, the structural model to test the proposed hypotheses reflecting trust model was estimated by a partial least square analysis method.

4.2. Results of Study 2

It shows that male (65.8%) is more than female (34.2%), and approximately 67% of respondents are 34 years or younger. Around 45% of respondents have a bachelor's degree and approximately 70% of subjects appeared the annual household income less than US$ 60,000. Initially, the normality of the data distribution has been checked based upon the cut-off as a skewness value of ± 2. There was no item showing it over threshold. A partial least square analysis was, then, used to examine the constructs of trust in service robots, and nomological validity of the artificial intelligence trust with other related constructs such as perceived risk and behavioral intention to use it.

A confirmatory factor analysis was conducted to estimate the measurement model for understanding the structures of first-order constructs. The results of confirmatory factor analysis are consistent to ones of the first study. Indeed, the factor loadings of items in each construct are over cut-off, 0.60. In terms of discriminant validity, average variances extracted of the focal constructs are larger than the cross-correlations of other constructs and the squared average variance extracted of each trust construct is over 0.75 as well. Next, the correlation result was checked to assess potentials of collinearity between constructs, and that it shows less concern on the issue. Thus, these results confirm convergent and discriminant validity of the first-order constructs (see Table 2).

[Please insert Table 2 about here]

The second-order formative models of trust in service robots were, then, developed by multidimensional constructs following the Study 1. Four types of validity estimations were conducted including (1) variance inflation factor test (2) multitrait-multimethod matrix analysis (see Appendix 3) (3) redundancy analysis and (4) heterotrait-monotrait test (see Appendix 4). The results of VIF test were satisfactory by showing values – performance (1.91), process (1.74), and purpose (2.17). Figure 6 presents that the performance is the most critical factor explaining trust in service robots (b = 0.40, $p < 0.001$), followed by purpose (b = 0.38, $p < 0.001$) and process (b = 0.38, $p < 0.001$). It is shown that the heterotrait-monotrait value between purpose and performance places on the cut-off value as 0.90. This study, nevertheless, argues that the constructs between purpose and performance are distinctively validated based on other additional estimations including Fornell-Larcker criterion, heterotrait-monotrait analysis, and variance inflation factor. In the redundancy analysis, a benchmark construct of a reflectively operationalized trust is strongly correlated to the trust in service robots comprising performance, purpose and process (r = 0.81).

[Please insert Figure 6 about here]

A following analysis tests the proposed relationships of trust in service robots (see Figure 7). Two constructs of institution-based trust including structural assurance (b = 0.43, $p < 0.001$) and situational normality (b = 0.33, $p < 0.001$) have positive influences on trust in service robots, which ultimately affect intention to book the hotels adopting service robots (b = 0.76, $p < 0.001$, $R^2 = 0.58$). Furthermore, several model fits in PLS estimations reinforced the statistical results. VIFs of both structural assurance and situational normality are below cut-off values as 1.60, respectively. Standardized Root Mean Square Residual (0.03) and Normed Fit Index (0.99) meet the certain threshold as Standardized Root Mean Square Residual < 0.08 and Normed Fit Index > 0.90 (Hair, Hult, Ringle, & Sarstedt, 2016). Thus, the statistical results accept all three hypotheses.

[Please insert Figure 7 about here]

In order to test the common method error, a couple of estimations have been checked. There was no correlation value over 0.90. Checking Harman's single factor analysis with unrotated principal component analysis, the total variance explained with all the items assessed in the nomological test shows 47.58%, which is below the cut-off. These results suggest limited concerns of common method bias in this study.

5. Discussion and Conclusions

With the rapid technological innovation of artificial intelligence and autonomous technology, this study suggests a conceptualization of trust in intelligent service robots in the tourism context, and offers a reliable and valid construct to describe that trust. Indeed, this research provides detailed insights into the factors associated with a multidimensional structure of trust, rather than a single dimensional approach. It also delineates a comprehensive trust model in service robots.

