

Are consumers more attracted to restaurants featuring humanoid or non-humanoid service robots?

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ABSTRACT

The restaurant industry has witnessed a dramatic rise of service robots. Previous research suggests that humanoid service robots are perceived as social entities and thus might lead to more favorable consumer responses than non-humanoid service robots. However, not all consumers prefer the presence of social entities when eating out. The current research reveals that consumers' reactions to restaurants featuring humanoid versus non-humanoid service robots depend on whether they will dine out alone (i.e., solo diners) or with others (i.e., group diners). Specifically, the findings suggest that group diners exhibit more favorable attitudes and behavioral intentions toward restaurants featuring humanoid (vs. non-humanoid) service robots, whereas solo diners respond more favorably toward restaurants featuring non-humanoid (vs. humanoid) service robots. Furthermore, anticipated psychological comfort is revealed as the underlying mechanism explaining these effects.

1. Introduction

In the restaurant industry, one of the impactful global trends is the increasing adoption of service robots (Akdim et al., 2021; Lu et al., 2021). According to a recent marketing study, the global food robotics market was assessed at 1.9 billion in 2020, and it is anticipated to achieve \$4.0 billion by 2026 (Markets and Markets, 2020). Service robots not only have been used to save labor costs and streamline services but also to serve as an important marketing tool to attract consumers (Ivanov and Webster, 2020; Shin and Kang, 2020). For example, the "Wall-E"-themed restaurant in China and the robotic pizza restaurant in Pakistan have doubled their sales several months after adopting service robots (Agency, 2017; Nguyen, 2016). The COVID-19 pandemic has speeded up the progress of service robot adoption in restaurants. For example, many restaurants around the world have recently replaced human waiters with service robots, such as the FOODOM Tianjiang Food Kingdom in China, Mad for Garlic in Korea, and Royal Palace Renesse in Netherlands (Funk, 2020; Lyons, 2020; Teller Report, 2020), as service robots can help reduce the risk of human-to-human transmission and create a safer dining environment (Liu et al., 2022; Romero and Lado, 2021; Wan et al., 2020).

By appearance, service robots have been categorized into humanoid and non-humanoid service robots (Gong and Nass, 2007; Yam et al., 2021). Humanoid service robots are characterized by their human-like appearances (e.g., a head, arms, and legs) and motions. It is noteworthy that some humanoid service robots contain human-like features that are often simplified or stylized and do not realistically like humans in appearance, such as the robots in the Netherlands Royal Palace Renesse restaurant (Lyons, 2020). Some have an appearance that is close to a real human as technically possible, such as the robotic receptionists in Henn na Hotel that look like real women (Kikuchi, 2018). However, a large body of research has shown that humanoid service robots with a highly human-like appearance are often perceived as creepy and create aversive reactions, such as feelings of eeriness (Walters et al., 2008; Yam et al., 2021), and thereby are excluded in our investigation. In this research, we focus on humanoid service robots with moderately human-like features and non-humanoid¹ service robots with machine-like appearances because they are commonly used in the restaurant industry.

Given the rapid rise of service robots, growing research attention has been dedicated to understanding consumers' evaluations of service robots (Akdim et al., 2021; Chang and Kim, 2022; Kim et al., 2019; Liu

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¹ It is important to note that non-humanoid service robots can be mechanical that do not have human-like features (as the one used in the present research) but could also be zoomorphic and caricatured such as Amazon Astro that looks like a dog (Yam et al., 2021; Zhang et al., 2021).

et al., 2022; Lu et al., 2021; Qiu et al., 2020). Prior research on anthropomorphism and robots demonstrates that humanoid service robots are advantageous as their human-like features can lead consumers to perceive them as more approachable “social entities,” which helps enhance consumers’ acceptance and evaluations of service robots (Doorn et al., 2017; Pinxteren et al., 2019; Qiu et al., 2020). As a result, consumers may respond more favorably to humanoid service robots than non-humanoid service robots (Li et al., 2010; Pinxteren et al., 2019; Qiu et al., 2020). Indeed, some restaurateurs are willing to adopt humanoid service robots even though they are nearly four times as expensive as non-humanoid service robots (Color Depot, 2021; eBay, 2021).

