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CAN A ROBOT SERVE YOU? THE ROLE OF CONSUMER AND ROBOT CHARACTERISTICS IN SHAPING ENGAGEMENT WITH A ROBOT BARTENDER

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ABSTRACT

Aim/Purpose	This paper examines how robot anthropomorphism, gender, and individual characteristics shape perceptions, attitudes, and intentions toward robot bartenders.

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Background	The paper examines human–robot interaction in a bar setting by exploring factors that promote positive perceptions and interactions between consumers and robot bartenders.
Methodology	The study was conducted through an in loco survey administered during recreational events. A between-subjects design was employed. Participants (N = 192) completed an online questionnaire by scanning a QR code and evaluating a randomly assigned robot image. The robot stimuli varied in levels of anthropomorphism and gender, resulting in four different robot conditions. Two questionnaires were used: the need for affiliation, measured using the Interpersonal Orientation Scale (Hill, 1987), and participants' perceptions of the robot, assessed with items adapted from T. Kim et al. (2023).
Contribution	The paper contributes to the Human-Robot Interaction literature by highlighting how individual differences and social context shape perceptions and acceptance of service robots in the hospitality sector.
Findings	The findings indicate that male participants reported greater optimism and a stronger intention to use robot bartenders compared to female participants. Anthropomorphic robots were perceived as more human-like; however, they also elicited higher levels of consumer resistance. Additionally, participants attending the event alone perceived the robots as more human-like than those in group settings. Finally, a positive correlation emerged between Need for Affiliation and resistance to interacting with robot bartenders, suggesting that individuals with stronger interpersonal orientation may be more reluctant to engage with robotic service providers.
Recommendations for Practitioners	Hospitality providers, robot designers, and service managers should consider both robot design features and customers' psychological and social characteristics to enhance acceptance of robot bartenders. While aligning robot gender with societal service-role stereotypes may increase user comfort, this approach risks reinforcing biased expectations and raising ethical concerns. Therefore, moderately anthropomorphic or gender-neutral robots that emphasize functionality and relational appropriateness may be more suitable for bar settings. Practitioners are also encouraged to adopt flexible, hybrid human–robot service models that adapt to different social contexts and customer preferences, while ensuring ethical, inclusive, and user-centred design choices.
Recommendations for Researchers	Researchers are encouraged to include individual and contextual variables in studies on service robot acceptance and to adopt theoretical models that integrate human psychological factors with robot-related features.
Impact on Society	The study highlights the importance of designing human–robot interactions that account for individual, psychological, and social differences to foster comfortable, socially acceptable customer experiences. By promoting more inclusive and user-centred robot design, the findings support the responsible integration of service robots into public and recreational environments.
Future Research	Future research should examine how consumers' emotional states, familiarity, and prior experience shape acceptance, trust, and interactions with service robots. Further studies are needed on psychological evaluation processes, robot gender attribution, and the balance between human-like and machine-like features. Longitudinal and multi-user interaction studies would also help clarify group dynamics and sustained engagement in hospitality settings.

Keywords service robot, social robot, robot bartender, human-robot interaction (HRI), anthropomorphism, gender stereotypes

INTRODUCTION

Driven by technological advances associated with the Fourth Industrial Revolution, the development of service robots and their integration into the hospitality sector have accelerated rapidly (Kang et al., 2023; H. Kim et al., 2024; Lee, 2021; Ye et al., 2022). Despite increasing scholarly interest, a significant gap remains: most HRI studies in the hospitality sector have been carried out in simulated or laboratory settings, focusing separately on robot-related features, individual differences, and situational factors. Evidence from actual leisure and bar environments remains notably scarce, and the combined influence of robot design, consumer psychology, and social context on acceptance is poorly understood. This study seeks to directly address these gaps. According to the International Federation of Robotics (2021), service robots are systems that "perform useful tasks for humans or equipment, excluding industrial automation applications." Building on this definition, Wirtz et al. (2018) describe service robots as "system-based autonomous and adaptable interfaces that interact, communicate, and deliver services to an organisation's customers," highlighting their interactive and social capabilities. This perspective emphasises the relational dimension of service robots, underlining their flexibility, adaptability, and capacity to engage with humans in service activities (Wu et al., 2025).

Service robots represent highly complex socio-technical systems, as they combine service-oriented functionalities with advanced human–robot interaction (HRI) capabilities (Belanche et al., 2020). Their development relies on integrating multiple technologies, including computer vision, speech recognition, sensors, and artificial intelligence algorithms (Lajante et al., 2023). From an organisational perspective, advanced service robots offer substantial potential benefits, such as consistent service quality, continuous availability, and reduced staffing costs (Lee, 2021; Wang et al., 2021). Moreover, they can operate either alongside human workers or as partial substitutes, depending on task requirements and organisational strategies (T. Kim et al., 2023; S. Seo, 2022).

From a psychological perspective, research on HRI in the hospitality domain has primarily focused on constructs such as personalisation and robot characteristics (Kang et al., 2023; H. Kim et al., 2024; Rossi et al., 2022b, 2025), emotional intelligence and social skills (Collins, 2020; Morandini et al., 2025; Phillips et al., 2018; Rana et al., 2025), human mental models (Borelli et al., 2025; Cucciniello et al., 2023), and customers' psychological acceptance and trust based on robots' appearance and behaviour (Ladeira et al., 2023; K. H. Seo & Lee, 2021; Tussyadiah et al., 2020). Within this body of literature, several studies have highlighted that individuals' interactions with robots are influenced by gender stereotypes (Parlangeli et al., 2022; Perugia & Lisy, 2023) and gender-role expectations (Bernotat et al., 2021; S. Seo, 2022).

In addition, human-likeness (HL) and anthropomorphism have emerged as central topics in HRI research. While HL refers to the degree of similarity between a robot's physical features and those of humans (e.g., the presence of a torso, head, and limbs) (Belanche et al., 2020), anthropomorphism concerns users' attribution of human characteristics to robots, such as the ability to think, be sociable, and experience emotions (Blut et al., 2021; Epley et al., 2007). Accordingly, anthropomorphism extends beyond physical appearance and includes non-physical, psychological attributes perceived by users during interaction (H. Kim et al., 2024; Sacino et al., 2022).

Several theoretical frameworks have been developed to explain how users evaluate and engage with robots in HRI and hospitality contexts (T. Kim et al., 2023). Technology-oriented models such as the Technology Acceptance Model (TAM) (Davis, 1985) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003, 2012) emphasise the role of perceived usefulness, ease of use, and social influence in shaping behavioural intentions. Similarly, the Service Robot Ac-

ceptance Model (sRAM) (Wirtz et al., 2018) integrates functional aspects with relational features, including social interactivity, social presence, and perceived empathy (S. Seo, 2022). The I-C-E model (Abrams & Pütten, 2020) adds a social identity perspective, focusing on group-level processes that influence evaluations of both human and non-human agents. Considered jointly, these frameworks provide the theoretical basis for the present study's hypotheses, as elaborated in the Related Work section.

The bartending domain represents a particularly challenging context for service robot deployment, as it combines the manipulation of objects (e.g., preparing and serving drinks) with informal, spontaneous, and socially dense interactions with customers (Rossi et al., 2022b). Only a few studies have examined customer perceptions of service robots in actual hospitality environments, such as restaurants (Odekerken-Schröder et al., 2022; Shah et al., 2023). With specific reference to bar settings, evidence remains scarce, with notable exceptions such as a field study by Rossi et al. (2025) conducted at the Maker Faire in Rome, which assessed customer responses to a robotic bartender operating in a public event context.

In the present study, we address a set of interrelated gaps in the HRI literature within hospitality contexts. Previous research has extensively examined the effects of robot appearance and gender cues on customer attitudes toward service robots, particularly in hotels and restaurants (S. Seo, 2022; Zhu & Chang, 2020). Building on this literature, the present research investigates how robot human-likeness and stereotypical gender cues jointly shape customers' acceptance of a robotic bartender, a service role characterised by high social visibility and relational expectations. Participants were exposed to a realistic scenario in which a human bartender was hypothetically replaced by a robot whose appearance varied systematically in terms of human-likeness (high vs. low) and perceived gender (female vs. male). This design enables the examination of users' anticipatory evaluations of robotic bartenders, including perceived autonomy, resistance, optimism, and intention to use robotic services.