Specifically, Study 1 identified that the perceived trust in service robots at a setting of order and payment at a restaurant comprises three dimensions: performance, process, and purpose (Lee & See, 2004; Söllner et al., 2012). The findings of Study 1 suggest a higher-order formative model of the trust concept, showing that the performance construct is the most influential dimension, followed by purpose and process. Other than a series of estimations of the convergent validity, the results of the nomological validity test reveal that perceived risk and a behavioral intention to use the service robot, are significantly related to the proposed trust construct, in line with extant tourism studies (e.g., Islam & Rahman, 2016; Park & Tussyadiah, 2017).

Study 2 reinforces the findings of Study 1. The results demonstrate the second-order formative structure of trust consisting of performance, process and purpose in the context of accommodation. More importantly, based upon the interdisciplinary trust model, this study identified the linear relationships of multidimensional trust in service robots (i.e., trusting beliefs) to institution-based trust and a behavioral intention to purchase the tourism services. More specifically, both structural and situational normality positively affect trust in service robots that ultimately leads to an intention to stay at the hotel.

As a result, this paper addresses theoretical and practical implications in tourism. In terms of its academic contribution, this study attempts to not only define a notion of trust in tourism service robots, but also propose multidimensional constructs of it. A recent study of Tussyadiah et al (2019) that propose trust in intelligent robots suggests three constructs including functionality, helpfulness, and reliability on the basis of McKnight's trust in a specific technology. This research, however, provides empirical evidence to propose a formative model containing three sub-dimensions that focuses on trust in automation (see Lee & See, 2004) as a key feature of service robots: performance, process, and purpose. The multidimensional trust model in tourism service robots theoretically reflects *what* the robots do (performance), *how* the service robots operate (process) and *why* the service robot is developed (purpose). Importantly, the consistent weights of the foregoing three dimensions have been identified between two different settings of tourism services environments i.e., a restaurant and accommodation.

Considering extant tourism literature on trust in information technology, most of studies have proposed a unidimensional construct of trust (e.g., Kaushik et al., 2015; Kim et al., 2011). This study, however, suggests a comprehensive understanding of perceived trust in tourism service robots, including not only capability of the service robots but also predictability/understandability of the robots and benevolence of a robot developer. These findings develop the knowledge in the trust literature regarding tourism and information technology. It is shown that the extant tourism studies investigating online technology/platforms (Kim et al., 2011; Ponte, Carvajal-Trujillo, & Escobar-Rodr ǵuez, 2015) have regarded IT as a mediator facilitating communication between people or groups of organizations. In this vein, a concept of interpersonal trust proposed by Mayer et al. (1995) has frequently been cited and employed as a means of understanding trust in information technology. However, this research suggests an understanding of perceived trust that is essentially related to human-robot interaction from the perspective of tourism services, considering the service robots as the trustee itself. This study also suggests a second-order formative structure of trust construct based upon theoretical insights on trust in automated technology (Lee & Moray, 1992). As part of methodological contributions, the assessment of a measurement model satisfies the guidelines of Cenfetelli and Bassellier (2009) for testing a valid and reliable formative construct, such as redundancy analysis.

Furthermore, by applying a trust model in information systems (McKnight et al., 2002), this study reveals the associations of multifaceted trust in tourism service robots with trust constructs, as refer to situational characteristics (institution-based trust) and trust outcome (a behavioral intention). This finding highlights the importance of the development of service robots itself as well as the environment in which travelers interface with the automated technology.

With respect to management, there are several implications of the findings that bear on design requirements for employing service robots in the tourism and hospitality industries. It is important to ensure the capability of the robots to perform their functions in a proper manner. More specifically, the service robots should be able to provide accurate and up-to-date information for consumers; this improves their perceived reliability. With regard to process, robot designers are required to consider data integrity and confidentiality. Along with a desire for continuous development of technology, current consumers have been found to be sensitive to privacy and security issues relative to their personal data (King & Raja, 2012). In this sense, it is important for robot developers, as well as service operators who install the robots, to clearly inform consumers about a strict policy for data security. From the purpose perspective, robot designers and hospitality operators are required to make clear the key benefits of adopting the service robots for consumers. One of vital purposes to adopt service robots is to enhance consumer experiences by offering more personalized information as well as services, based on the benevolence and reliability of the service robots. As a result, people can come to trust tourism service robots and develop a high degree of willingness to use such systems in service settings.