However, the existing stream of research on consumer responses to service robots has mainly focused on group diners (i.e., those who dine out with others) (Lu et al., 2021; Pinxteren et al., 2019; Qiu et al., 2020), and our understanding of solo diners’ decision-making regarding restaurants featuring service robots is limited. Such a research gap should be addressed since the number of solo diners (i.e., those who dine out alone) is rapidly rising due to the changing demographic and individualized lifestyles (Bianchi, 2016; Her and Seo, 2018). For example, recent marketing research revealed that solo diners accounted for 35% of restaurant visits (15.4 billion) in the U.S. in 2019 (Group, 2020). In this research, we propose that consumer responses to restaurants featuring non-humanoid versus humanoid service robots are contingent on diner type (solo vs. group). Specifically, in the online reservation context, we propose that the positive effect of humanoid (vs. non-humanoid) service robots is only held among group diners but not among solo diners. Compared to group diners, solo diners tend to feel uncomfortable with the presence of others and have a people-avoidance motive at restaurants since they often receive social gaze and anticipate negative inferences from others about their social connectedness (Brown et al., 2020; Her and Seo, 2018). As humanoid (vs. non-humanoid) service robots are more likely to be perceived as “social entities” (Doorn et al., 2017), solo diners tend to anticipate that dining out at a restaurant featuring humanoid (vs. non-humanoid) service robots will be less comfortable, and thus respond less favorably toward the restaurant. Specifically, we predict that solo diners will indicate more favorable attitudes toward the restaurant, visit intention, and e-WOM intention toward restaurants featuring non-humanoid (vs. humanoid) service robots. Furthermore, we propose that anticipated psychological comfort will mediate the joint effects of robot type (non-humanoid vs. humanoid) and diner type (solo vs. group) on consumer responses.

This research offers several contributions. First, previous research on service robots has mostly focused on human-robot interaction processes and investigated the impact of robot type on consumer responses during consumption (Lu et al., 2021; Qiu et al., 2020); yet, we center on the pre-consumption stage and examine how robot type affects consumers’ attitudes and behavioral intention. In doing so, we extend the hospitality marketing literature on robot innovations by demonstrating that robot type can be an important factor that influences marketing effectiveness. Second, while previous research emphasizes the merits of humanoid service robots (Li et al., 2010; Pinxteren et al., 2019; Qiu et al., 2020), this work identifies a situation in which humanoid service robots can backfire and are less appealing than non-humanoid service robots by taking diner type into consideration. To our knowledge, this work is among the first to examine the congruency effect of robot type and diner type. The findings show that group diners indicate more favorable attitudes and behavioral intentions toward restaurants featuring humanoid (vs. non-humanoid) service robots, whereas solo diners respond more favorably toward restaurants featuring non-humanoid (vs. humanoid) service robots. These findings also advance our understanding of solo diners and extend the burgeoning literature on solo dining. Third, we demonstrate that anticipated psychological comfort is the mechanism driving the congruency effect between robot type and diner type, contributing to recent research underscoring the importance of anticipated psychological comfort in consumers’ decision-making (Brown

et al., 2020; Her and Seo, 2018). Managerially speaking, this research offers restaurateurs important insights regarding how to utilize robot type and their target customer type, solo or group diners, to boost restaurant visits.

2. Conceptual background

2.1. Service robots as a marketing tool

The hospitality and tourism industries, particularly the restaurant industry, have recently witnessed a dramatic rise of robots (Akdim et al., 2021; Kim et al., 2022; Lin et al., 2022; Lu et al., 2021; Zhang et al., 2021). Compared to human employees, robots have prominent advantages in operation management, such as cost efficiency, being free of fatigue and task errors, and consistently providing homogenous services at a fast speed (Huang and Rust, 2018; Wirtz et al., 2018). Some robots can be used for front-of-house tasks (e.g., check-in/check-out, information provision, item delivery, etc.) (Ivanov and Webster, 2020). For example, many restaurants, such as Yamm World Buffet restaurant in Scotland and Touch Restaurant in Turkey, utilize robots to serve customers (Hwang et al., 2020). These robots can be applied to various service delivery processes in restaurants, such as providing menu information, taking orders, delivering foods to customers, picking up used dishes, and processing payments (Hwang et al., 2020). On the other hand, some robots can be used for back-of-house tasks (e.g., cooking, cleaning, information analysis, etc.) (Ivanov and Webster, 2020). For example, Spyce restaurant in Boston (Beltis, 2021) and Komodo Chinese Cuisine in Brick use robots in their kitchens to cook food (Schneider, 2021).