Importantly, the study extends prior work by integrating individual and contextual variables that have received limited empirical attention in hospitality-focused HRI research. First, we consider the Need for Affiliation (Hill, 1987), a motivational trait reflecting individuals' desire for social connection and interpersonal closeness. While social robots are often assumed to appeal to socially oriented users, empirical evidence on how affiliation motives influence resistance or acceptance in leisure service contexts remains limited. Second, we examine the role of Social Context, operationalised as attending the bar alone, with one other person, or in a group. This variable captures the relational setting in which evaluations of service robots occur and aligns with the I–C–E framework (Abrams & Pütten, 2020), which emphasises the role of group processes and shared social norms in shaping responses to non-human service agents.

From an informing science perspective (E. B. Cohen, 2009; Gill & Cohen, 2009), technologies can be conceptualized as informing systems that mediate the flow of information between technological artefacts and human users. In the case of service robots, design features such as human-likeness, gender cues, and perceived autonomy act as informational signals that shape how users interpret the system's capabilities, intentions, and social role. Users do not merely evaluate functional attributes; rather, they construct mental models of the technology based on these signals, which in turn influence their expectations, trust, and behavioural intentions. By examining how robot design cues, individual affiliation motives, and social context jointly affect users' anticipatory evaluations of a robotic bartender, this study contributes to the informing science field by clarifying how technological artefacts inform users and how users interpret and respond to these informational cues within socially situated environments.

A further contribution of this study lies in its ecologically valid design. Data were collected in two real bar settings during public social events, allowing participants to evaluate robotic bartenders within a naturalistic leisure environment. This approach makes it possible to investigate psychological

and social dynamics that are difficult to capture in laboratory studies, while maintaining experimental control over key robot-related variables.

Overall, this study aims to advance current understanding of service robot acceptance by integrating robot design features, individual social motivations, and situational context within a single empirical framework. By focusing on a socially dense and interaction-oriented service role, the findings contribute to a more nuanced understanding of when and for whom humanoid service robots are perceived as appealing, unsettling, or appropriate, with direct implications for the design and deployment of robots in hospitality settings.

RELATED WORK

ANTHROPOMORPHISM AND HUMAN-LIKENESS (HL)

Although semi- or fully autonomous machines ("vending machines") have been used to serve coffee, other cold/hot drinks, and snacks since the 20th century, they have significantly improved in recent years. From being metal parallelepipeds with touch-selection interfaces, with all components inside, they are now gaining skills and social abilities and incorporating head and limb-like arms to interact with clients. As they become more human-like, the anthropomorphism of these machines has attracted research interest (Becker et al., 2023; S. Seo, 2022) because it significantly enhances consumers' intention to use service robots (Chuah et al., 2021). HL in service robots typically involves everything that makes the robot appear human (limbs, arms, faces, hair, eyes, and legs or wheels for movement) (Lu et al., 2021). Simultaneously, anthropomorphism relates human characteristics to non-human entities, such as animals or robots. These concern the ability to produce speech, recognise and adapt to human emotion, and inspire trust, empathy, and cognitive abilities related to the socio-psychological characteristics of human beings (Blut et al., 2021; Qian & Wan, 2024). The integration of human-like features in service robots has emerged as one of the most debated design choices in HRI research, with evidence indicating both facilitation and inhibition effects on consumer acceptance. Within the sRAM framework (Wirtz et al., 2018), robot design is conceptualised not merely in functional terms but as a relational interface: the degree to which a robot conveys social presence, perceived empathy, and interactional naturalness directly shapes consumer willingness to engage.

Evidence broadly supports the idea that increasing HL and anthropomorphism enhances perceived social presence and consumer engagement. A study by Odekerken-Schröder et al. (2022) found that humanoid robots with anthropomorphic features can contribute to a more engaging and satisfying service experience when combined with other factors, such as personalisation. Rossi et al. (2025) found that robots with empathetic, human-like interaction styles increased customer engagement and positive emotions compared to neutral styles. Qian and Wan (2024) demonstrated that anthropomorphic restaurant robots elicited more positive consumer attitudes and greater willingness to accept robotic service than non-anthropomorphic counterparts.

However, this facilitative effect is not linear. A competing body of evidence – consistent with the Uncanny Valley hypothesis (Mori, 1970) – shows that beyond a certain level of human-likeness, consumer comfort turns to discomfort and resistance. T. Kim et al. (2023) found that the best configuration for acceptance was medium visual anthropomorphism combined with high autonomy, suggesting that pushing physical resemblance too far may reduce acceptance rather than boost it. Becker et al. (2023) also noted that exaggerated human-like expectations can cause discomfort when robots fail to meet those expectations, while Gao et al. (2025) linked high HL to insecurity and unease in service environments. Ruiz-Equihua et al. (2023) further observed that anthropomorphism is not always essential for positive outcomes, implying that other factors, such as utility, perceived competence, and contextual relevance, may be more important in some settings.

This ambivalence is theoretically coherent within the sRAM: social presence and perceived empathy are assets only when they align with consumer expectations and relational norms of the service context. In a bar setting, characterised by informal, spontaneous, and socially dense interactions (Rossi et al., 2022b), the gap between a highly humanoid robot's implied relational promise and its actual interactional capacity may be particularly salient, amplifying resistance. We therefore propose two complementary hypotheses:

H1: Robots with higher levels of human-likeness are expected to receive higher ratings for perceived similarity to humans and to be considered more autonomous.

H1a: Robots with higher levels of human-likeness could also elicit ambivalent or resistant attitudes when perceived as too similar to humans, in line with the Uncanny Valley.

Gender Stereotypes

Gender constitutes one of the most immediate and powerful social cues in interpersonal interaction, and its effects extend to human-robot interaction (Ahn et al., 2022; S. Seo et al., 2024). In HRI, gender cues are elicited from voice, colour, physical dimension and proportion (Perugia & Lisy, 2023). Drawing on TAM (Davis, 1985) and UTAUT (Venkatesh et al., 2003, 2012), gender-congruent design is expected to reduce cognitive friction and increase behavioural intention by aligning robot appearance with users' pre-existing social schemas (Palmitesta et al., 2024; Parlangeli et al., 2022; Venkatesh et al., 2003). In service contexts, female robots have been associated with communal traits – warmth, approachability, and verbal responsiveness – while male robots are perceived as more agentic and task-competent (Ahn et al., 2022; S. Seo et al., 2024). Because service roles are culturally coded as female-oriented (S. Seo, 2022), this stereotype predicts greater acceptance of female-presenting robots in hospitality settings.

Gender stereotypes are relatively fixed in people's minds, assuming that men and women have different characteristics that suit different roles or occupations (Fiske, 2018). Empirical evidence partially supports this prediction. S. Seo (2022) found that feminine humanoid robots elicited more positive engagement expectations than male ones in service roles. Studies on gender-role congruency consistently show that robots that match the stereotypical gender of a task role are rated more favourably, whereas mismatches reduce interaction intentions (Hu et al., 2022; Wang et al., 2021). The gender (dis-)match effect also operates at the dyadic level: S. Seo et al. (2024) found that cross-gender customer-robot pairings outperformed gender-matched ones, suggesting that opposite-gender bias, well-documented in human service interactions, transfers to robotic service contexts.

The picture, however, is complicated by findings that challenge a straightforward female-preference model. Huang et al. (2026) found that feminine service robots were perceived as equally agentic as masculine ones, blurring the competence-warmth distinction. Perugia and Lisy (2023) note that gender attribution to robots depends heavily on the combination of physical, vocal, and contextual cues, and that image-only evaluations may not fully activate the social schemas driving gender-congruency effects. These considerations are relevant to the present study, which uses image-based stimuli and thus may produce more conservative gender effects than studies involving embodied or interactive robots. Nonetheless, given the theoretical grounding and the weight of available evidence, we maintain directional hypotheses:

H2: Female robots will elicit greater acceptance and intention to use in serving tasks, reflecting gender-role congruency with the bartending/service role as culturally perceived. Conversely, a gender mismatch will elicit increased consumer resistance (H2a).