While this paper provides a number of important implications, there are some limitations that future research can address. This research used two types of methodological stimuli—images and a video—to allow the respondents to have a second-hand interaction. In order to enhance the human-robot interaction environment, it is suggested that future studies design the actual service settings and obtain accounts of personal experiences with the service robots. Information technology literature has suggested the importance of applying longitudinal research design, given that trust is not only about a single time interaction, but also further develops as interactions occur (Gefen, Benbasat, & Pavlou, 2008). The longitudinal approach would enable researchers to understand how people acquire and deepen trust of new information technology artifacts and how changes occur to the structure of that trust over time (MacKay & Vogt, 2012; Zahedi & Song, 2008). It has been suggested that anthropomorphism of service robots is a key aspect affecting perceived trust in a service robot and consequently leading to a behavioral intention to use the service robot (Murphy et al., 2017). Thus, this study recommends future researchers to take into consideration the shapes of service robots to better understand user experience.

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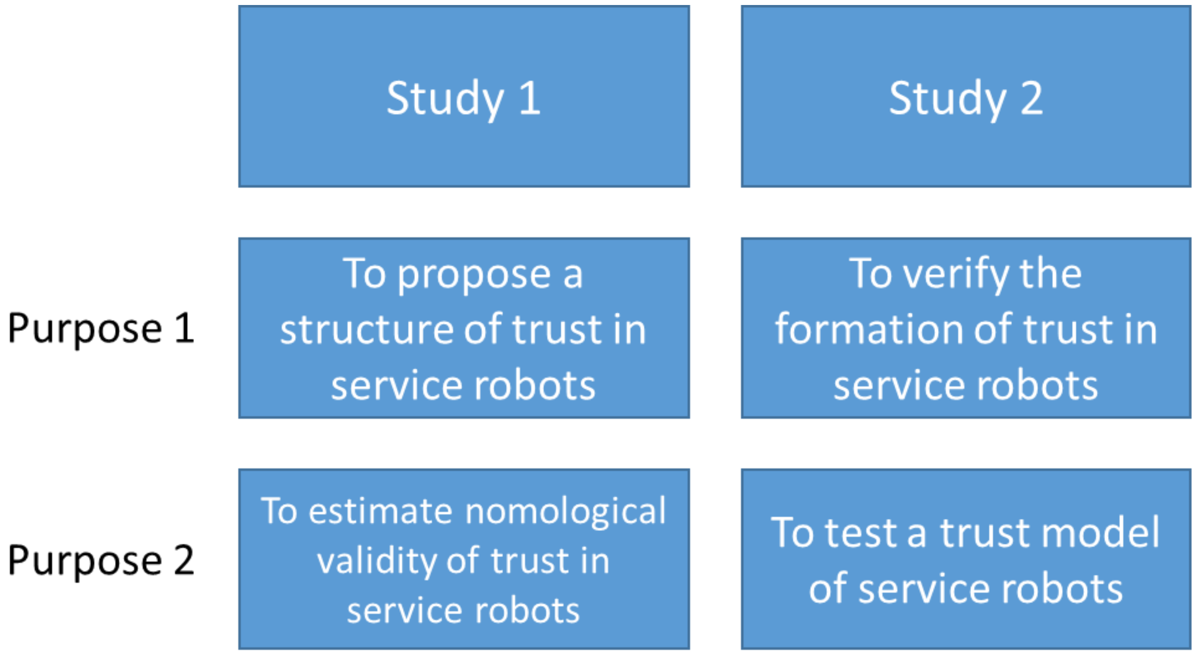