In this research, we focused on robots that work in the front-of-house, which can interact, communicate and deliver services to consumers and have been referred to as “service robots” (Lu et al., 2021; Ivanov and Webster, 2020; Romero et al., 2021; Wirtz et al., 2018; Zhang et al., 2021). First, unlike robots in the back-of-house that do not have interactions with consumers, service robots need to interact with consumers in the service delivery process and thus directly influence consumers’ service experiences (Wirtz et al., 2018). Consistent with this view, previous research shows that service robots can affect consumers’ service satisfaction (Chang and Kim, 2022), revisit intention (Lu et al., 2021), brand image (Hwang et al., 2020), and the purchase amount (Kanda et al., 2010). Second, service robots often require consumers’ involvement and thus enhance uncertainties in service delivery processes (Ivanov and Webster, 2020). For example, consumers might feel frustrated if they do not know how to place an order with a service robot. Last but most importantly, recent research has started to pay attention to the potential marketing implications of service robots, calling for more future research on this field (Murphy et al., 2019; Ivanov and Webster, 2020). Indeed, as service robots can offer service experiences different from those that are offered by human employees, they could be used as a marketing tool to attract consumers (Ivanov and Webster, 2020; Pinxteren et al., 2019).

The importance of service robots as a marketing tool has increased since the COVID-19 outbreak. The hospitality and tourism industries have been greatly hit by the COVID-19 pandemic, and many consumers are worried or reluctant to go to public service places such as restaurants and hotels. To provide a safer environment and attract consumers, a growing number of restaurants, hotels, airports, and other service companies worldwide have implemented service robots (Funk, 2020; Lyons, 2020; Teller Report, 2020; Wan et al., 2020). Recent hospitality and tourism research has started to recognize the significant role of service robots as a marketing tool in attracting consumers. For example, Chuah et al. (2022) find that consumers are willing to visit and even pay more for restaurants with service robots as they have a higher need for physical distancing during the COVID-19 pandemic. In the hotel setting, Kim et al. (2021) reveal that consumers prefer to stay in robot-staffed rather than human-staffed hotels when the risk of contracting

COVID-19 is high. Similarly, Romero and Lado (2021) show that generation Z consumers believe that robots can reduce the contagion risk of the COVID-19 pandemic and thus are willing to book hotels adopting robots. Therefore, it is theoretically and practically important to investigate the marketing implications of service robots in today's marketplace.

While service robots have been widely utilized in various industries, there are consumers resistant to service robots and reluctant to accept services delivered by robots, representing a major obstacle to the integration of service robots (Fu et al., 2022; Ivanov and Webster, 2020; Rodríguez Sánchez et al., 2020). Prior research has investigated several factors that influence consumer responses toward service robots, which can be categorized into four types, including 1) robot design factor, 2) consumer features factor, 3) contextual factor, and 4) organizational factor (Chang and Kim, 2022). Specifically, robot design factors include anthropomorphism (Akdin et al., 2021; Lu et al., 2021; Murphy et al., 2019; Romero et al., 2021; Zhang et al., 2021), robot gender (Seo, 2022), functional-related features such as perceived usefulness (Schepers and Wetzels, 2007; Song et al., 2022) and perceived intelligence (Kervenoael et al., 2020; Kim et al., 2022), etc. For example, Kim et al. (2022) reveal that consumers' perceived intelligence, perceived social presence, and perceived social interactivity of service robots are positively related to their acceptance of service robots. Consumer features factors could be individual differences such as technology readiness (Hwang et al., 2020) and the need for social interaction (Yoganathan et al., 2021). For example, Yoganathan et al. (2021) suggest that consumers with a high need for social interaction tend to experience high psychological risk when they interact with service robots, which negatively influences their intention to visit hotels with service robots. Contextual factors include social influence (Lu et al., 2019), social crowding (Hou et al., 2021), task type (Lin et al., 2022; McLeay et al., 2021), and the risk of COVID-19 pandemic (Kim et al., 2021; Liu et al., 2022; Shin et al., 2020), etc. For example, Hou et al. (2021) find that increasing social crowding in destinations can motivate consumers to choose hotel services provided by service robots rather than human staff. Organizational factor mainly focuses on a firm's relationship orientation (Chang and Kim, 2022; Fan et al., 2021). For example, Chang and Kim (2022) demonstrate that consumers' responses to different types of service robots depend on whether the company is adopting a communal or exchange relationship orientation.