H3: The effects of customer gender may decrease with age, highlighting a general increase in resistance to the use of robot bartenders.

Need for Relationships and Social Context

The need for social relationships is fundamental for human beings (Cacioppo & Cacioppo, 2014; S. Cohen, 2004), and its implications for technology acceptance in service contexts remain somewhat underexplored. The Ingroup Identification–Cohesion–Entitativity (I-C-E) framework (Abrams & Pütten, 2020) offers a theoretically grounded perspective for exploring how social identity processes and relational dynamics influence evaluations of non-human agents.

At a group level, people judge service agents, human or robotic, based on their ability to affirm a sense of belonging, uphold norms, and support interactions, not just on technical skills. A robot that fails these social functions may be viewed negatively, not (only) because of technical flaws, but because it breaches social norms.

At an individual level, the Need for Affiliation (McClelland, 1985) denotes an individual's inclination to experience a sense of belonging and connection with others. The Need for Affiliation is one of the three primary motivation needs, alongside achievement and power. Individuals high in Need for Affiliation do not merely prefer social interaction in the abstract; they seek emotionally resonant, responsive, and genuinely reciprocal exchanges (Hill, 1987). Customer affiliation needs are a complex issue within the hospitality industry (Memon et al., 2025). These needs can significantly influence attitudes, decision-making, and behavioural and affective responses (Ralph et al., 2024). Such needs are closely linked to consumer involvement and engagement, and the overall experience with such services depends on the interplay between customers' internal dispositions and perceived service quality (Memon et al., 2025). A challenge in hospitality services is providing interactions to create customer-to-robot value (Lu et al., 2019). Service robots, however sophisticated, remain functionally constrained in their capacity to meet these needs: they cannot provide authentic emotional responsiveness, spontaneous relational attunement, or the sense of being truly seen and understood that characterises satisfying human interaction (Gao et al., 2025; Pelau et al., 2021). From this perspective, high Need for Affiliation should predict greater resistance to robotic service, not despite the robot's social appearance, but precisely because that appearance raises relational expectations the robot cannot fulfil, a functional gap between the affiliation need and the robot's interactional capacity. This interpretation is consistent with evidence showing that socially oriented individuals prefer human over robotic service providers (Preusse et al., 2021; Qian & Wan, 2024) or are more prone to accept a human-robot staff mix (H. Kim et al., 2024). Furthermore, robots perceived as unable to adapt to customers' emotional and relational needs are experienced as cold and unsatisfying (Chong & Zhang, 2025).

At the situational level, the I-C-E framework (Abrams & Pütten, 2020) predicts that the social context in which a consumer encounters a service robot influences both the prominence of relational norms and the evaluative standards applied to the robot. When alone, consumers lack a social reference to calibrate responses; without others' reactions, perceptual processes dominate, heightening focus on the robot's appearance and human cues. In groups, shared norms and conformity can suppress individual perceptions and cause polarization, either scepticism or trust contagion, reducing perceptual differences (Martinez et al., 2023).

Previous research indicates that groups interact more easily with public robots than individuals do (Preusse et al., 2021), although group members also tend to be more variable in their trust judgments, swinging between greater suspicion and greater acceptance depending on emerging social norms within the group (Khoa & Chan, 2024). Importantly, Social Context's effects may vary across robot acceptance dimensions. Perceived visual traits – an immediate, perceptual response – may be affected by social conditions, such as being alone or with others. However, higher-order assessments such as perceived autonomy and intent to use may rely more on individual traits and robot design than situational context. This asymmetry aligns with the I-C-E framework, which separates perceptual responses from evaluative judgments about an agent's role and competence. We thus propose the following hypotheses.

H4: Participants with higher levels of Need for Affiliation are expected to report greater resistance and lower intention to use a robot bartender.

H5: Participants attending the event alone will perceive the robot as more visually human-like than those attending in a group, due to heightened individual attentiveness in the absence of shared social reference.

In summary, the present study tests five hypotheses organised around three thematic clusters. The first concerns the role of robot design: we expect that higher human-likeness will enhance perceived visual similarity and autonomy (H1) but will also elicit greater consumer resistance due to Uncanny Valley dynamics (H1a), and that female-typed robots will receive greater acceptance in a serving role (H2), while gender mismatch will increase resistance (H2a). The second cluster addresses individual differences: older participants and female participants are expected to show lower optimism and intention to use (H3), and individuals with higher Need for Affiliation are expected to report greater resistance, given the functional gap between their relational needs and the robot's interactional capacity (H4). The third cluster concerns situational context: participants attending the event alone are expected to perceive the robot as more visually human-like than those in a group (H5). These hypotheses are tested within an ecologically valid design, described in the following section.

THE STUDY

This study explores participants' perceptions of interacting with a robotic bartender. We focused on two key variables – HL (high/low) and the robot's gender characteristics (female or male) – and examined how these factors influence perception and acceptability. Additionally, we examined participants' gender, Need for Affiliation and Social Context (operationalised as "being alone", "with one other person", or "in a group") to uncover how relational dynamics influence acceptance and willingness to interact with service robots. The experiment was conducted in two real bar settings during social events to elicit authentic social perceptions and emotional responses. The events were the Siena Summer Festival (Siena, Italy) and the Follonica Summer Nights (Follonica, Italy), held from July 2023 to September 2023. These yearly events are typical of Italian summers and represent a collection of events related to art, spectacle, and music.

METHODS

SAMPLE CHARACTERISTICS

Participants were recruited via convenience sampling: a researcher was present at the bar counter during each event, approaching attendees opportunistically, briefly explaining the study's purpose, and inviting them to participate by scanning a QR code with their smartphones. Participation was voluntary, anonymous, and limited to adults aged 18 or older. No other inclusion or exclusion criteria were used. The data collection took place at publicly accessible summer events showcasing art, music, and live performances, reflecting the local recreational setting where the study was conducted.

The sample included 192 participants, balanced concerning gender, with 96 females (50%), ages ranging between 18 and 60 years old ($M_f = 31$, $SD_f = 10.2$; $M_m = 31$, $SD_m = 9.7$). We found no other gender identifications reported. Among the participants, 130 (68%) had not previously been served by robots, and 148 (77%) reported no previous interactions with humanoid robots.

DESIGN

The study employed a 2×2×2 between-subjects factorial design. Two factors were experimentally manipulated: robot human-likeness (high vs. low) and robot gender cues (male-typed vs. female-typed). Participant gender (male vs. female) was included as a measured between-subjects factor. Par-

ticipants were randomly assigned to one of the four robot conditions defined by the 2×2 manipulation, and participant gender was recorded to examine whether gender congruency and human-likeness interact in shaping perceptions and acceptance of service robots.

A power analysis based on conventional criteria for factorial designs indicated that the final sample size (N = 192) represents a reasonable and sufficient number of participants, particularly given the event-based data collection context. While the sample size is adequate for detecting effects of practical relevance, especially main effects and lower-order interactions, the number of participants per experimental cell suggests that three-way interaction effects should be interpreted with caution.

We selected the images of four robots from both the Anthropomorphic roBOT (ABOT; https://www.abotdatabase.info/) database (Phillips et al., 2018) and the Humanoid ROBOts Gender and Age Perception (ROBO-GAP; https://robo-gap.unisi.it/) dataset (Perugia et al., 2022). The selection was based on two criteria: robots' HL scores, and stereotypical gender features. The robots included Geminoid (male, high HL), Lego Vernie (male, low HL), Erica (female, high HL), and Sanbot (female, low HL). The robots and their characteristics are presented in Table 1.

Table 1. Names, pictures, and characteristics of the four robots regarding gender stereotypical characteristics and HL scores

Robot name	Robot picture	Femininity score (M)	Masculinity score (M)	Score (M)
Erika		6.8	1	89.6
Sanbot		5.8	1.3	22.24
Geminoid		1	6.8	92.6
Lego Vernie		1.8	5.5	24.32

Procedure and Measures

We structured four questionnaires – one for each of the robots selected for the study – differing only in the image of the robot they displayed. Participants were randomly assigned to one of the four robot conditions. These assignments were performed by scanning a QR code with the participants'

smartphones directly at the bar counter. The QR codes were distributed during two leisure events at the counters of two bars. Participants were informed about the study and its objectives and asked to give consent to participate.