Figure 1. Research Framework

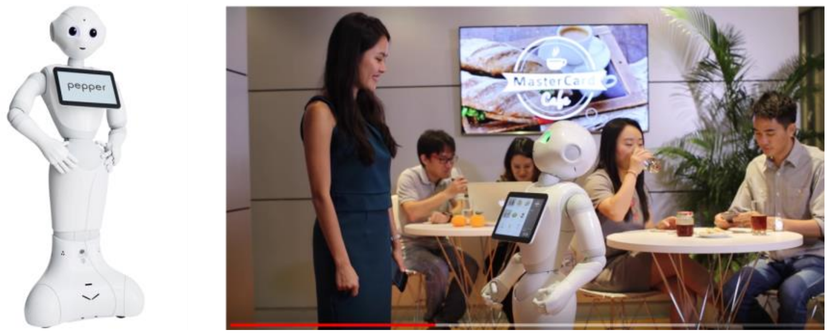
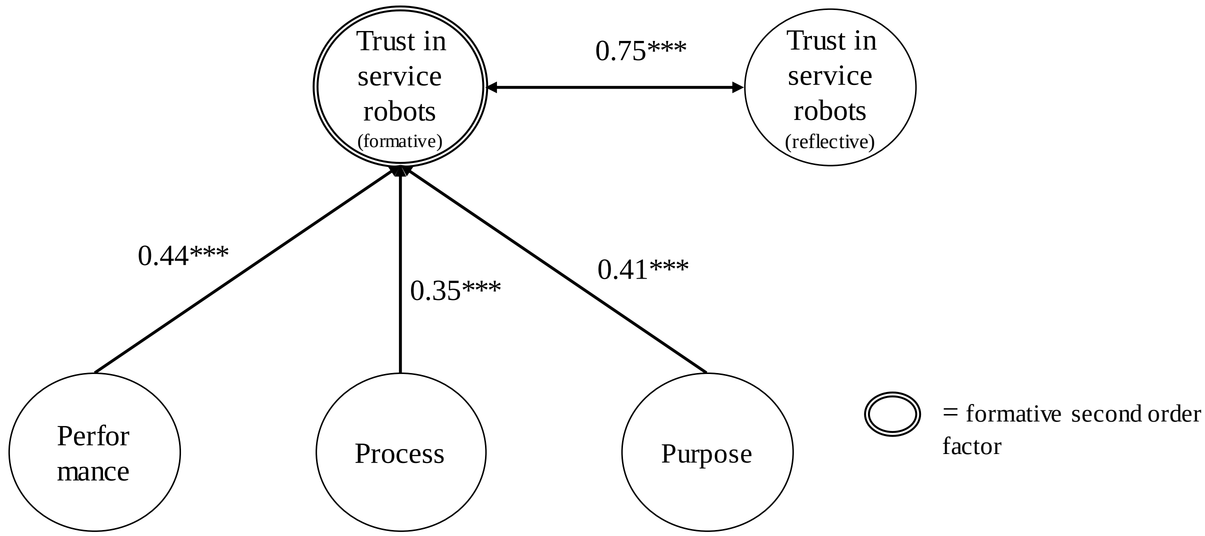
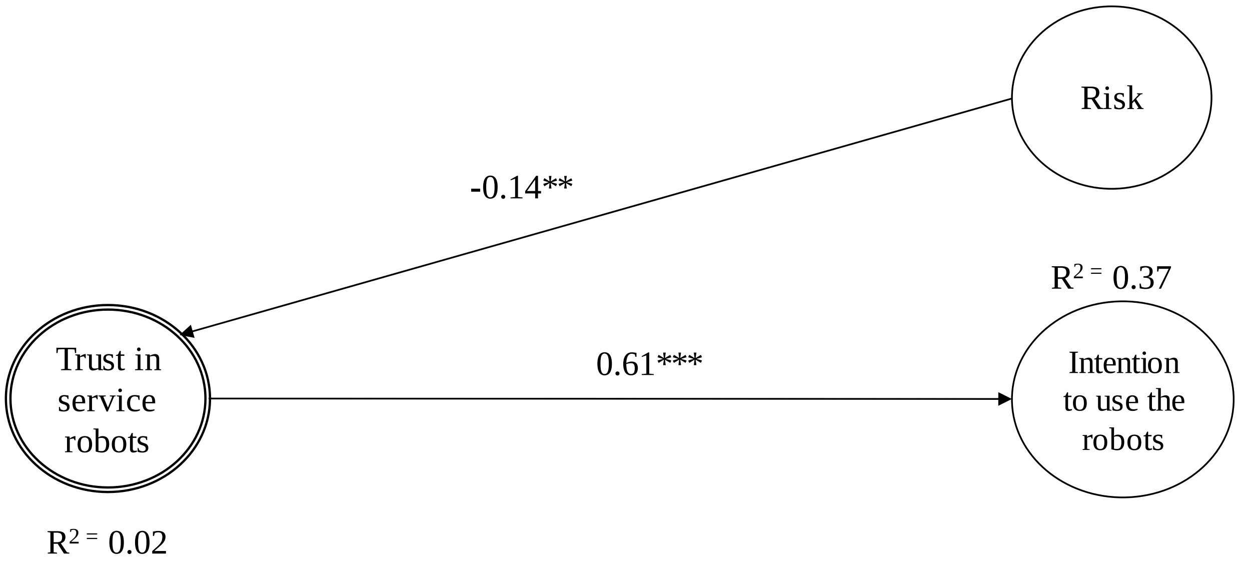


