Human–robot interactions in the restaurant setting: the role of social cognition, psychological ownership, and anthropomorphism

Abstract

Purpose – The usage of robot waiters in the hospitality industry is growing, thus increasing the number of human–robot interactions in frontline services. Focusing on robot waiters in restaurants, this study proposes the SC-PO-CR model, while examining the association between social cognition, psychological ownership, robot anthropomorphism, and customer responses.

Design/methodology/approach – These study hypotheses are tested using a three-step mixed-method approach that includes partial least squares structural equation modeling (PLS-SEM), necessary condition analysis (NCA), and fuzzy-set qualitative comparative analysis (fsQCA).

Findings – PLS-SEM demonstrates the mediating role of psychological ownership on the relationship between social cognition, customer attitudes regarding being attended by a robot, and revisiting intentions. Robot anthropomorphism enhances the relationship between social cognition and psychological ownership. NCA indicates that social cognition and psychological ownership are necessary conditions for the presence of favorable attitudes and revisiting intentions. FsQCA suggests that different configurations of the antecedent conditions lead to better attitudes and revisiting intentions.

Practical implications – Frontline hospitality robots need to be perceived as warm, competent, responsive, and adaptable to customer requests to elicit positive responses. Managers should employ attractive robots displaying anthropomorphic features. Managers need to ensure that customers have some knowledge about robots before

interacting with them. Managers should also consider customer heterogeneity and the context in which the robots will be deployed.

Originality/value – Based on the psychological ownership theory, this paper analyzes the relationship between social cognition, psychological ownership, and customer responses. Anthropomorphism moderates the relationship between social cognition and psychological ownership.

Keywords: psychological ownership, social cognition, robot anthropomorphism, customer responses, NCA, fsQCA

Paper type – Research paper

1. Introduction

Robots are starting to be present in different areas including hospitality services (Tussyadiah and Park, 2018; Gaur *et al*., 2021). By 2030 robots will carry out up to 25% of hospitality tasks (Stipes, 2019). Particularly, frontline robots in restaurants – the focus of this research – perform several tasks such as greeting, seating, taking orders, or delivering food to the table (Gaur *et al.*, 2021; Tuomi *et al*., 2021). Customers' frontline experiences in restaurants are already starting to change as human–robot interactions (HRI) are on the rise (e.g., Belanche *et al*., 2021; Mariani and Borghi, 2021; Yu *et al*., 2022; Zhu and Chang, 2020).

Despite this robotization trend in restaurants, knowledge of its implementation in restaurants in terms of the impact of HRI on customer responses (CR) is limited (Byrd *et al*., 2021). Previous research regarding HRI is mainly theoretical (e.g., van Doorn *et al*., 2017; Law *et al*., 2022; Shin *et al*., 2021), ignoring how customers interact with robots and the effect of such interaction on CR (Delgosha and Hajiheydari, 2021). Findings about other disruptive technologies that do not integrate artificial intelligence (for example, self-service kiosks) or about artificial intelligence that is not physically embodied cannot be applied to restaurant robotization (Zhang *et al.*, 2022), thus are not appropriate to shed light on the impact of HRI on CR in restaurants.

CR to HRI may be shaped by robot capabilities to engage customers in social encounters. In this regard, social cognition (SC) and psychological ownership (PO) are two important variables that could influence CR in HRI (van Doorn *et al.*, 2017). SC refers to the first impression that individuals receive when meeting a social being, comprising two components: warmth, which refers to helpfulness, sincerity, or friendliness, and competence, which is associated to being skillful or efficacious (Fiske and Macrae, 2012).

PO refers to perceptions of ownership toward material or immaterial objects (Pierce *et al.*, 2001).

Researchers analyze warmth and competence perceptions as drivers of CR, such as attitudes (e.g., Belanche *et al*., 2021) to robots. However, the impact of PO on CR remains almost unexplored, thus impeding properly managing both elements, SC and PO, during HRI. Thus, this omission can limit managerial actions available to companies. Particularly, a poorer management of HRI in restaurants may reduce the benefits associated with robotization for these hospitality firms.

Hence, this research proposes the SC-PO-CR model and aims to analyze the joint impact of SC and PO on two important CR to robotization, namely attitudes and behavioral intentions arising from HRI in restaurants (Belanche *et al*., 2021; Byrd *et al*., 2021; Delgosha and Hajiheydari, 2021). Customer attitudes are positive or negative perceptions regarding almost anything: a person, product, service, place, or behavior (Akdim *et al*., 2021). This research focuses on customer attitudes about being attended by a robot waiter. Intentions are an indicator of how much customers are willing to perform certain behaviors (Reimer and Benkenstein, 2016). This research analyzes intentions to revisit a restaurant after having been attended by a robot waiter.

According to PO theory (Pierce *et al.*, 2001, 2003), PO can emerge due to socialization with objects. Consequently, PO might be related to SC. Therefore, this research studies the influence of SC and PO on CR to robots in restaurants, arguing that SC and PO are related. This research proposes that this relationship is affected by robot anthropomorphism, as attributing humanlike characteristics to nonhuman agents (Kim *et al*., 2019) (e.g., robots) enhances social perceptions and psychological consequences of technologies (e.g., Delgosha and Hajiheydari, 2021).

This research offers the following contributions. First, this study analyses the link between SC, PO, and CR in the hospitality industry, particularly robot waiters in restaurants. Second, this study combines three methods to analyze HRI in hospitality: PLS-SEM, NCA, and fsQCA, following calls for applying NCA in tourism research (Tóth *et al.*, 2019). NCA complements the results of PLS-SEM and fsQCA (Richter *et al.*, 2020; Tóth *et al.*, 2019). NCA (Dul, 2019) identifies necessary conditions, while the other two techniques focus more on sufficient conditions and their combinations (Tóth *et al.*, 2019).

2. Theoretical background

2.1. Psychological ownership

PO toward specific objects occurs when individuals control the object, know it intimately, or invest themselves in the object (Pierce *et al.*, 2001, 2003). Controlling the object means "the ability to use and to control the use of objects" (Pierce *et al.*, 2001, p. 301). Knowing the object intimately represents people's feelings of extensively and deeply knowing the object (Jussila *et al.*, 2015). Investing oneself in the object refers to people's investment of time, and psychological, physical, intellectual energies into the object (Pierce *et al.*, 2001). Some objects' features make them more prone to generate ownership feelings (Pierce *et al.*, 2003): attractiveness, manipulability, visibility, accessibility, availability, and openness (Jussila *et al.*, 2015).