Amongst the aforementioned factors, anthropomorphism has received great academic attention and has been recognized as a decisive force in boosting consumers' acceptance of service robots (Akdin et al., 2021; Lu et al., 2021; Murphy et al., 2019; Romero et al., 2021; Zhang et al., 2021). However, prior hospitality research on service robot anthropomorphism predominately centers on human-robot interaction processes and examines the impact of robot type on consumer responses during consumption (Akdin et al., 2021; Kim et al., 2019; Lu et al., 2021; Qiu et al., 2020; Zhang et al., 2021). Surprisingly, little work has yet to focus on the pre-consumption stage. Hence, it is still unclear whether the type of service robots featured in a restaurant's advertisement affect consumers' perceptions and decisions to visit the restaurant. More importantly, the existing research examining consumer responses toward service robots has not considered the consumer feature factor of diner type (i.e., diners eating alone or with a companion in restaurants). To fill these gaps, the current research centers on the online reservation context and takes diner type into account to investigate when and how robot type (non-humanoid vs. humanoid) influences consumer responses, including attitudes toward the restaurant, visit intention, and e-WOM intention.

2.2. Humanoid service robots as "social entities"

Prior service research generally conceptualizes social agents as human beings that consumers encounter in the service setting (e.g., waiters and other consumers in restaurants) and has examined how

consumers' decision-making processes are influenced by the mere presence of social agents (Argo et al., 2005; Liu and Mattila, 2015). However, recent research posits that social agents are not necessarily real humans but could be technology-generated entities (Doorn et al., 2017). It is worth noticing that technologies, such as service robots, can create a sense of automated social presence, which describes the extent to which technologies lead people to feel the presence of "social entities" (Chang and Kim, 2022; Doorn et al., 2017; Yoganathan et al., 2021). For example, Chang and Kim (2022) find that service robots can be perceived as social entities that consumers interact with at service encounters and thus they could be evaluated based on the competence and warmth dimensions of social judgement. In today's service industries, service robots have been applied to numerous frontline service encounters and make consumers feel that they are interacting with "social entities," altering the nature of service experiences (Choi et al., 2019; Larivière et al., 2017).

More importantly, it has been shown that service robots with high anthropomorphism tend to generate a feeling of automated social presence and be perceived as "social entities," which results in positive consumer responses (Doorn et al., 2017; Kim et al., 2022; Yoganathan et al., 2021). Anthropomorphism describes a tendency that people ascribe human-like characteristics, traits, and behaviors to nonhuman agents (e.g., service robots), and such a tendency is more salient when agents possess human-like features (Aggarwal and McGill, 2007; Fan et al., 2020). Although service robots are not truly humans, their human-like features, such as human-like appearances, motions, or simply human names, often promote people to perceive these robots as social beings with human-like minds (Yoganathan et al., 2021). For example, Yoganathan et al. (2021) show that as compared to self-service machines that don't have any human-like features, humanoid robots can generate a higher level of automated social presence, which in turn boosts consumers' intention to visit hotels. Therefore, people are very likely to spontaneously and unconsciously apply knowledge and belief used in interpersonal communication to service robots that include human-like features (Pinxteren et al., 2019; Qiu et al., 2020).

Drawing on the anthropomorphism theory, previous research has suggested that compared to non-humanoid service robots, humanoid service robots are superior in motivating people to form social judgments and beliefs of the agent, which subsequently result in more positive evaluations and behavioral outcomes (Kim et al., 2019; Lu et al., 2021; Yoganathan et al., 2021). For instance, Kim et al. (2019) find that compared to non-humanoid service robots, humanoid service robots are considered as warmer and more sociable, thus motivating people to bond with them. Moreover, Pinxteren et al. (2019) show that humanoid robots serving as hotel receptionists can induce a sense of trust and enhance consumers' enjoyment and usage intentions. Similarly, in both the restaurant and hotel contexts, Qiu et al. (2020) show that consumers would like to spend more time with humanoid rather than non-humanoid service robots. More recently, Lu et al. (2021) suggested that humanoid (vs. non-humanoid) service robots are perceived as more credible, thus subsequently inducing more favorable responses for robotic services in restaurants. Yoganathan et al. (2021) show that as compared to non-humanoid service robots, humanoid service robots can enhance consumers' expected quality and lead to a higher willingness to pay.