Figure 2. Examples for Study 1 with a Peper Robot



Note: Weights of three first-order factors affecting a higher-order latent variable (trust in service robots) were derived using a principal components factor analysis in PLS; ****p* < 0.001

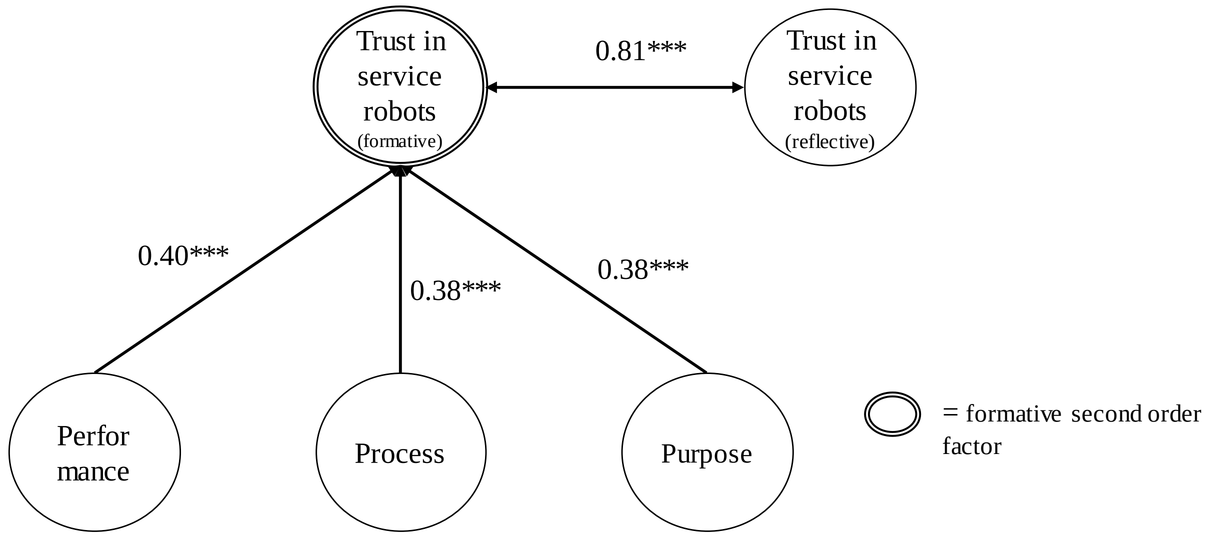
Figure 3. Testing of a Formative Model of Trust in Service Robots with a Pepper Robot in a Restaurant