Regarding HRI, van Doorn *et al*. (2017) theoretically suggest that PO can provoke better CR regarding services provided by robots, due to a subject's perceptions of robot receptiveness, attractiveness, and manipulability (van Doorn *et al*., 2017). Applied to robots, manipulability comprises the service customization provided by this technology (Jussila *et al*., 2015; Guan *et al*., 2022), receptiveness indicates its responsiveness and helpfulness (Dabholkar *et al.*, 1996; Parasuraman *et al.*, 1988), and attractiveness is

related to its physically appealing appearance (Keh *et al.*, 2013). These features work as components of PO when analyzing the incorporation of artificial intelligence in services (van Doorn *et al.*, 2017). This research adopted this conceptualization due to its specificity for services and its coherence with PO theory (Pierce *et al.*, 2001, 2003).

2.2. Social cognition

SC refers to how humans evaluate their conspecifics in terms of warmth and competence dimensions that arise from social interactions (Fiske *et al.*, 2007). Whenever human beings meet with their conspecifics, they tend to assess the others' good or evil intent (related to warmth) and their ability to perform intended actions (related to competence) (Fiske *et al.*, 2007). Perceptions of warmth and competence are crucial in frontline services because these settings require a high degree of interpersonal skills and because customers expect services to fulfill their needs (Belanche *et al.*, 2021). Service organizations aim to infuse technologies (such as robots) that can mimic their employees in frontline settings (van Doorn *et al.*, 2017). Customers engage with robots in social interactions generating SC evaluations (Yoganathan *et al.*, 2021). Thus, SC mechanisms are activated when customers interact with robots, in the same way as when customers interact with other customers (Belanche *et al*., 2021). For example, the warmth and competence of robot staff in hotels influence service quality evaluations (Yoganathan *et al.*, 2021). In the case of robot waiters, these assessments are related to service functional, monetary, and emotional value (Belanche *et al*., 2021). In the same vein, the competence of robot chefs in restaurants enhances customer food quality perceptions (Zhu and Chang, 2020).

2.3. Hypotheses development

Knowing an object intimately is one of the mechanisms from which PO arises (Pierce *et al.*, 2001, 2003). Individuals know an object intimately during an interaction process when individuals become familiar with the object, and hence ownership feelings appear (Pierce *et al.*, 2003). During such interactions "the more information and the better knowledge an individual has about [it], the deeper the relationship between the self and the object and, hence, the stronger the feeling of ownership toward it" (Pierce *et al*., 2001, p. 301). The SC – through its warmth dimension, which reflects traits such as helpfulness, sincerity or friendliness (Fiske *et al.*, 2007) – is expected to facilitate HRI, leading to a deeper understanding of the robot, and consequently developing ownership feelings. Additionally, the robot's warmth may make the robot more appealing and receptive to customer perceptions, enhancing the rise of PO feelings (Keh *et al.*, 2013).

Controlling the object is another mechanism that generates PO feelings (Pierce *et al.*, 2001, 2003). Customers' perceptions of control over company products elicit ownership feelings regarding the product. Customers have such ownership feelings as they somehow perceive themselves to be responsible for the product outcomes, eliciting positive responses related to the product (Fuchs *et al.*, 2010). Thus, customers interacting with a competent robot (that is skillful or efficacious – Fiske *et al.*, 2007) may develop ownership feelings because customers perceive that they can co-produce the desired service with the robot (Belanche *et al.*, 2021). Thus, SC through its competence dimension can help to elicit better control perceptions, hence people developing ownership feelings. In addition, these better control perceptions may lead people to consider the robot more capable of providing customized services, that is, having higher manipulability (van Doorn *et al.*, 2017).

Customer attitudes and behavioral intentions regarding technology are antecedents of actual behaviors involving such technologies (Guan *et al*., 2022). PO and SC generate

valuable CR in services, such as service upgrading intentions or loyalty (Belanche *et al*., 2021; Guan *et al*., 2022). Given that SC may yield higher PO feelings, and that both variables generate positive responses in customers, the following hypotheses in restaurants attended by robots are proposed:

Hypothesis 1: SC causes, via PO, positive attitudes about being attended by a robot waiter.

Hypothesis 2: SC causes, via PO, positive restaurant revisiting intentions about being attended by a robot waiter.

This research also considers that robot anthropomorphism can strengthen the relationship between SC and PO, hence enhancing CR. Humans have the tendency to assign humanlike characteristics such as motivations, intentions, or emotions, to non-human agents (Kim *et al*., 2019). Human appearance in robots facilitates human–robot interactions and the development of social norms (Belanche *et al.*, 2021), making robots be perceived as social entities (Whang and Im, 2021). Robot anthropomorphism facilitates its acceptance among individuals (e.g., Tussyadiah and Park, 2018). The closer the robot's appearance is to that of a human, the greater the user's affinity tends to be. However, robot anthropomorphism might also reach a point that appears eerie to individuals, with this feeling disappearing if human-looking features increase and the robot becomes indistinguishable from a human (e.g., Zhu *et al.,* 2020).

Hospitality research mainly finds a positive effect of anthropomorphism on customers' perceptions (Tussyadiah and Park, 2018). Accordingly, positive effects that SC exert on PO can be augmented or diminished depending on the perceived robot anthropomorphism. Highly anthropomorphized robots generate the feeling that the customer is interacting with a social entity, then enhancing the relationship between SC

and PO. In contrast, when robots are perceived as less anthropomorphized, customers have difficulties in imbuing social characteristics to robots, thus diminishing the effect of SC on PO. Therefore, robot anthropomorphism will enhance the impact of SC, via PO, on CR. Particularly, the following hypothesis is suggested:

Hypothesis 3: Increasing (decreasing) robot anthropomorphism leads to a larger (smaller) indirect effect of SC via PO on CR.

The research hypotheses – consistent with a symmetric modelling approach – are shown in Figure 1a. Four control variables that could influence reactions to technology are considered: age (Ruiz-Equihua *et al.*, 2021), gender (Sungjun *et al.*, 2022), past experience with robot waiters (Seyitoğlu and Ivanov, 2022), and restaurant setting (de Kervenoael *et al.*, 2020).

Additionally, this research adopts an asymmetrical modelling approach (Figure 1b) to analyze the connections between SC, PO, and CR in HRI in hospitality services. Failure to investigate causal asymmetrical modeling can produce incomplete results, leading to an inadequate understanding of the issue under research. Causal asymmetrical modeling analysis provides deeper insights to explain reality, in comparison with symmetrical modeling, allowing investigators to identify complex causal associations, and configurational combinations on outcome conditions.

FIGURE 1

3. Materials and methods

3.1. Data collection and sample

Data were collected through a questionnaire implemented in Qualtrics to test the hypotheses. The estimated time to complete the questionnaire was 7–9 minutes,

approximately. Participants were compensated with USD 1.00 for completing the survey. Prolific assisted us in the sample collection (e.g., Filieri *et al*., 2021). The Prolific online panel sample of customers in the United States consisted of 854 individuals, being balanced in terms of gender including 50.1% (n = 428) of male and 49.9% (n = 426) female respondents. Respondents were aged 18–20 (16.9%), 20–24 (25.1%), 25–34 (13.7%), 35–44 (12.9%), 45–54 (10.4%), 55–64 (10.4%), and more than 65 (10.7%).