The questionnaires began with the scenario description: "*We are thinking of replacing the counter staff with the robot barista you see below (a random image of one of the four robots was shown). Please look carefully at the picture and answer the following questions sincerely. For each of the following statements, express your degree of agreement.*" Three sections followed the scenario description. The first and the second sections presented sets of statements through which participants had to evaluate: (a) the robots' appearance, and (b) the participants' need for affiliation. The third section collected information about participants' sociodemographic characteristics, previous interactions with robots, and whether they were attending the event alone, together with another person, or with others.

The first set of statements was adapted from the scale developed by T. Kim et al. (2023). For the present study, we focused on five of the six measures reported by the authors. Two items on the Optimism subdomain were removed due to incongruent meaning in the Italian translation. The five domains concern a general attitude towards a service robot: Perceived Visual Characteristics, Perceived Autonomy, Consumer Resistance, Optimism, and Intention to Use Service Robots. Responses were provided on 13 items using a 7-point Likert scale, ranging from "absolutely disagree" to "absolutely agree".

The second set of statements focused on the participants' Need for Affiliation assessed through the Inter-personal Orientation Scale (IOS), developed by Hill (1987), which identifies four dimensions: Emotional Support, Attention, Positive Stimulation, and Social Comparison. For the present study, we selected 12 items from the original scale based on their consistency with the study's aim. Responses were collected on a 5-point Likert scale, from "not at all true" to "absolutely true". The third section covered sociodemographic information (age, gender, and experience with AI robotic systems). At the end of the questionnaires, we asked two questions about prior interactions with robots and a question regarding the Social Context ("being alone", "with another person", or "in a group"). The study procedure was approved by the Ethical Committee of the University of Siena (CAREUS), protocol number 33/2023.

Data Analysis

We computed participants' scores on the scales measuring individual characteristics, aggregating the scores for the corresponding items in the survey. For all the scales and eventual subscales, reliability was assessed by computing Cronbach's alpha. Concerning the acceptance subdomain, we found a mid-to-good internal consistency for Perceived Visual Characteristics (*α*: 0.84), Perceived Autonomy (*α*: 0.82), Consumer Resistance (*α*: 0.75), Optimism (*α*: 0.71) and Intention to Use Service Robots (*α*: 0.70). Concerning the Need for Affiliation measure (Interpersonal Orientation Scale), we found an acceptable internal consistency (*α*: 0.68). We performed ANOVAs to analyse participants' ratings about the five domains of the robots' Acceptance and Need for Affiliation measures, and correlations between continuous variables. All the analyses were conducted using RStudio (version 4.0.2).

Results

The results show three main patterns: (1) there are statistically significant differences between participants' gender, with males generally reporting a more positive attitude toward robots compared to females; (2) contrasting results concerning anthropomorphism, but coherent with "Uncanny Valley" theory (Mori, 1970), humanoid robots are perceived as similar to humans, but elicit greater resistance to use; and (3) significant correlations between Need for Affiliation and robots' interaction, suggesting that the Social Context and relational factor influence technology acceptance.

Age and Gender

Before testing the main hypotheses, we performed a correlation analysis (Pearson's r) between Age and measures of the Robots' Acceptance (Perceived Visual Characteristics; Perceived Autonomy; Consumer Resistance; Optimism; and Intention to Use Service Robots) (H3). The results concerning Age showed no statistical significance for the domains of Perceived Visual Characteristics, Perceived Autonomy and Consumer Resistance; while for the domains of Optimism and Intention to Use Service Robots we found a negative correlation with Age (respectively $r = -0.28$; $p < 0.001$, and $r = -0.27$; $p < 0.001$). Older participants seem not to think positively about robots and are less inclined to use them. Linear regression models confirm that Age is a predictor of the domains of Optimism ($F(3,188) = 10.83$; $p < 0.001$; Adjusted R2: 0.13) and Intention to Use Service Robots ($F(3, 188) = 8.31$, $p < 0.001$; Adjusted $R^2 = 0.10$): older participants reported lower levels of optimism ($b = -0.054$, $p < 0.001$) and a lower intention to use service robots ($b = -0.051$, $p = 0.002$). We found no significant interactions between Age and Gender on Robots' Acceptance measures. Moreover, we performed an ANOVA between Gender and measures of the Robots' Acceptance (Perceived Visual Characteristics; Perceived Autonomy; Consumer Resistance; Optimism, and Intention to Use Service Robots). All domains of Robots' Acceptance showed a significant difference between females and males, except for Perceived Visual Characteristics (Table 2).

Table 2. Results of one-way ANOVA test on acceptance measures by gender

Measures	F	df/residuals	p
Perceived Visual Characteristics	3.28	1/190	0.07
Perceived Autonomy	4.07	1/190	**0.045**
Consumer Resistance	8.38	1/190	**0.004**
Optimism	12.46	1/190	**<0.001**
Intention to Use Service Robots	8.78	1/190	**0.003**

In Table 2, significant gender differences emerge on all acceptance dimensions except Perceived Visual Characteristics, with males scoring higher on autonomy, optimism, and intention to use, and females scoring higher on consumer resistance. Males participants rated higher scores on Perceived Autonomy (M_m-M_f = 0.39; $p = 0.045$), Optimism (M_m-M_f = 0.73; $p < 0.001$), and Intention to Use Service Robots (M_m-M_f = 0.72; $p = 0.003$); while females participants reported higher scores on Consumer Resistance (M_m-M_f = -0.73; $p = 0.004$) (Figure 1).

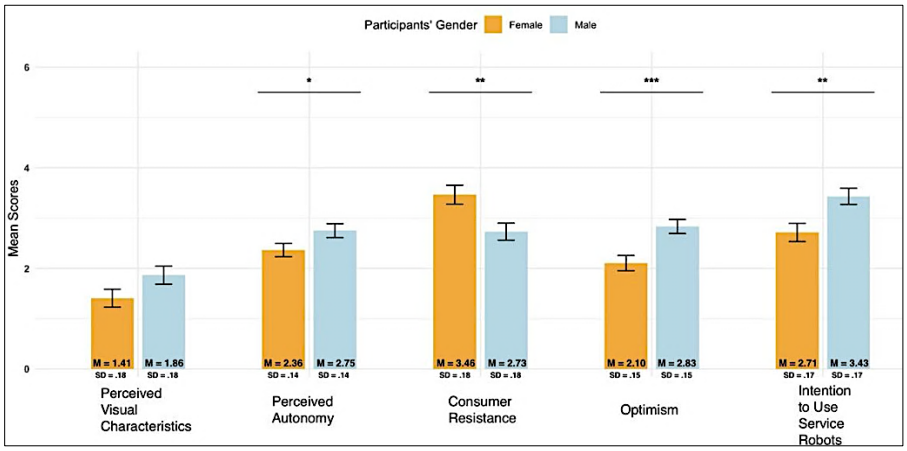

Figure 1. Gender differences on robots' acceptance measures, with means and standard deviations

Note: The significance level is marked with one asterisk for $p<.05$, two asterisks for $p < 0.01$, and three asterisks for $p < 0.001$.

Figure 1 shows that male participants consistently report more positive attitudes towards robot bartenders across all significant dimensions, with the largest gap observed in Optimism and Consumer Resistance.

Acceptance of Robots

We analysed the social robots' acceptance through 3-way ANOVA comparisons in the five domains of the Robots' Acceptance measure (Perceived Visual Characteristics; Perceived Autonomy; Consumer Resistance; Optimism, and Intention to Use Service Robots), using the HL (H1, H1a) and Robot's Gender (H2, H2a) as manipulated factors and the Participants' Gender as subjective variable (Table 3). Tukey HSD post-hoc tests were applied for pairwise comparisons following significant main effects and interactions. In Table 3, the main effects of Participants' Gender are significant across all dimensions, except Perceived Visual Characteristics; HL drives effects on Perceived Visual Characteristics and Consumer Resistance; significant three-way interactions emerge for Perceived Visual Characteristics and Perceived Autonomy.