Note: **p < 0.01, ***p < 0.001

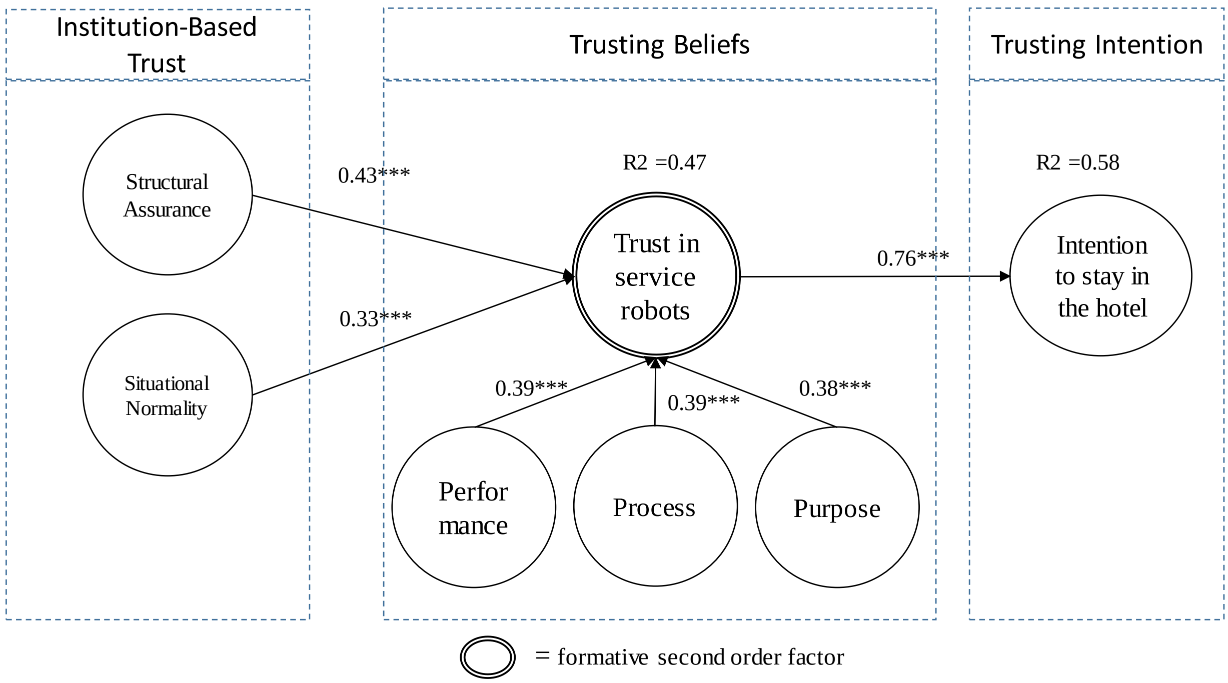
Figure 4. Nomological Validity of Trust in Service Robots with a Pepper Robot

Figure 5. Examples for Study 2 with a NAO Robot



Note: Weights of three first-order factors affecting a higher-order latent variable (trust in service robots) were derived using a principal components factor analysis in PLS; ***p < 0.001

Figure 6. Testing of a Formative Model of Trust in Service Robots with a NAO Robot in a Hotel



Note: ***p < 0.001

Figure 7. Testing Relationships of Trust Model in Study 2

Table 1. Latent Correlation Analysis of Study 1

	CA	CR	1	2	3	4	5
1. Performance	0.78	0.87	**0.83**				
2. Process	0.64	0.81	0.42	**0.76**			
3. Purpose	0.66	0.82	0.63	0.54	**0.77**		
4. Risk	0.95	0.92	-0.22	0.05	-0.16	**0.90**	
5. Behavioral intention	0.88	0.93	0.41	0.56	0.53	-0.02	**0.90**

Note: CA refers to Cronbach's Alpha; CR refers to composite reliability; Items on the diagonal (in bold) represent AVE scores

Table 2. Latent Correlation Analysis of Study 2

	CA	CR	1	2	3	4	5	6
1. Performance	0.75	0.86	**0.82**					
2. Process	0.71	0.84	0.56	**0.80**				
3. Purpose	0.70	0.83	0.67	0.63	**0.79**			
4. Normality	0.87	0.90	0.58	0.46	0.50	**0.84**		
5. Assurance	0.86	0.91	0.53	0.57	0.53	0.62	**0.84**	
6. Behavioral intention	0.89	0.93	0.62	0.67	0.67	0.48	0.57	**0.91**

Note: CA refers to Cronbach's Alpha; CR refers to composite reliability; Items on the diagonal (in bold) represent AVE scores