To ensure data quality, the questionnaire was prepared to minimize recall and common method bias. To do so, attention questions and commitment techniques were employed. The questionnaire describes a situation in which the respondent decides to go to a restaurant in the city for dinner. Given that technology acceptance depends on the context (de Kervenoael *et al.*, 2020), three different restaurant images from TripAdvisor (corresponding to cheap eats, mid-range, and fine-dining restaurants) were randomly shown, together with a description that highlights restaurant attributes: decor, meal elaborateness, and prices. By doing so, this research avoids circumscribing the results to a specific type of restaurant. Next, the questionnaire indicated that a robot waiter, shown in a picture, was attending them during their dinner. Participants observed one of twelve different robot images, more or less anthropomorphic and randomly presented (e.g., Belanche *et al*., 2021), aiming to achieve enough variability in this construct. Subsequently, participants answered the questions about research variables.

3.2. Measurement scales and validation

Customer attitudes, revisiting intentions, and robot anthropomorphism were measured as first-order reflective constructs taken from previous research, see Table 1. Past experience was assessed with two dichotomous items. The first item captures if the respondent has ever seen a robot waiter. If so, the second item asks whether the respondent has been ever

attended by a robot waiter. Using these items, the past experience variable had the three levels: 1 – the respondent has never seen a robot waiter, 2 – the respondent has seen a robot waiter but has not been attended by one, and 3 – the respondent has been attended by a robot waiter. The restaurant setting was measured with a semantical differential scale of one item.

Consistent with SC and PO conceptualizations (Fiske *et al.*, 2007; Pierce *et al.*, 2001, 2003), both variables were measured as type II reflective-formative second-order constructs (Hair *et al.*, 2022) – second-order formative constructs composed by reflective first-order constructs: warmth and competence for SC (Fiske *et al.*, 2007); and receptiveness, manipulability, and attractiveness for PO (van Doorn *et al.*, 2017). Warmth and competence scales were adapted from Kim *et al*. (2019); and receptiveness, manipulability, and attractiveness scales from Dabholkar *et al*. (1996), Keh *et al*. (2013), and Parasuraman *et al*. (1988).

TABLE 1 ABOUT HERE

3.3. Realism and manipulation checks

We checked whether the situations presented to participants were realistic and credible, using two items adapted from Bagozzi *et al.* (2016): "The situation shown in this questionnaire is credible" and "The situation shown in this questionnaire is realistic" (7-point Likert scales). The results confirmed the questionnaire suitability ($M_{realism} = 4.57$, significantly above the midpoint of the scale, $p < 0.01$; $M_{credibility} = 4.71$, $p < 0.01$).

Despite not following an experimental design, this research also evaluated whether the situations presented to participants had the intended variability in terms of restaurant setting and robot anthropomorphism. The restaurant settings (ANOVA: $F = 1138.77$, $p < 0.01$) and robot images ($F = 17.64$, $p < 0.01$) differed in terms of service level and

anthropomorphism perceptions, respectively. Therefore, the results are not limited to a specific restaurant setting, and the findings regarding anthropomorphism are not conditioned by lacking variability in the questionnaire.

3.4. Analytical approaches

Three analytical approaches were employed: PLS-SEM (symmetrical technique), and NCA and fsQCA (asymmetrical techniques). Symmetrical tests of inferential statistics tools, such as multiple regression analysis, explicitly consider symmetrical association among variables, where high values of an independent antecedent (*X*) are associated with high values in the dependent outcome (*Y*), and vice versa (Pappas and Woodside, 2021). Asymmetrical approaches can identify necessary conditions that symmetrical analyses cannot, that is, they can handle situations where high values of *X* can be necessary but are not sufficient for high values of *Y*. Additionally, asymmetrical approaches can identify specific combinations of *n* conditions $X_1, X_2, \ldots X_n$ that are sufficient to produce high levels of *Y*. By combining symmetrical (i.e., PLS-SEM) and asymmetrical (i.e., NCA and fsQCA) analyses, this study offers a unique view of the link between SC and PO regarding CR during people's interaction with robots.

PLS-SEM allows the analysis of relationships between latent variables and tests the SC-PO-CR model from a predictive perspective, widely used in hospitality research (Loureiro *et al.*, 2021; Romero and Lado, 2021). This technique assesses the measurement model to capture latent variables and evaluates the relationships a model variables (Hair *et al.*, 2022). As a symmetrical approach, PLS-SEM results indicate whether a variable is sufficient to produce an outcome, as depicted in Figure 1a (which suggests a causal chain leading from SC, through PO, to attitude and revisiting intentions). Thus, this technique is appropriate for hypothesis testing.

Based on complexity theory, widely used in hospitality and tourism research (Harms *et al*., 2021), symmetrical approaches attempt to identify variables that are relevant to producing an outcome, either individually as necessary conditions or together as sufficient conditions. This study uses approaches to provide a deeper understanding of the interconnected structures of the constructs and the complex nature of their interdependencies, beyond hypothesis testing (Figure 1b). Following Tóth *et al.* (2019), NCA was first performed to explore whether each causal antecedent is, on its own, a necessary condition of attitudes about being attended by a robot waiter and of revisiting intention. Subsequently, following Richter *et al*. (2020), fsQCA was applied to identify combinations of causal antecedents that are sufficient to achieve high levels of attitude and revisiting intentions. While NCA provides an isolated view of each causal antecedent, fsQCA delivers a joint diagnostic of a group of causal antecedents – thus providing a complementary view of the phenomenon under analysis. With regard to PLS-SEM, fsQCA offers a sufficiency analysis of variables at group level (vs. at an individual level).

4. Results

4.1. PLS-SEM

4.1.1. Measurement model

The reliability and convergent validity of the first-order constructs included in the SC-PO-CR model were evaluated (Table 1). Cronbach's alpha is above the 0.70 threshold value, between 0.79 and 0.94 (Hair *et al.*, 2022). The composite reliability fluctuates between 0.88 and 0.97. The constructs indicators loadings are higher than the 0.7 threshold, supporting the constructs' reliability. Additionally, the average variance extracted (AVE) is higher than the cut-off value, varying between 0.74 and 0.89 (Hair *et al*., 2022).

Next, the discriminant validity of the constructs was supported using two criteria (Table 2): (1) The AVE of each construct is higher than their correlations with other constructs. (2) The HTMT of the correlations between constructs is below the 0.85 threshold (Hair *et al.*, 2022).

TABLE 2 ABOUT HERE

Once we had evaluated the measurement model of the first-order constructs, the second step was to reestimate the model that incorporates warmth and competence's latent scores as SC indicators; and receptiveness, manipulability, and attractiveness as PO indicators. All the SC and PO indicators were positive and, according to a non-parametric bootstrapping procedure with 10,000 subsamples, significant at a 95% level. Subsequently, multicollinearity was discarded through the VIF factors. In sum, SC and PO constructs cover all the crucial aspects for index construction (Hair *et al*., 2022).