Table 3. Main and interaction effects (with F-statistic and p-value) on outcome variables (ANOVA results)

	Main effects			Interaction
Measure	**Participants' gender**	**Robots' gender**	**HL**	**3-way interaction**
Perceived Visual Characteristics	4.00; 0.054	6.97; **0.13**	23.15; **<0.001**	5.15; **0.036**
Perceived Autonomy	4.11; **0.044**	0.001; 0.97	1.36; 0.25	5.8; **0.02**
Consumer Resistance	8.66; **0.004**	0.27; 0.60	7.35; **0.007**	0.46; 0.50
Optimism	12.86; **<0.001**	0.01; 0.92	4.33; **0.04**	1.30; 0.26
Intention to Use Service Robots	9.15; **0.003**	0.001; 0.98	2.47; 0.12	1.41; 0.24

Note: Significant *p*-values are in bold.

A three-way ANOVA was conducted to examine the effects of Participants' Gender, Robots' Gender, and HL on Perceived Visual Characteristics. The analysis revealed significant main effects of Robots' Gender ($F(1, 184) = 6.35$; $p = 0.013$; $\eta^2 = 0.03$) and HL ($F(1, 184) = 21.92$; $p < 0.001$; $\eta^2 = 0.11$), with male and humanoid robots being rated more positively. No significant two-way interactions were found. However, a significant three-way interaction emerged between Participants' Gender, Robots' Gender, and HL ($F(1, 184) = 4.47$; $p = 0.036$; $\eta^2 = 0.02$). Tukey post-hoc tests indicated that male participants rated humanoid male robots significantly higher on Perceived Visual Characteristics than all other combinations (e.g., Vs. female participants evaluating non-humanoid female robots $\Delta = 4.05$; $p < 0.001$), suggesting a preference influenced by gender-role congruency and human-likeness. Female participants showed more moderate evaluations across conditions, with generally lower ratings of male robots. These results highlight that visual appeal is not only driven by robot design but also shaped by the users' own gender and social expectations (Figure 2A).

Another three-way ANOVA model was performed on Perceived Autonomy. The analysis revealed a significant main effect of Participants' Gender ($F(1, 184) = 4.11$; $p = 0.044$; $\eta^2 = 0.02$), with male participants reporting higher autonomy scores overall. While no significant main effects were found for Robots' Gender or HL individually, a significant three-way interaction again emerged between Participants' Gender, Robots' Gender, and HL ($F(1, 184) = 5.80$; $p = 0.017$; $\eta^2 = 0.03$). Although no pairwise comparisons reached statistical significance after adjustment, Tukey post-hoc tests suggested that male participants tended to rate male humanoid robots and female nonhumanoid robots as more autonomous than other robot types. In contrast, female participants showed a slight preference for female humanoid and male non-humanoid robots. However, across conditions, their autonomy ratings remained generally lower than those of male participants (Figure 2B). These results suggest that

perceptions of autonomy may be influenced by gender-matching cues and robot morphology, with users potentially attributing competence based on stereotype-congruent characteristics. In Figure 2, male participants rate humanoid male robots highest on Perceived Visual Characteristics, while the pattern for Perceived Autonomy reflects gender-congruency effects moderated by human-likeness.

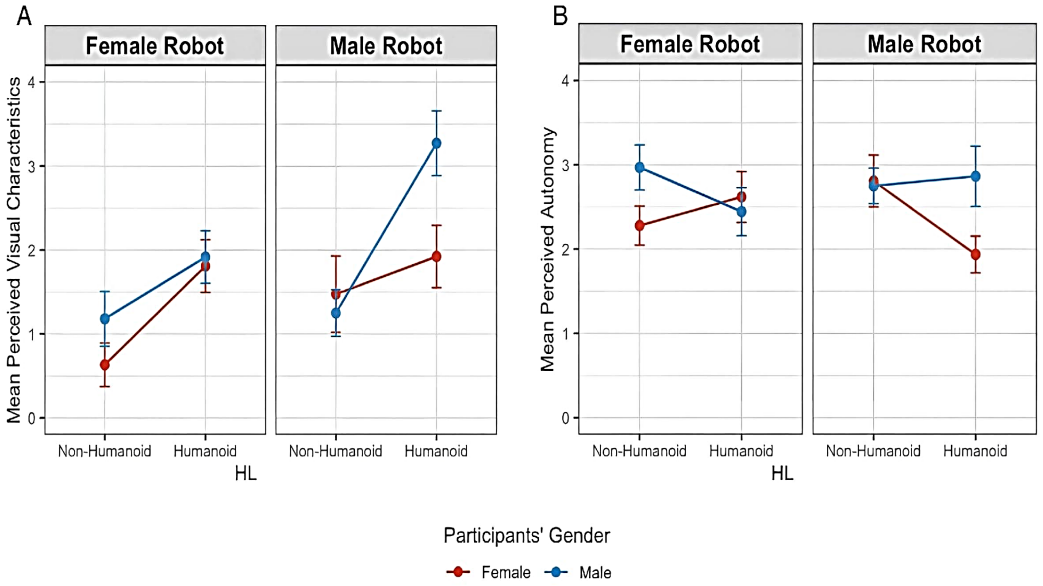

Figure 2. 3-way ANOVA models interactions on perceived visual characteristics (A) and perceived autonomy (B) by participants' gender, robots' gender and HL

We reported the results of planned comparisons on marginal means across the levels of Participants' Gender, Robots' Gender, and Human-Likeness, including standard deviations and significance levels (Table 4). In Table 4, the high-HL robots score higher on Perceived Visual Characteristics but also elicit greater Consumer Resistance; male participants report higher Optimism and Intention to Use across conditions.

Table 4. Main and interaction effects on outcome variables (ANOVA results)

Measure	Participants' gender Male M (SD) Female M (SD)	Robots' gender Male M (SD) Female M (SD)	HL High HL M (SD) Low HL M (SD)
Perceived Visual Characteristics	1.91 (0.17) 1.46 (0.17)	**1.98 (0.17)*** **1.39 (0.17)***	**2.23 (0.17)***** **1.13 (0.17)*****
Perceived Autonomy	2.76 (0.14) 2.41 (0.14)	2.59 (0.14) 2.58 (0.14)	2.47 (0.14) 2.70 (0.14)
Consumer Resistance	**2.76 (0.18)*** **3.42 (0.18)***	3.14 (0.18) 3.04 (0.18)	**3.43 (0.18)*** **2.75 (0.18)***
Optimism	**2.81 (0.14)*** **2.16 (0.15)***	2.49 (0.15) 2.47 (0.14)	**2.27 (0.15)*** **2.69 (0.14)***
Intention to Use Service Robots	**3.40 (0.17)*** **2.79 (0.17)***	3.10 (0.17) 3.09 (0.17)	2.91 (0.17) 3.29 (0.17)

Note: Significant *p*-values are in bold. Asterisks indicate significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Concerning the 3-way ANOVA on Consumer Resistance variable, the analysis revealed a significant main effect of Participants' Gender ($F(1, 184) = 8.66$; $p = 0.004$; $\eta^2 = 0.04$) and a significant main effect of HL ($F(1, 184) = 7.35$; $p = 0.007$; $\eta^2 = 0.04$). Moreover, a significant interaction emerged between HL and Robots' Gender ($F(1, 184) = 4.28$; $p = 0.04$; $\eta^2 = 0.02$). Tukey post hoc tests showed that male non-humanoid robots were rated significantly lower on consumer resistance compared to male humanoid robots (Mm_huMm_NonHu= 1.19; $p = 0.005$), suggesting that more mechanical-looking male robots may elicit greater trust or lower rejection; instead, female robots did not show significant differences in HL (Figure 3.A). Results on Optimism 3-way ANOVA revealed a main effect of Participants' Gender ($F(1, 184) = 12.86$; $p = <0.001$; $\eta^2 = 0.07$) and a main effect of HL ($F(1, 184) = 4.33$; $p = 0.039$; $\eta^2 = 0.02$); moreover, a significant HL and Robot Gender interaction emerged ($F(1, 184) = 7.59$; $p = 0.019$; $\eta^2 = 0.03$). Tukey post-hoc tests showed that male non-humanoid robots were perceived as more optimistic than male humanoid robots ($M_{m\_Hu} - M_{m\_NonHu} = -1.12$; $p = 0.006$), potentially reflecting discomfort or mismatch with expectations. Female robots did not show significant differences (Figure 3.B).