2.3. The congruency between robot type and diner type

While hospitality researchers and practitioners have demonstrated humanoid (vs. non-humanoid) service robots' competitive advantages of being perceived as "social entities" (Doorn et al., 2017; Qiu et al., 2020; Lu et al., 2021), they have neglected an important fact. That is, not all diners desire the presence of social entities when eating out. Indeed, prior research suggests that compared to group diners, solo diners tend to feel uncomfortable with the presence of others when eating at restaurants (Her and Seo, 2018; Hwang et al., 2018). For one thing, as

dining out has generally been considered as a group activity, solo diners often receive unwanted social gaze and are seen as lonely, which can make them feel highly stressed and embarrassed (Takeda and Melby, 2017). For another, when eating out alone at a restaurant, solo diners may anticipate negative inferences from others (Her and Seo, 2018; Ratner and Hamilton, 2015). Therefore, solo diners often try to avoid people when dining out at restaurants to mitigate the uncomfortable feeling (Hwang et al., 2018). For example, solo diners may prefer to sit in a place far away from others and eat very quickly (Choi et al., 2020). These findings suggest that compared to group diners, solo diners tend to have a people-avoidance motive when eating out (Hwang et al., 2018). Indeed, several strategies have been used in the restaurant industry to meet solo diners' people-avoidance motive, such as providing single tables (Hwang et al., 2018), arranging their seats relatively far away from others (Moon et al., 2020), using curtains to block views from waiters and other diners (Dai, 2018). Recently, in a qualitative study, Brown et al. (2020) mentioned that utilizing service robots might help attract solo diners and improve their dining experience by reducing the interaction with human waiters, though they did not look into the differences between non-humanoid versus humanoid service robots.

In the online reservation context, we argue that consumer responses to restaurants featuring non-humanoid versus humanoid service robots depend on diner type (solo vs. group). As discussed earlier, humanoid (vs. non-humanoid) service robots are more likely to be perceived as "social entities" (Doorn et al., 2017). Given that solo diners tend to feel uncomfortable with the presence of others (Brown et al., 2020; Her and Seo, 2018), they should prefer to visit a restaurant featuring non-humanoid rather than humanoid service robots. In contrast, given that group diners are less influenced by others' social presence (Ratner and Hamilton, 2015), they should fully embrace humanoid service robots. In other words, solo diners should better match with non-humanoid service robots, whereas group diners would better fit with humanoid service robots. Therefore, we expect that the congruency between robot type and diner type (i.e., using non-humanoid service robot to attract solo diners and using humanoid service robots to attract group diners) will lead to more positive consumer responses, including 1) attitudes toward the restaurant, 2) visit intention, and 3) electronic word-of-mouth (e-WOM) intention.² Formally,

H1.. For solo diners, restaurants featuring non-humanoid (vs. humanoid) service robots will create more favorable (a) attitudes toward the restaurant, (b) visit intention, and (c) e-WOM intention.

H2.. For group diners, restaurants featuring humanoid (vs. non-humanoid) service robots will create more favorable (a) attitudes toward the restaurant, (b) visit intention, and (c) e-WOM intention.

2.4. The mediating role of anticipated psychological comfort

Psychological comfort refers to a state of being comfortable, relaxed, and at ease in an environment, such as dining at a restaurant (Pijls et al., 2017). It is vital to enhance consumers' psychological comfort in the service context since it can positively influence their visit intention (Choi et al., 2020), satisfaction (Kivela and Chu, 2001), evaluations of service quality (Paswan and Ganesh, 2005), e-WOM (Lloyd and Luk, 2011), and loyalty behaviors (Butcher et al., 2001). Given that the service delivery process often involves face-to-face communications between service providers and consumers, the service provider's appearance could be a critical factor that affects consumers' psychological comfort (Baumann et al., 2016; Rosenbaum and Montoya, 2007). For example, Rosenbaum and Montoya (2007) show that consumers are likely to feel comfortable in restaurants when they are served by waiters

with similar ethnicity. Baumann et al. (2016) suggest that consumers tend to feel uncomfortable when they are served by employees with Tattoos. As service is intangible, in the pre-consumption process, consumers often anticipate the psychological comfort of the service experience and make judgments based on external cues, such as the service provider's appearance (Koernig and Page, 2002). Following this logic, service robots' appearance (i.e., robot type) could be an important external cue that affects consumers' anticipated psychological comfort and subsequently influences their decision-making.