4.1.2. Structural model

First, the endogenous variables of the SC-PO-CR model were checked through adjusted R^2 and Q^2. The adjusted R^2 are 0.57 for PO, 0.51 for attitudes, and 0.43 for revisit intentions, thus being moderate for PO and attitudes, and weak for revisiting intentions (Hair *et al.*, 2022). The Q^2 scores for PO (0.35), attitudes (0.41), and revisiting intentions (0.37) indicate the model has predictive relevance (Hair *et al.*, 2022).

4.1.3. Hypotheses testing

To test the hypotheses, the path coefficients in the SC-PO-CR model were evaluated (Table 3) through a 10,000 subsamples non-parametric bootstrapping procedure. Bootstrap analysis assesses the effect of an independent variable on a dependent variable through a mediator variable by calculating a confidence interval (Hair *et al.,* 2022). The

results indicate that PO mediates the effect of SC on attitudes regarding being attended by a robot waiter (confidence interval: 0.45–0.54), and the effect of SC on restaurant revisiting intentions (confidence interval: 0.41–0.50), supporting H1 and H2 (Table 3). VAF approach values range between 20% and 80% (SC → A = 42.63%, SC → RI = 43.66%), indicating a partial mediation (Hair *et al.*, 2022; Ramaya *et al.*, 2018).

Following Hair *et al.* (2022), the orthogonalized approach was employed to test whether robot waiter anthropomorphism moderates the association between SC and PO (H3). The results support H3. Robot anthropomorphism moderates the relationship between SC and PO ($\beta = 0.05$; $p < 0.05$). Higher/lower PO arises from SC when robots are more/less anthropomorphic.

TABLE 3 ABOUT HERE

4.2. NCA

Following Richter *et al.* (2020), this analysis departs from the latent variables scores provided by PLS-SEM as input to perform NCA, using the R package NCA (Dul, 2019). Two alternative techniques were considered: (1) ceiling regression (CR) and (2) ceiling envelopment (CE) with free disposal hull (FDH), together with the effect size to evaluate NCA (Dul, 2019).

CE-FDH ceiling draws a piecewise straight line, while the CR-FDH ceiling line draws a trend line between the edged points of the CE-FDH ceiling line (Figure 3). Ceiling lines define the size of the "empty" space (Tóth *et al.*, 2019). The empty space in the upper left corner represents the presence of a necessary condition or the effect size of a necessary condition.

Figure 2 shows the empty spaces in the upper left corner of the scatterplot with the ceiling lines of SC, PO, and robot anthropomorphism for attitudes and revisiting intentions (left and right sides of the plot, respectively). These results suggest the presence of two necessary conditions for both CR. Considering attitude as outcome, the results reveal a significant effect (medium effect) for SC (effect sizes = 0.20 and 0.19 for CE-FDH and CR-FDH, respectively; both $p < 0.01$) and PO (effect sizes = 0.17 and 0.16; both $p < 0.01$). Similarly, considering revisiting intentions as outcome, the results show a significant effect (small effect) of SC (0.09 and 0.08; both $p < 0.01$) and PO (0.09 and 0.09; both $p < 0.01$). Anthropomorphism does not have a significant effect on either attitudes or revisiting intentions. These results suggest that SC and PO are necessary conditions to generate favorable customer attitudes and revisiting intentions.

FIGURE 2 ABOUT HERE

4.3. fsQCA

Next, fsQCA (Fiss, 2011; Pappas and Woodside, 2021; Ragin, 2008) was applied to identify several causal configurations, also known as "solutions." A solution consists of a combination of conditions (specific level of variables) that all together are sufficient for achieving high levels of positive attitudes and revisiting intentions (e.g., Olya and Akhshik, 2019). The fsQCA assumes asymmetrical associations among the conditions and the outcome (i.e., the absence of conditions does not necessarily generate the absence of the outcome). Control variables were incorporated in this analysis, as fsQCA results depend on the variables included in the model (as in PLS-SEM). Additionally, this technique can reveal if the main variables (SC, PO, and anthropomorphism) only exert their effects if specific conditions related to the control variables are present or absent.

4.3.1. Data calibration

The calibration was performed using the direct method (Ragin, 2008) to transform latent score measures in fuzzy-set scores oscillating between 0 and 1, employing average scores. Three qualitative anchors are assigned for the calibration (Ragin, 2008): (1) full membership (fuzzy score = 0.95), (2) the crossover point (fuzzy score = 0.5), and (3). the threshold for full non-membership (fuzzy score = 0.05). Following Fiss (2011), the full membership threshold, the crossover point, and the full non-membership threshold, are assigned to the 95th, 50th, and 5th percentile of each variable, respectively. The control variables – gender, age, past experience, and restaurant setting – were calibrated following Prentice and Loureiro (2017).

4.3.2. Constructing the truth table

A truth table was constructed using the Quine-McCluskey algorithm, which produces three different sets of solutions: (1) complex, (2) parsimonious, and (3) intermediate (Pappas and Woodside, 2021). The parsimonious and intermediate sets of solutions are integrated to produce core and peripheral conditions associated with the outcome of interest (Fiss, 2011). Core condition refers to a condition which belongs to both parsimonious and intermediate solutions, reflecting a strong causal relationship with the outcome. Peripheral condition refers to a condition which appears only in the intermediate solution and reflects a weaker causal relationship with the outcome. This study used two common thresholds – coverage and consistency – which are referred to for refining sufficient and consistent causal antecedents of the outcome.

4.3.3. fsQCA findings

Two sets of fsQCA analysis were studied, for positive attitudes and for revisiting intentions, with SC, PO, robot anthropomorphism, gender, age, past experience, and restaurant setting as causal antecedent conditions. The configurations of both analyses, as well as their overall solutions, achieve an acceptable consistency (greater than or equal to 0.91).

The analysis for high attitudes (that is, a high level of positive attitudes) results in three solutions, showing three causal paths. The analysis for revisiting intentions shows three solutions too, which are equivalent to those of attitudes. Thus, for parsimony, they are referred as solution 1, solution 2, and solution 3 for both attitudes and revisiting intentions (Table 4).

Solutions 1, 2 and 3 indicate that SC, PO, and anthropomorphism are core conditions for achieving high levels of attitudes and revisiting intentions. Additionally, gender (namely, being male) and past experience appear as peripheral conditions across solutions (they have a weaker influence than SC, PO, and anthropomorphism). Thus, solutions indicate that high levels of attitudes and revisiting intentions occur when SC, PO, and anthropomorphism are present, for males with a previous experience with robots (solution 1), specially for older customers (solution 2). Furthermore, high levels of attitudes and revisiting intentions can also occur for males with previous experience with robots, who are young and who interact with this technology at cheaper restaurants.