Appendix 1. Results of Confirmatory Factor Analysis – Study 1

	Performance	Process	Purpose	Trust in robots	Risk	Intention
Performance _1	**0.81**	0.35	0.54	0.70	-0.18	0.33
Performance _2	**0.82**	0.36	0.52	0.69	-0.16	0.35
Performance _3	**0.86**	0.32	0.52	0.70	-0.21	0.34
Process_1	0.27	**0.78**	0.38	0.56	0.02	0.45
Process_2	0.43	**0.70**	0.45	0.62	0.00	0.37
Process_3	0.24	**0.81**	0.40	0.57	0.10	0.47
Purpose_1	0.46	0.35	**0.73**	0.62	-0.09	0.27
Purpose_2	0.56	0.46	**0.80**	0.73	-0.18	0.43
Purpose_3	0.44	0.44	**0.78**	0.68	-0.08	0.53
Risk_1	-0.11	0.09	-0.14	-0.07	**0.84**	-0.02
Risk_2	-0.18	0.05	-0.13	-0.11	**0.90**	0.01
Risk_3	-0.26	0.02	-0.15	-0.16	**0.94**	-0.03
Intention_1	0.49	0.49	0.53	0.61	-0.06	**0.90**
Intention_2	0.31	0.54	0.48	0.53	0.04	**0.88**
Intention_3	0.26	0.49	0.40	0.46	-0.02	**0.91**

Appendix 2. Study 1 - HTMT Results

	Behavioral intention	Performance	Process	Purpose	Risk
Behavioral intention					
Performance	0.48				
Process	0.75	0.58			
Purpose	0.68	0.88	0.82		
Risk	0.05	0.24	0.11	0.20	

Appendix 3 Results of Confirmatory Factor Analysis – Study 2

	Performance	Process	Purpose	Trust in robots	Assurance	Normality	Intention
Performance _1	**0.79**	0.51	0.54	0.72	0.44	0.47	0.55
Performance _2	**0.82**	0.42	0.53	0.69	0.45	0.46	0.46
Performance _3	**0.84**	0.43	0.56	0.71	0.41	0.49	0.49
Process_1	0.45	**0.85**	0.51	0.70	0.47	0.33	0.57
Process_2	0.45	**0.72**	0.46	0.62	0.43	0.41	0.44
Process_3	0.43	**0.82**	0.53	0.69	0.48	0.36	0.59
Purpose_1	0.49	0.49	**0.79**	0.68	0.42	0.38	0.45
Purpose_2	0.47	0.34	**0.73**	0.59	0.35	0.33	0.37
Purpose_3	0.60	0.62	**0.84**	0.80	0.47	0.46	0.73
Assurance_1	0.46	0.46	0.42	0.52	**0.81**	0.56	0.45
Assurance_2	0.48	0.50	0.50	0.57	**0.85**	0.53	0.53
Assurance_3	0.43	0.51	0.42	0.53	**0.85**	0.48	0.48
Assurance_4	0.42	0.45	0.44	0.51	**0.85**	0.51	0.44
Normality_1	0.51	0.36	0.41	0.49	0.50	**0.83**	0.36
Normality_2	0.49	0.40	0.43	0.51	0.53	**0.85**	0.44
Normality_3	0.47	0.40	0.37	0.48	0.51	**0.83**	0.45
Normality_4	0.46	0.39	0.46	0.51	0.53	**0.84**	0.37
Intention_1	0.54	0.61	0.60	0.68	0.49	0.41	**0.90**
Intention_2	0.57	0.60	0.61	0.69	0.53	0.44	**0.90**
Intention_3	0.56	0.61	0.62	0.69	0.52	0.46	**0.91**

Appendix 4. Study 2 - HTMT Results

	Assurance	Intention	Normalit y	Performanc e	Process	Purpose
Assurance						
Intention	0.65					
Normality	0.72	0.55				
Performance	0.66	0.75	0.72			
Process	0.73	0.84	0.59	0.76		
Purpose	0.67	0.83	0.63	0.90	0.87	