In the online reservation context, we propose that consumers' anticipated psychological comfort of the dining experience depends on whether the robot type is congruent with diner type. Prior research suggests that humanoid service robots are superior to non-humanoid service robots in increasing consumers' feelings of comfort about the robotic service (Qiu et al., 2020). For example, Qiu et al. (2020) find that people tend to feel uncomfortable with robotic services due to the lack of humanness in service robots, and moderately increasing humanness (i.e., humanoid service robots) can enhance consumers' feelings of comfort with robotic hospitality services. Similarly, Nakanishi et al. (2018) show that humanoid service robots in hotels might generate a heartwarming perception and make guests feel comfortable with the service. However, these studies did not consider the consumer type of being solo or group. In this research, we expect that the level of anticipated psychological comfort will be enhanced when robot type (non-humanoid vs. humanoid) "matches" diner type (solo vs. group). Specifically, we predict that the congruency between robot type and diner type (i.e., using non-humanoid service robots to attract solo diners and using humanoid service robots to attract group diners) will enhance consumers' anticipated psychological comfort, which in turn, leads to favorable consumer responses. Therefore, we propose that anticipated psychological comfort is the underlying mechanism driving the congruency effect between robot type and diner type. Formally,

H3.. Anticipated psychological comfort will mediate the impact of robot type and diner type on (a) attitudes toward the restaurant, (b) visit intention, and (c) e-WOM intention.

The conceptual framework is provided in Fig. 1.

3. Methodology

3.1. Study design

The current research used a 2 (robot type: non-humanoid vs. humanoid) $\times$ 2 (diner type: solo vs. group) between-subjects experimental design. One hundred eighty-nine U.S. adults MTurkers (Daly and Natarajan, 2015; Paolacci et al., 2010) took part in the experiment. In terms of demographics, respondents' age ranged from 18 and 69 ($M = 39.4$), 57.7% were male, 72.0% were Caucasian, 83.6% held a college degree or higher, and 79.4% reported an annual household income of \$40,000 or above.³

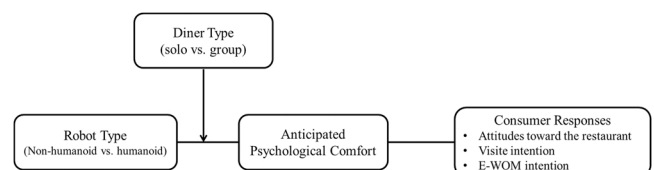


Fig. 1. Conceptual framework.

² We also examine consumer responses to robot type in terms of e-WOM intention as consumers' e-WOM is a powerful factor affecting sales (Eisingerich et al., 2015).

³ Similar patterns of results were observed when including consumers' previous experiences with service robots as a control variable in the statistical analyses.

3.2. Procedures and measurement

Respondents in this study were instructed to imagine that they wanted to have a dinner at a casual dining restaurant. While searching on an online reservation platform, they encountered a casual dining restaurant called Robotic Eatery (fictitious name) that was run by service robots. Diner type was manipulated by asking respondents to imagine that they were going to dine out alone (solo condition) or with friends (group condition), adapted from Her and Seo (2018). Robot type was manipulated through pictorial stimuli following real service robots in the marketplace (Loizos, 2020; Lyons, 2020). Specifically, non-humanoid service robots did not have any human-like design, whereas humanoid service robots have basic body structures (e.g., a head and arms; see Appendix A).

Attitudes toward the restaurant were captured with three items (negative/positive, unfavorable/favorable, bad/good; $\alpha = 0.89$), adapted from Sujaan and Bettman (1989). Visit intention was captured with three items by asking respondents to indicate their likelihood to dine out at this restaurant (unlikely/likely, impossible/possible, improbable/probable; $\alpha = 0.89$), adapted from Yi (1993). E-WOM intention was captured with four items adapted from Eisingerich et al. (2015). Specifically, we asked respondents to report their likelihood that they would “say positive things about this restaurant on social media sites (e.g., Yelp, Instagram, Twitter, Facebook),” “use social media sites to encourage friends and relatives to patronize this restaurant,” “recommend this restaurant on social media sites,” and “become a fan of this restaurant on social media sites” (not at all/very much; $\alpha = 0.93$). Respondents also indicated their anticipated psychological comfort if they were to dine out at Robotic Eatery alone [with friends] (uncomfortable/comfortable, not at ease/at ease, unrelaxed/relaxed; $\alpha = 0.90$), adapted from Pijls et al. (2017). All variables were captured by using a 7-point scale.