TABLE 4 ABOUT HERE

5. Discussion and conclusions

5.1. Discussion

This study examines the associations between SC, PO, robot anthropomorphism, attitude about being attended by a robot waiter, and restaurant revisiting intentions. This research proposed the SC-PO-CR model, in which the relationships were examined using a three-step mixed-method approach including PLS-SEM, NCA, and fsQCA.

By means of PLS-SEM, this study finds that SC causes positive CR via PO, specifically attitudes regarding being attended by a robot waiter and restaurant revisiting intentions. Previous research suggests that SC can generate beneficial CR (e.g., Belanche *et al*., 2021; van Doorn *et al*., 2017; Yoganathan *et al.,* 2021). This study adds to research showing that this effect occurs due the arise of PO. When restaurant customers positively evaluate a robot warmth and competence, they are likely to try to find out more about that robot, feel that it can control the outcome of the service, and consider that the robot is willing to adapt to their needs.

Yet, PO partially mediates the relationship between SC and CR, implying that SC still influences CR beyond PO. Thus, aligned with Belanche *et al*. (2021), SC can generate other positive perceptions among restaurant customers, such as value perceptions. Moreover, increasing (decreasing) robot anthropomorphism leads to a larger (smaller) indirect effect of SC via PO on CR. A novel impact of anthropomorphism on customers was uncovered, consistent with previous hospitality research that finds a positive effect of this feature on individuals (e.g., Romero and Lado, 2021; Yoganathan *et al*., 2021). Probably, anthropomorphism enhances the social nature of HRI (van Doorn *et al*., 2017).

According to the NCA findings, SC and PO are necessary conditions for attitude and revisiting intentions. In contrast, robot anthropomorphism is not required to obtain positive attitudes and revisiting intentions from customers. Thus, these results suggest that SC and PO need be present for positive attitude and revisiting intentions to occur, in

line with the partial mediation of PO detected by PLS-SEM. Similarly, the NCA finding for anthropomorphism is consistent with a mere moderating role of this variable in the relationship between SC and PO. Hence, the results advance previous research by classifying SC and PO as necessary conditions to achieve positive CR to robots in hospitality. Such research, focused on SC, applies sufficiency analysis for each variable independently (Yoganathan *et al.,* 2021; Zhu and Chang, 2020).

The fsQCA analyses provide evidence that three configurations can lead to high levels of positive attitude and revisiting intentions. Specifically, fsQCA points out that SC, PO, and robot anthropomorphism are core conditions that generate high levels of positive attitudes and revisiting intentions. Hence, these results support the role of SC and PO as necessary conditions detected by NCA and attribute a high importance to anthropomorphism, which PLS-SEM identifies as an enhancer of PO due to its moderating role. Higher attitudes and revisiting intentions occur when SC, PO, and anthropomorphism are present all together.

Additionally, fsQCA findings reveal that males with higher levels of past experience with robots are prone to develop such attitudes and intentions. Age and the context where the robot is used are also relevant in this regard. Particularly, older customers, and younger customers who interact with robots at cheaper restaurants, are more likely to show high levels of positive attitudes and revisiting intentions. Therefore, these results are consistent with studies that find that gender (Sungjun *et al*., 2022), age (Ruiz-Equihua *et al*., 2021), and past experience (Seyitoğlu and Ivanov, 2022) influence customer responses to technology in the hospitality industry. Similarly, the results support literature indicating that technology acceptance is contextual (de Kervenoael *et al*., 2020).

5.2 Theoretical implications

This study deepens the knowledge about HRI in hospitality services. First, the results demonstrate that PO partially mediates the relationship between SC and CR. Thus, we contribute to the PO theory, enhancing the knowledge of the mechanisms when ownership arises (Pierce *et al.*, 2001, 2003). Researchers analyzing the impact of SC and/or PO on HRI need to consider the connection between these two concepts in their studies. Additionally, researchers could explore the existence of mediating variables other than PO in the connection between SC and CR. Second, results demonstrate that robot anthropomorphism enhances the relationship between SC and PO. Further studies about HRI in the hospitality industry based on the PO theory should control this moderating impact of anthropomorphism when designing their research. This recommendation may be also applied to research exploring new potential mediators between SC and CR.

Third, SC and PO are necessary variables to reach positive CR. The absence of any of these variables can provoke low attitudes and revisiting intentions. Researchers studying CR arising from interactions with robots need to incorporate them in their research designs to avoid finding non-significant relationships in their studies due to not incorporating these necessary conditions.

Fourth, if SC and PO are present, anthropomorphism is also required to generate the most positive CR, in line with the aforementioned moderating role of this variable. This suggests that researchers who analyze CR to robots need to consider that their results concerning anthropomorphism may depend on the presence of other variables in their studies; and that previous research incorporating anthropomorphism may have obtained contradictory results about it (e.g., Kim *et al.*, 2019; Zhu and Chang, 2020) due to this reason.

Fifth, some specific combinations of gender, age, and context lead to high attitudes and revisiting intentions. Consequently, researchers need to incorporate customer and context heterogeneity in future studies. Such incorporation cannot be performed at a single variable level but consider that these variables are relevant when they are jointly present. Past experience plays an important role in determining CR. Researchers should also incorporate past experience into their model to better understand the impact of their variables of interest. Thus, the research added to the theory by demonstrating that CR to robots can evolve when the user accumulates experience with service robots. Consequently, future research about the topic might require applying a dynamic approach (that is, longitudinal vs. cross-sectional)

Finally, from a methodological point of view, this study illustrates the usefulness of jointly applying PLS-SEM, NCA, and fsQCA in hospitality research (Rasoolimanesh *et al.*, 2021). The joint use of these analytical techniques complements the results obtained from each technique separately. Particularly, NCA and fsQCA analyses enhance PLS-SEM findings by detecting the critical factors and causal configurations that lead to a high level of positive attitude and revisiting intentions. The findings encourage future studies to consider using these analytical techniques (PLS-SEM, NCA, and fsQCA) jointly for theory development.

5.3 Managerial implications

Hospitality managers, specifically those in restaurants, can benefit from the findings to enhance the use of robot waiters in customer frontline experiences. SC perceptions regarding robot waiters are crucial to generating PO and beneficial CR. Thus, restaurants managers should invest in frontline robots that their customers perceive as being warm and competent. These attributes contribute to eliciting positive attitudes about being

attended by the robot, as well as restaurant revisiting intentions. Second, managers need to strengthen the positive effects of SC on CR through communication actions. For example, firms could disseminate advertising messages that show robots that react in a friendly manner in their interactions with humans. Similarly, these messages could emphasize robot efficiency in specific aspects and its impact on service. For instance, in the case of restaurants, messages could convey that robots can serve customers quickly, thus reducing waiting times.