Concerning 3-way ANOVA on the Intention to Use Service Robots variable, the 3-way ANOVA model yielded a significant main effect of Participants' Gender ($F(1,184) = 9.15$; $p = 0.003$; $\eta^2 = 0.05$) and a significant interaction between HL and Robots' Gender ($F(1, 184) = 9.75$; $p = 0.002$; $\eta^2 = 0.05$), although no significant main effects were detected. Tukey post-hoc tests indicated that intention to use was highest for male non-humanoid robots, and significantly lower for male humanoid robots ($M_{m\_Hu} - M_{m\_NonHu} = -1.12$; $p = 0.006$). Evaluations of female robots were more consistent across both HL levels (Figure 3C). Figure 3 shows that for male robots, higher human-likeness increases Consumer Resistance and reduces Optimism and Intention to Use, while female robots show more consistent evaluations across HL levels.

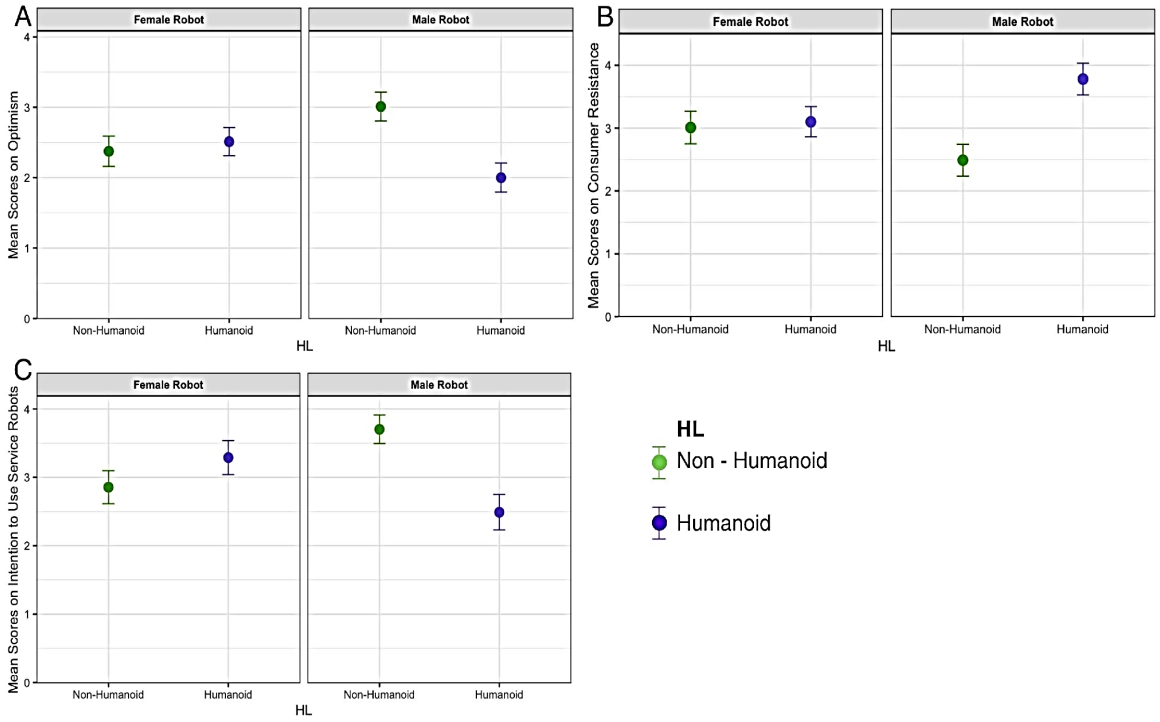

Figure 3. Interaction between robots' gender and HL on consumer resistance (A), optimism (B) and intention to use service robots (C)

Need for Affiliation and Social Context

We performed a correlation analysis between the measures of Robots' Acceptance (Perceived Visual Characteristics, Perceived Autonomy, Consumer Resistance, Optimism and Intention to Use Service Robots) and the Interpersonal Orientation Scale and subdomains (Emotional Support, Attention, Positive Stimulation, and Social Comparison), to explore the relationship between perception elicited by robots and social-emotional aspects which could influence their acceptability (H4). We used Pearson's coefficient to compute the linear relationship between the variables. However, due to the non-normal distribution of some variables, we complemented the analysis with Spearman's coefficient. Both analyses produced consistent results with only negligible differences (Figure 4). Figure 4 shows that the Need for Affiliation correlates positively with Consumer Resistance, particularly through the Emotional Support and Positive Stimulation subdomains, whereas it shows negligible associations with other acceptance dimensions.

The results highlighted a positive relationship between internal domains of the robots' acceptance measure. Consumer Resistance showed negative correlations with other acceptance measures, as expected, given that it captures a reversed dimension (i.e., non-acceptance). This is particularly evident between Consumer Resistance, Optimism, and Intention to Use Service Robots domains (respectively, $r = -0.74$; $p = <0.001$ and $r = -0.72$; $p = <0.001$). Similar positive correlation results emerge between the Interpersonal Orientation Scale and its domains. Moreover, a positive correlation was found between Consumer Resistance and the Interpersonal Orientation Scale total score ($r = 0.20$; $p = 0.003$), as well as Emotional Support ($r = 0.26$; $p = 0.0003$) and Positive Stimulation subdomains ($r = 0.28$; $p < 0.001$). Participants with higher Need for Affiliation are more likely to score higher on Consumer Resistance, that is, being cautious and distrustful toward robots.

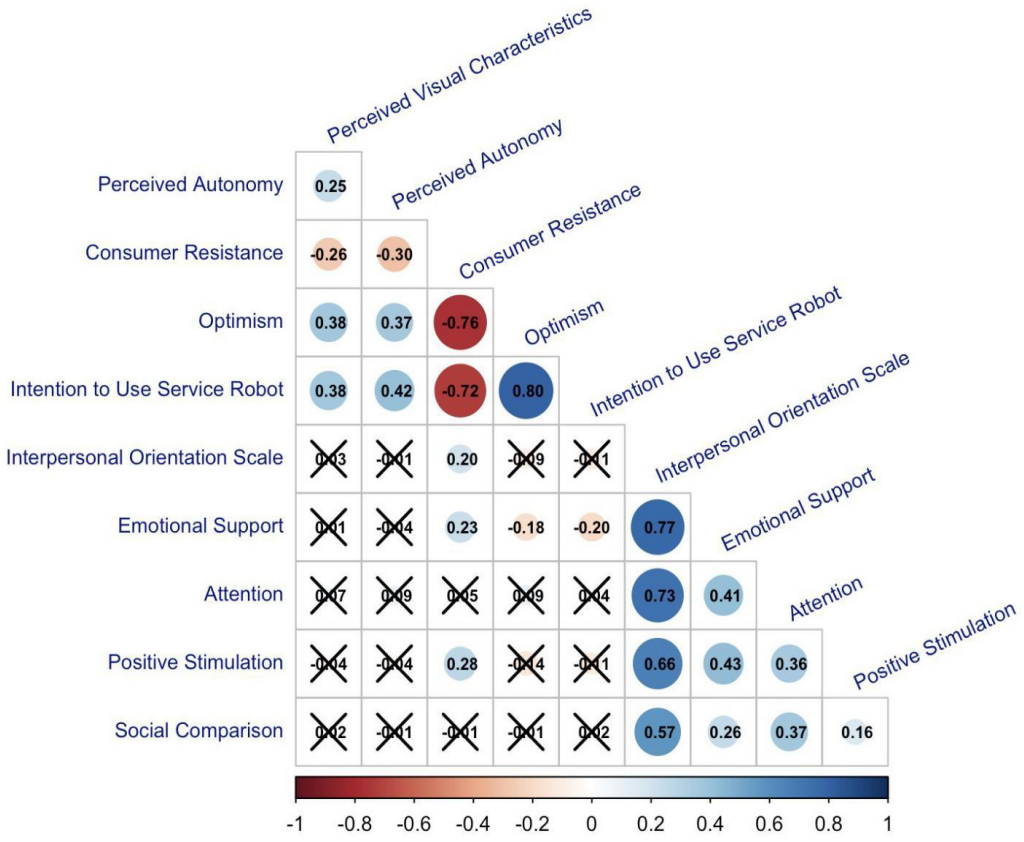

Figure 4. Pearson's correlation results between robots' acceptance and need for affiliation measures