Appendix 5. Survey Items

Study 1		
Measurement items	Mean	Standard deviation
Trust in Service Robots (formative) (Lee & See, 2004; Söllner, et al., 2012)		
Performance		
Pepper Robot has all functionalities needed to fulfill its goal.	4.10	0.95
I can count on the information provided by Pepper Robot to be accurate.	4.07	0.95
I can rely on Pepper Robot to order menu and payment in the restaurant.	4.13	0.83
Process		
I think that no one can pretend to be me within the process of order-and-payment at the restaurant via Pepper Robot.	3.49	1.13
I understand how Pepper Robot works.	4.04	0.91
I think that Pepper Robot does not change or use my data for other purposes without being noticed.	3.57	1.11
Purpose		
I think that my personal data is used for delivering the services Pepper Robot offers.	3.98	0.81
I think that the designers of Pepper Robot want to help me for order-and-payment at the restaurant.	4.06	0.87
I think Pepper Robot will be a useful for managing restaurant guest experiences in the future.	4.11	0.97
Trust in Service Robots (reflective model for redundancy analysis) (Gefen, 2002)		
Pepper Robot is trustworthy.	3.95	0.86
I have a good feeling when relying on Pepper Robot.	4.03	0.96
I can trust the information presented by Pepper Robot.	4.15	0.81
Engagement (De Graaf & Allouch, 2013)		
I feel emotionally connected to Pepper Robot.	3.15	1.31
Pepper Robot is very dear to me.	3.19	1.42
I have a bond with Pepper Robot.	3.11	1.36
I am very attached to Pepper Robot.	3.04	1.36
Pepper Robot has a special place in my restaurant experiences.	3.28	1.35
Pepper Robot means a lot to me.	3.08	1.42
Risk (Pavlou & Gefen, 2004)		
There is a considerable risk involved in interacting with Pepper Robot.	3.00	1.19

There is a high potential for loss involved in interacting with Pepper Robot.	3.01	1.21
My decision of the order-and-payment with the Pepper Robot is risky.	3.10	1.32
Behavioral intention to book the accommodation (Heerink, Kröse, Evers, & Wielinga, 2010)		
I'm thinking of using the robot when visiting these restaurants.	3.70	1.11
I am planning to use the robot when visiting these restaurants.	3.86	1.14
I am certainly going to use the robot when visiting these restaurants.	3.78	1.05

Study 2		
Measurement items	Mean	Standard deviation
Trust in Service Robots (formative) (Lee & See, 2004; Söllner, et al., 2012)		
Performance		
NAO Robot has all functionalities needed to fulfill its goal.	3.90	0.95
I can count on the information provided by NAO Robot to be accurate.	4.00	0.90
I can rely on NAO Robot to check in the hotel room.	4.06	0.81
Process		
I think that no one can pretend to be me within the process checking in the hotel via NAO Robot.	3.42	1.19
I understand how NAO Robot works.	3.90	0.94
I think that NAO Robot does not change or use my data for other purposes without being noticed.	3.60	1.08
Purpose		
I think that my personal data is used for delivering the services NAO Robot offers.	3.99	0.83
I think that the designers of NAO Robot want to help me to check-in a hotel.	4.13	0.89
I think NAO Robot will be an useful for managing hotel guest experiences in the future.	3.92	1.02
Trust in Service Robots (reflective model for redundancy analysis) (Gefen, 2002)		
NAO Robot is trustworthy.	3.96	0.83
I have a good feeling when relying on NAO Robot.	3.80	1.07
I can trust the information presented by NAO Robot.	4.06	0.88
Structural Assurance (Gefen, Karahanna, & Straub, 2003; Mcknight, Carter, Thatcher, & Clay, 2011)		
I feel okay using self-service / automated technologies because they are backed by vendor protections.	3.89	0.90
Warranty makes it feel all right to use self-service / automated technologies.	3.83	0.98
Favorable legal structures help me feel safe using self-service / automated technologies.	3.80	1.00
Having the backing of legal statutes and processes makes me feel secure in using self-service / automated technologies.	3.86	0.95
Situational Normality (Gefen, Karahanna, & Straub, 2003; Mcknight, Carter, Thatcher, & Clay, 2011)		

I am totally comfortable using self-service / automated technologies.	4.05	0.90
I feel very good about how things go when I use self-service / automated technologies.	3.96	0.93
I always feel confident that the right things will happen when I use self-service / automated technologies.	3.84	1.01
It appears that things will be fine when I utilize self-service / automated technologies.	3.97	0.90
Behavioral intention to purchase the accommodation services		
(McKnight, Choudhury, & Kacmar, 2002)		
How likely is it that you will…		
recommend these hotels to someone who seeks your advice?	3.76	1.05
encourage friends and relatives to book these hotels?	3.70	1.10
consider these hotels as your first choice for future accommodation?	3.69	1.11
do more business with these hotels?	3.78	1.08

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