Third, robot manipulability, receptiveness, and attractiveness can foster ownership feelings among customers attended by robots, Thus, beyond warmth and competence perception, hospitality managers need to consider these features when investing in robots for their business. These robots need to be responsive and able to properly adapt themselves to customers' requests. Customers' perceptions in this regard could be potentiated through communication actions that show situations where robot manipulability and receptiveness are illustrated. Robot appearance is also important. Apart from ensuring robot attractiveness, restaurant managers should invest in anthropomorphized robots.

Fourth, this study highlights the importance of implementing rigorous analyses to identify which customers (with specific socio-demographics) and which business characteristics (for example, type of meal or location in the case of having several outlets) are more prone to having positive reactions to HRI. NCA and fsQCA can be useful techniques for this task. Thus, managers should apply them to detect necessary conditions and combinations of variables that lead to highly positive attitudes and behaviors. FsQCA can be especially useful to detect adequate combinations of customer and business characteristics, which could be employed to determine company strategic decisions (particularly in terms of customer segments to serve with specific business positioning

that includes robotization) and to prioritize necessary resource deployment to improve attitudes and revisiting intentions.

Finally, facilitating customer experience with robots prior to service delivery is recommended. Hospitality firms could assess whether customers have any experience with robots. If not, the firm should offer information to them that compensates for the lack of experience, as experience has somehow to be present to achieve highest attitudes and revisiting intentions.

5.4 Limitations and further research

This work is not free of limitations, which can provide further insights if properly solved. First, despite the sample being balanced in terms of gender and age, it would be advisable to replicate this research employing samples of several markets where robots are implemented and compare their results. This would allow gaining of extra insights about the role of customers' heterogeneity in CR to robots. Second, this study incorporates anthropomorphism as a moderator of the relationship between SC and CR. However, previous research suggests that other moderators – such as technology readiness or the need for social interaction – may also have a moderating role for CR antecedents (e.g., Belanche *et al.*, 2021; van Doorn *et al.*, 2017; Yoganathan *et al.*, 2021). So, future research should explore such moderators. Third, PO theory posits that some mechanisms might provoke PO (e.g., control, knowledge, etc.), which are not considered in this study. Future studies could incorporate them to obtain a better picture of how PO determines CR. Fourth, this research considers two specific CR: attitude and revisiting intentions. Further research should replicate the SC-PO-CR model including other valuable responses, such as satisfaction, engagement, or loyalty. Finally, this research is based on

a specific hospitality service (namely, restaurants), which might influence CR. Further studies could replicate the model in other hospitality services, such as hotels.

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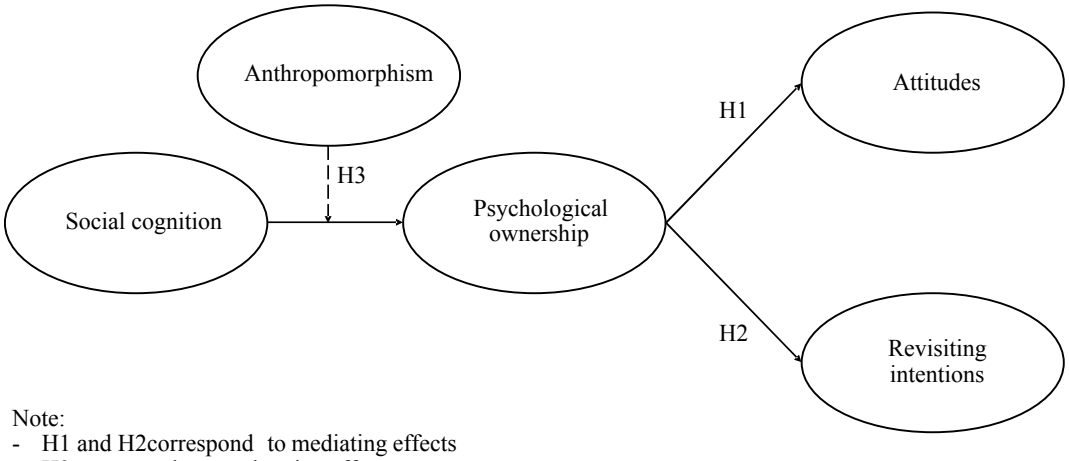
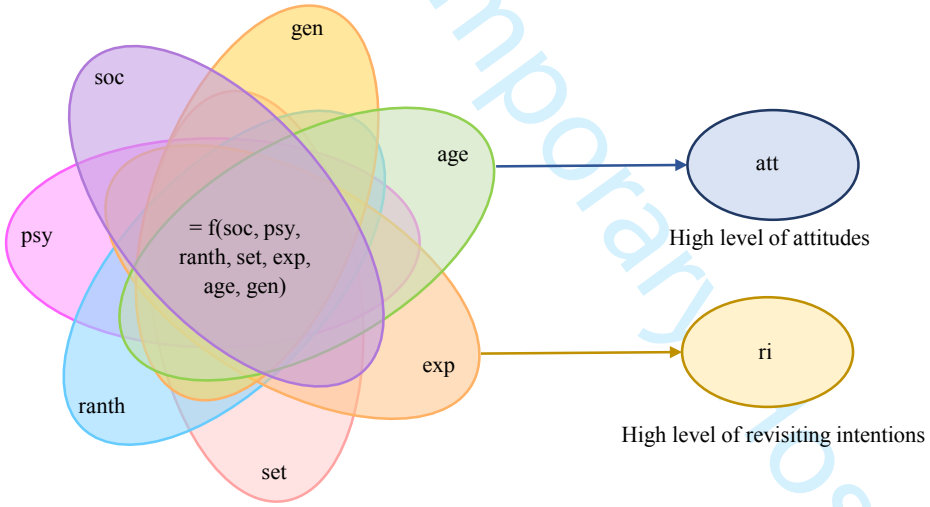
Figure 1. SC-PO-CR and fsQCA models

a)



Note:
- H1 and H2correspond to mediating effects
- H3correspond to moderating effect
- Control variables:age ,gender ,past experience, and restaurant setting.

b)