Further analysis has been conducted to explore the influence of Social Context as a predictor of Robots' Acceptance measures (H5). Social Context has been defined as being alone, with another person, or in a group at the bar. In the sample, 26 participants were alone, 64 were with another person, and 102 were in a group. We checked for homogeneity of variance between groups (Levene's Test), normality of residuals (Shapiro-Wilk Test), and Q-Q plots for each measure to proceed with ANOVA. We found no statistically significant difference in Social Context scores on the Robots' Acceptance measures in linear regression models with the Interpersonal Orientation Scale as a covariate.

We performed a 1-way ANOVA on the Robots' Acceptance measures, in which only the Perceived Visual Characteristics model was statistically significant. Although there was only a violation (Shapiro-Wilk) of the assumption for the ANOVA (valid but susceptible to normality variation), we decided to use the Kruskal-Wallis test (ANOVA was significant and post hoc showed the same significance). Results showed a significant difference between customers in a group and those alone (chisq = 7.37; df = 2; p = 0.025). Figure 5 shows that participants who attend alone rate the robot significantly higher on Perceived Visual Characteristics than those in a group, suggesting that social context influences perceptual, but not evaluative, responses.

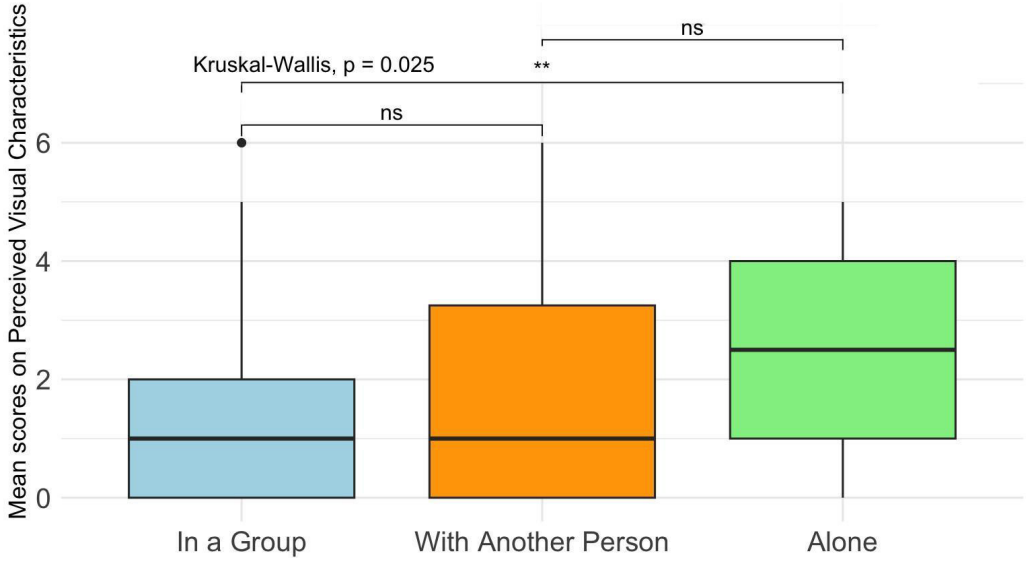

Figure 5. Kruskal-Wallis test on perceived visual characteristics by social context

DISCUSSION AND CONCLUSION

THEORETICAL IMPLICATION

The results confirm that human-likeness operates as a double-edged design feature in the acceptance of service robots. Consistent with the sRAM (Wirtz et al., 2018), higher HL enhanced perceived visual characteristics, suggesting that moderate human-like appearance successfully activates social presence cues and raises the robot's relational salience (Khoa & Chan, 2024; Qian & Wan, 2024). However, the same robots caused more consumer resistance, aligned with Uncanny Valley theory (Mori, 1970), but better explained by sRAM in informal, emotional bar interactions, a highly humanoid robot raises relational expectations it cannot fulfil. Our data show that non-humanoid scores are lower on Perceived Visual Characteristics, in line with Becker et al. (2023), indicating that robot appearance is an important aspect (H1). Nevertheless, the Consumer Resistance measure scores show that non-humanoid robots receive less refusal, as confirmed by the Optimism measure scores, which suggest that in this context, participants are more inclined to relate to non-humanoid robots (Mende et al.,

2019), contrary to prior findings (Qian & Wan, 2024; Ruiz-Equihua et al., 2023) (H1a). Notably, this ambivalence was moderated by robot gender: while humanoid female robots showed consistent evaluations across acceptance dimensions, humanoid male robots elicited the strongest resistance and the lowest optimism, suggesting that gender-congruency cues and human-likeness do not operate independently. H1 was therefore confirmed; support was found specifically for H1a in the context of male humanoid robots, a finding that complicates straightforward applications of the sRAM and calls for more nuanced models of how multiple design dimensions interact in shaping social presence perceptions.

Robot gender cues had a more limited influence on acceptance than expected, affecting only how robots were visually perceived, not how they were evaluated or accepted. The data only partly supported H2 and completely failed to support H2a. Robot gender significantly influenced perceived visual features, with male-typed robots rated more positively, but no significant differences were found in resistance, optimism, or intention to use. This is especially notable given that, in service settings, female robots and gender-congruent job expectations tend to be preferred (S. Seo, 2022), and bartending could reasonably be seen as a social, relational role more aligned with female stereotypes. Rather than disproving gender-congruency theory, this pattern indicates a boundary condition: assigning gender to robots depends on the convergence of physical, vocal, and contextual cues (Perugia & Lisy, 2023), and visual stimuli alone activate only some of these. Without movement, voice, or live interaction, the social schemas underpinning gender-congruency effects may not be sufficiently engaged to influence behavioural intentions, as seen in Huang et al. (2026).

The current findings, therefore, suggest that robot gender effects in HRI depend on the modality. The tendency to attribute greater agency to male-featured robots (reflected here in higher perceived visual qualities) is consistent with previous research (Ahn et al., 2022) but contrasts with the female-serving stereotype often observed in hospitality contexts (Cai et al., 2024; Perugia & Lisy, 2023). The lack of gender effects on behavioural measures aligns with Huang et al. (2026), who found that feminine service robots are perceived as more communal but equally agentic as masculine ones, blurring the functional distinctions implied by gender-congruency theory. Overall, these results suggest that the gendered perception of robots influences views on appropriateness and agency (Guidi et al., 2022; Hu et al., 2022; S. Seo, 2022; Wang et al., 2021), but such effects may only fully manifest in live interactions where vocal, behavioural, and contextual cues combine to activate gender-related social schemas.

The results underscore that service robot acceptance is not a uniform response to design features but a psychologically mediated process shaped by stable individual characteristics. Male participants reported higher perceived autonomy, optimism, and intention to use, while female participants showed greater resistance – a pattern consistent with gender-stereotype research suggesting that women may evaluate robotic service through a lens of societal role expectations and relational norms that robots currently fail to meet (Forgas-Coll et al., 2022; Odekerken-Schröder et al., 2022). Age similarly moderated acceptance, with older participants reporting lower optimism and intention to use, replicating findings by Ferber and Vaziri (2024) and suggesting that generational familiarity with technology remains a relevant adoption barrier even in ecologically valid settings, partially confirming H3. This partially contrasts with Roozen et al. (2023), who reported no significant age effect on perceived service quality, suggesting a complex relationship between age and robot acceptance that warrants further exploration.

Contrary to the intuitive belief that socially oriented individuals would be attracted to humanoid robots, a higher Need for Affiliation, which reflects a tendency towards emotional closeness and genuine reciprocal interaction, predicted increased consumer resistance, thus fully supporting H4. In the I-C-E framework (Abrams & Pütten, 2020), this outcome highlights a fundamental functional gap: individuals seeking emotionally resonant, reciprocal, and authentically responsive interactions perceive the robot not as a social partner but as an inadequate substitute for human connection (Preusse

et al., 2021; Qian & Wan, 2024). The robot's human-like appearance may paradoxically intensify this effect by making the disparity between relational promise and actual capacity more apparent.

Both the Need for Affiliation and Social Context findings share a key theoretical insight: acceptance of service robots is not solely determined by design features but is fundamentally influenced by the relational and social conditions surrounding the interaction, affecting how the informing process between robot and consumer develops.

The influence of social context was notable but limited: participants alone rated the robot higher on perceived visual features than those in a group, while no significant differences appeared regarding autonomy, optimism, or intention to use, partly supporting H5. In the I-C-E framework, this pattern can be explained: when alone, consumers lack a social reference group to base their evaluations on, increasing their focus on the robot's surface traits. In group settings, shared evaluative norms and conformity pressures reduce individual perceptual responses, resulting in more moderate and consistent visual assessments (Khoa & Chan, 2024; H. Kim et al., 2024). This finding also underscores a methodological boundary condition. With static visual stimuli, participants only see the robot's appearance, not its behaviour or capabilities. It is therefore logically consistent that Social Context influences visual perception – being more attentive and less influenced by group dynamics when alone – but not constructs such as autonomy and intention to use, which require a functional assessment that images cannot fully evoke. Whether these effects would appear in live interactions, where group dynamics, turn-taking, and shared experiences are fully involved, remains an open and crucial question for future research.

Taken together, these findings contribute to the Informing Science transdiscipline by showing that the informing process between a robotic bartender and its clients is not determined solely by the informer's design features, but is critically modulated by client characteristics – gender, age, Need for Affiliation – and situational context. This perspective aligns with experimental evidence demonstrating that individual differences in how users perceive and relate to robots, including their subjective assessment of human-likeness, shape the quality and outcomes of human-robot interaction itself (Cominelli et al., 2021). Optimising human-robot informing processes, therefore, requires attention to the psychological and social profile of the client, not only to the technical and aesthetic properties of the robot.

Practical Implications

The current findings have several practical implications for hospitality providers, robot designers, and service managers. First, in terms of robot design, the mixed effects of human-likeness suggest that moderately anthropomorphic robots – sufficiently human-like to generate social presence but not so human-like as to create unmet relational expectations – are more likely to be well received in bar environments than fully humanoid ones. Gender-neutral designs may also help minimise the risk of triggering stereotypical expectations that the robot cannot meet, while avoiding ethical issues related to reinforcing gendered service roles. Second, the individual difference findings emphasise that a one-size-fits-all approach to deploying robots is unlikely to be successful. Male and younger customers showed greater openness to robotic service, while female customers and those with higher Need for Affiliation expressed more resistance. Practitioners should consider flexible, hybrid human-robot service models that allow customers to choose their preferred interaction style – human or robotic – rather than imposing a single service format. In contexts where social dynamics are particularly important, such as group settings, robots should be designed to support rather than replace human social interaction, incorporating features that promote emotional comfort without overstepping relational boundaries. Finally, hospitality stakeholders are urged to approach robot deployment with ethical awareness, ensuring that design choices are inclusive, user-centred, and sensitive to the diverse psychological and social profiles of their clientele.

Limitations

The present study provides some limitations. The study employed convenience sampling at publicly accessible events, which may have resulted in a sample that over-represents younger, event-attending adults. The generalisability of the findings to broader bar clientele – including older customers, habitual bar-goers, or those with different cultural backgrounds – should therefore be interpreted with caution. Regarding sample size and representativeness, the study was conducted in specific cultural and geographical settings during summer events at real bars. While this enhances ecological validity in some respects, it also limits the cultural generalizability of the results, especially for gender-based comparisons. Additionally, although the study had sufficient power to detect small to medium effects, the sample size might not be large enough to identify very small interaction effects, which should be examined in future research with larger samples. The sensitivity and reliability of the measures used in the study pose a limitation. Specifically, the Interpersonal Orientation Scale (IOS) exhibited a reliability of = 0.68, marginally below the commonly accepted threshold. Future research might consider refining existing scales or adopting alternative, validated measures to improve reliability and sensitivity. The experimental design has inherent limitations, especially in balancing ecological validity with experimental control. While it enhances realism, the real-world context decreases control over participants' motivation and focus. Many participants were easily distracted and showed low intrinsic motivation, potentially compromising data quality. Additionally, the use of personal smartphones during the experiment introduced further interruptions, including notifications and external distractions, which likely affected the accuracy of their responses.

An additional limitation relates to the image-based nature of the stimuli. Participants assessed static photographs of robots rather than engaging with them directly, so their responses reflect anticipatory rather than experiential attitudes. Cues such as movement, voice, response latency, and physical proximity – all known to influence HRI perceptions – were absent, potentially reducing effects, especially concerning robot gender. The robots presented in the study were selected solely on the basis of HL and gender criteria, rather than specific bartender-related functionalities or competencies. Consequently, the robots' perceived abilities and suitability as bartenders might not have been fully captured. Another limitation concerns the absence of a human bartender control condition. Although the present study focused on variations in robot design characteristics within a real service context, including a human condition in future research would allow for a more direct comparison and more straightforward interpretation of the observed effects. A further limitation is the participants' limited prior experience with service robots. While this mirrors the current adoption stage in real-world hospitality settings, familiarity with robotic technologies could affect perceptions and attitudes. Future studies should consider including robot experience as a control or moderating variable to explore how familiarity influences acceptance and interaction patterns as exposure to service robots increases. Finally, our results need to be contextualised with previous research that examined moderating factors not discussed here. Research shows that factors such as interaction fluency, facial expressivity, engagement behaviours, voice and linguistic style, as well as robot and customer personality traits, influence acceptance. These suggest acceptance of service robots depends on deeper cognitive and relational processes, not just surface features like appearance or gender cues.

Future Studies

Future research should investigate how consumers' emotional states influence satisfaction and interaction with service robots, guiding more adaptive design and task allocation (Lajante et al., 2023; Rana et al., 2025). It should also delve into the psychological and interactive processes behind users' evaluations to better understand how these factors shape acceptance and trust. In particular, studies using physically present or video-based robot stimuli, rather than static images, would enable researchers to examine whether robot gender effects on behavioural intentions occur when vocal, movement, and proximity cues are available, addressing the modality-dependent boundary condition identified in the present study. Exploring the effects of familiarity and prior experience with robots is another valuable area, as these factors may influence perceptions of usefulness, comfort, and social

presence over time. Longitudinal designs would be particularly valuable for monitoring how repeated exposure to service robots influences acceptance trajectories in real hospitality settings. Further research on gender attribution and its alignment or misalignment with customer expectations can inform robot personalisation and acceptance (Aşkın et al., 2023; S. Seo et al., 2024). Finding the right mix of human-like and machine-like features is crucial, especially concerning comfort, resistance, and interaction quality (Becker et al., 2023). The Need for Affiliation has become a theoretically important individual difference variable; future research should investigate whether this effect replicates across various service contexts and whether it interacts with robot design features beyond human-likeness. Similarly, the influence of Social Context on higher-level acceptance dimensions (autonomy and intention to use) should be explored in live interaction settings where group dynamics are fully engaged. Lastly, studying multi-robot and multi-user interactions, along with the inclusion of a human bartender control condition, can provide insights into group dynamics, experiential learning, and sustained engagement in real-world hospitality environments.

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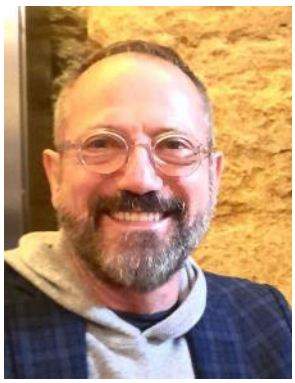

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