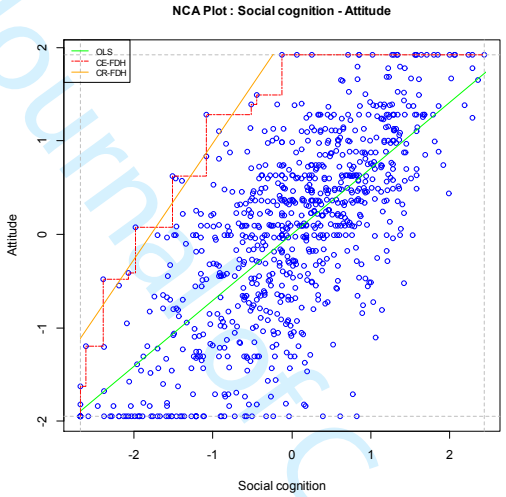


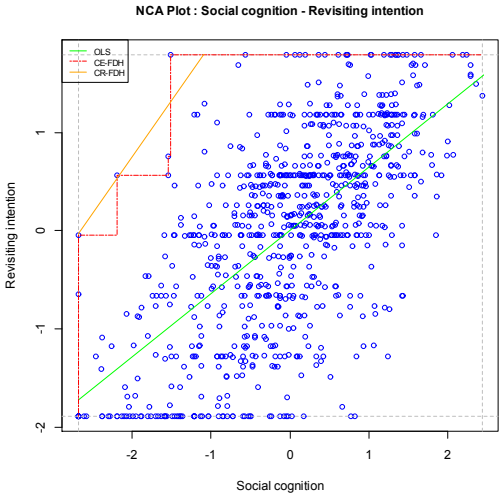
soc = social cognition; psy = psychological ownership; ranth = robot anthropomorphism; set = restaurant setting; exp = past-experience; gen = gender; att = attitude; ri = revisiting intentions

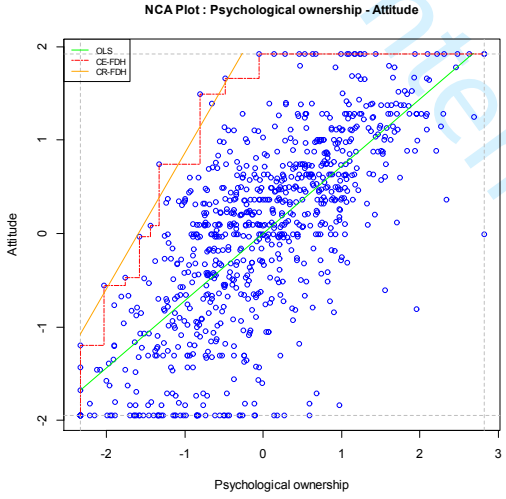
Figure 2. Scatter plot of all necessary conditions

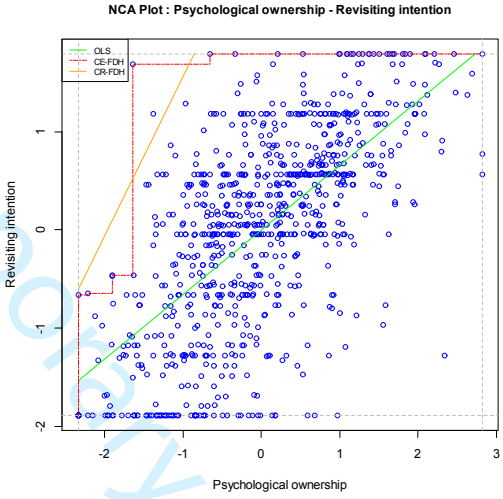
a) Attitudes

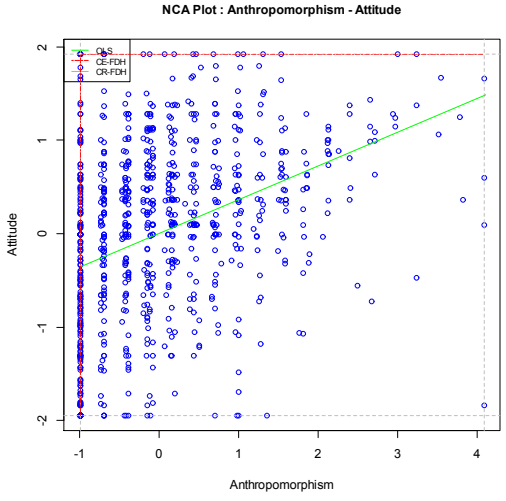
b) Revisiting intentions











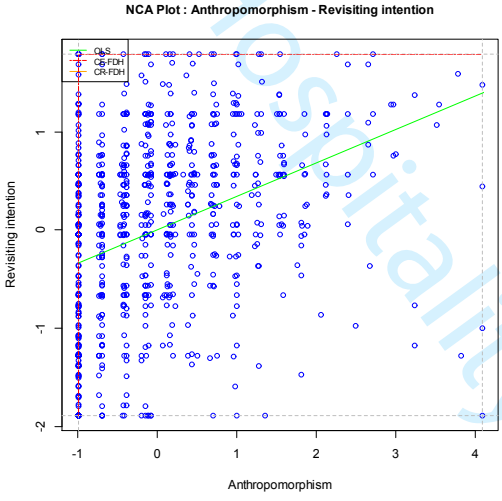


Table 1. Measurement items Items	Mean	SD	Excess Kurtosis	Skewness	Factor loading
Social cognition - warmth (Kim *et al.*, 2019) (α = 0.93; CR = 0.93; AVE = 0.78)					
This robot seems…					
Sociable	3.23	1.63	-0.92	0.22	0.89
Friendly	3.54	1.66	-0.98	0.03	0.91
Kind	3.62	1.73	-0.92	0.03	0.87
Likeable	3.73	1.69	-0.91	-0.08	0.90
Warm	2.82	1.57	-0.62	0.52	0.84
Social cognition – competence (Kim *et al.*, 2019) (α = 0.92; CR = 0.92; AVE = 0.75)					
This robot seems…					
Competent	4.74	1.47	-0.12	-0.56	0.88
Intelligent	4.49	1.64	-0.44	-0.47	0.79
Skillful	4.47	1.55	-0.43	-0.39	0.87
Efficient	4.99	1.46	0.07	-0.69	0.88
Capable	4.83	1.46	0.00	-0.60	0.91
Psychological ownership – receptiveness (Dabholkar *et al.*, 1996; Parasuraman *et al.*, 1988) (α = 0.90; CR = 0.90; AVE = 0.78)					
I believe that this robot will…					
Give a prompt service to customers	4.75	1.52	-0.29	-0.51	0.88
Give a service without unnecessary losing time	4.64	1.50	-0.31	-0.49	0.88
Be available when customers need it	4.74	1.45	-0.22	-0.52	0.89
Be available when customers request it	4.91	1.42	-0.03	-0.58	0.87
Psychological ownership – manipulability (Coelho and Henseler, 2012) (α = 0.88; CR = 0.88; AVE = 0.80)					
I believe that this robot can…					
Offer a service which satisfies the specific needs of each customer	4.02	1.59	-0.77	-0.20	0.89
Offer a different service for each customer	3.54	1.80	-1.08	0.19	0.88
Adapt themselves to the specific needs of each customer	3.83	1.64	-0.82	-0.07	0.91
Psychological ownership – attractiveness (Keh *et al.*, 2013) (α = 0.93; CR = 0.94; AVE = 0.89)					
I believe that this robot…					
Is good-looking	2.90	1.64	-0.62	0.52	0.95
Has an attractive appearance	2.99	1.72	-0.80	0.47	0.94
Would be considered pretty	2.91	1.65	-0.76	0.50	0.93
Customer attitude regard being attended by a robot (Davis *et al.*, 1989) (α = 0.94; CR = 0.95; AVE = 0.81).					
Being attended by this robot would be…					
Funny	4.73	1.79	-0.51	-0.63	0.83
Pleasurable	3.82	1.69	-0.82	-0.10	0.87
Recommendable	3.78	1.59	-0.57	-0.11	0.91
Pleasant	3.98	1.75	-0.84	-0.18	0.92
A good idea	3.93	1.78	-0.91	-0.16	0.88
Customer revisiting intentions (Reimer and Benkenstein, 2016) (α = 0.97; CR = 0.97; AVE = 0.87).					
After being attended by the robot if I were looking for a similar restaurant…					
The probability of coming back to this restaurant would be high	3.95	1.70	-0.81	-0.21	0.94
I would consider come back to this restaurant	4.19	1.77	-0.85	-0.30	0.94
I will give another chance to this restaurant	4.41	1.79	-0.71	-0.49	0.91
It is probable that I would come back to this restaurant	3.96	1.79	-0.96	-0.17	0.90
I would go again to this restaurant	3.99	1.71	-0.80	-0.19	0.96
I might choose this restaurant again	3.99	1.73	-0.83	-0.20	0.92
Robot anthropomorphism (Kim *et al.*, 2019) (α = 0.82; CR = 0.89; AVE = 0.74).					
This robot seems…					
Fake – Natural	2.50	1.40	-0.11	0.72	0.86
A machine – A human being	1.95	1.33	2.19	1.59	0.87
To have no moral sense – To have moral sense	2.03	1.39	1.20	1.37	0.78
Restaurant settings (α = N/A; CR = N/A; AVE = N/A).					
I would classify this restaurant as a…					
Cheap restaurant – fine-dining restaurant	4.49	1.88	-0.98	-0.29	N/A
Past experience (α = N/A; CR = N/A; AVE = N/A).					
Regarding my experience with robot waiters…					
I have been attended by a robot waiter in a restaurant	N/A	N/A	N/A	N/A	N/A
I have seen a robot waiter in a restaurant	N/A	N/A	N/A	N/A	N/A

All items are measured with a 7-point Likert scale anchoring strongly disagree (1) and strongly agree (7) except for robot anthropomorphism and restaurant settings which are measured with semantical differential scales. α = Cronbach's alpha, CR = composite reliability, AVE = average variance extracted, SD = standard deviation.

Table 2. Discriminant validity analysis.

	1	2	3	4	5	6	7	8
1. Anthropomorphism	*0.86*	0.41	0.54	0.35	0.18	0.38	0.27	0.55
2. Attitude	0.36	*0.90*	0.64	0.65	0.52	0.84	0.62	0.67
3. PO Attractiveness	0.48	0.60	*0.94*	0.48	0.31	0.58	0.43	0.64
4. PO Manipulability	0.30	0.59	0.44	*0.90*	0.66	0.57	0.62	0.49
5. PO Receptiveness	0.16	0.48	0.28	0.59	*0.89*	0.48	0.73	0.34
6. Revisit intentions	0.34	0.80	0.55	0.53	0.45	*0.93*	0.57	0.59
7. SC Competence	0.23	0.57	0.40	0.57	0.67	0.54	*0.87*	0.47
8. SC Warmth	0.48	0.63	0.60	0.45	0.32	0.56	0.44	*0.89*

Note: Italic numbers on the diagonal show the square root of the AVE values; numbers below the diagonal represent construct correlations; and numbers above the diagonal represent the HTMT radio

Table 3. Results of the structural equation analysis

	PC	f^2	t – value	Bias corrected confidence interval	
				Lower bound	Upper bound
Direct effects					
Social cognition → Psychological ownership	0.69	0.91	30.36***	0.64	0.73
Psychological ownership → Attitude	0.71	1.06	41.65***	0.68	0.75
Psychological ownership → Revisiting intention	0.65	0.75	30.36***	0.61	0.69
Anthropomorphism → Psychological ownership	0.13	0.03	4.60***	0.07	0.18
Moderating effect					
Social cognition*anthropomorphism → Psychological ownership	0.05	0.01	2.29*	0.01	0.89
Total effects					
Social cognition → Attitude	0.49	n/a	22.24***	0.45	0.54
Social cognition → Revisiting intention	0.45	n/a	19.73***	0.41	0.50
Control variables					
Age → Attitudes	-0.04	0.00	1.61ns	-0.08	0.01
Age → Revisiting intentions	-0.13	0.03	5.36***	-0.18	-0.084
Gender → Attitudes	0.03	0.00	1.25 ns	-0.017	0.076
Gender → Revisiting intentions	0.03	0.00	1.27 ns	-0.016	0.082
Past-experience → Attitudes	0.07	0.01	2.62**	0.01	0.11
Past-experience → Revisiting intentions	0.03	0.00	1.98 ns	-0.01	0.111
Restaurant setting→ Attitudes	-0.02	0.00	0.84 ns	-0.06	0.02
Restaurant setting → Revisiting intentions	-0.02	0.00	0.70 ns	-0.07	0.03

Constructs	Q^2 (= 1 – SSE/SSO)	Variance explained (R^2)
Psychological ownership	0.35	0.57
Attitudes	0.41	0.51
Revisiting intentions	0.37	0.43
Model fit		
SRMR		0.13
d_ULS		3.28
d_G		0.40
Chi-Square		1779.89
NFI		0.88
rms Theta		0.17

Note: PC: Path coefficient. *** p < 0.001. ** p < 0.01 * p < 0.05. ns Not significant.

Table 4. Configurations for achieving high level of attitude and revisiting intentions

a) Attitude	Solution		
Configurations	1	2	3
Social cognition	●	●	●
Psychological ownership	●	●	●
Robot anthropomorphism	●	●	●
Gender	•	•	
Age			⊗
Past experience	•	•	•
Restaurant setting			⊗
Consistency	0.94	0.94	0.92
Raw coverage	0.48	0.37	0.30
Unique coverage	0.04	0.02	0.02
Overall solution consistency	0.92		
Overall consistency coverage	0.51		
b) Revisiting intentions	Solution		
Configurations	1	2	3
Social cognition	●	●	●
Psychological ownership	●	●	●
Robot anthropomorphism	●	●	●
Gender	•	•	
Age		•	⊗
Past experience	•	•	•
Restaurant setting			⊗
Consistency	0.94	0.94	0.93
Raw coverage	0.48	0.38	0.30
Unique coverage	0.04	0.02	0.02
Overall solution consistency	0.91		
Overall consistency coverage	0.52		

Note: Black circles indicate the presence of a condition; and with circles indicate its absence. Large circles indicate core conditions, small circles peripheral conditions. Blank spaces indicate "do not care"