Regarding the manipulation check of diner type, respondents were instructed to report whether they have someone to dine out with in the scenario (1 = no, I dine out alone, 7 = yes, I dine out with others). The manipulation of robot type was checked by measuring the extent to which service robots are human-like with three items (human-like/machine-like; have features of a human being/do not have any features of a human being; look like a human being/look like a machine, $\alpha = 0.76$). Finally, respondents reported the realism of the scenario (1 = unrealistic, 7 = realistic).

4. Results

4.1. Manipulation check

The two-way ANOVA on the diner type manipulation check score showed a significant difference between solo condition and group condition ($M_{solo} = 3.23$, $M_{group} = 6.13$; $F(1, 185) = 117.67$, $p < 0.001$). The

two-way ANOVA on the robot type manipulation check score showed that the humanoid service robot was considered more human-like than the non-humanoid service robot ($M_{humanoid} = 4.77$, $M_{non-humanoid} = 5.68$; $F(1, 185) = 26.46$, $p < 0.001$). Moreover, respondents indicated that the scenario was realistic ($M = 5.51$; $t = 16.60$, $p < 0.001$, compared with the midpoint). Therefore, our manipulations were successful.

4.2. Consumer responses

The two-way ANOVA on attitudes toward the restaurant showed a main effect of diner type ($F(1, 185) = 5.66$, $p < 0.05$), and particularly, there was a significant two-way interaction between robot type and diner type ($F(1, 185) = 32.04$, $p < 0.001$), represented in Fig. 2 Panel a. The simple effect analysis revealed that in the solo condition, respondents reported more favorable attitudes toward the restaurant when it featured non-humanoid (vs. humanoid) service robots ($M_{non-humanoid} = 5.75$, $M_{humanoid} = 4.57$; $F(1, 185) = 19.55$, $p < 0.001$). In contrast, in the group condition, respondents reported more favorable attitudes toward the restaurant when it employed humanoid (vs. non-humanoid) service robots ($M_{non-humanoid} = 5.17$, $M_{humanoid} = 6.00$; $F(1, 185) = 12.57$, $p < 0.001$).

The two-way ANOVA on visit intention showed a main effect of diner type ($F(1, 185) = 6.39$, $p < 0.05$), and particularly, there was a significant two-way interaction between robot type and diner type ($F(1, 185) = 35.68$, $p < 0.001$), represented in Fig. 2 Panel b. The simple effect analysis indicated that in the solo condition, respondents indicated a higher level of visit intention when the restaurant featured non-humanoid (vs. humanoid) service robots ($M_{non-humanoid} = 5.88$, $M_{humanoid} = 4.54$; $F(1, 185) = 23.70$, $p < 0.001$). In contrast, in the group condition, respondents reported a higher level of visit intention when the restaurant employed humanoid (vs. non-humanoid) service robots ($M_{non-humanoid} = 5.25$, $M_{humanoid} = 6.10$; $F(1, 185) = 12.33$, $p < 0.001$).

The two-way ANOVA on e-WOM intention showed a main effect of diner type ($F(1, 185) = 10.29$, $p < 0.05$), and particularly, there was a significant two-way interaction between robot type and diner type ($F(1, 185) = 25.42$, $p < 0.001$), represented in Fig. 2 Panel c. The simple effect analysis revealed that in the solo condition, respondents indicated a higher level of e-WOM intention when the restaurant employed non-humanoid (vs. humanoid) service robots ($M_{non-humanoid} = 5.27$, $M_{humanoid} = 3.99$; $F(1, 185) = 17.19$, $p < 0.001$). In contrast, in the group condition, respondents reported a higher level of e-WOM intention when the restaurant featured humanoid (vs. non-humanoid) service robots ($M_{non-humanoid} = 4.89$, $M_{humanoid} = 5.69$; $F(1, 185) = 8.54$, $p < 0.05$).

4.3. Mediating effect of anticipated psychological comfort

Moderated mediation analyses were performed to explore the mediating role of anticipated psychological comfort (PROCESS Model 8, Hayes, 2017). In the moderated mediation model testing H3a, we

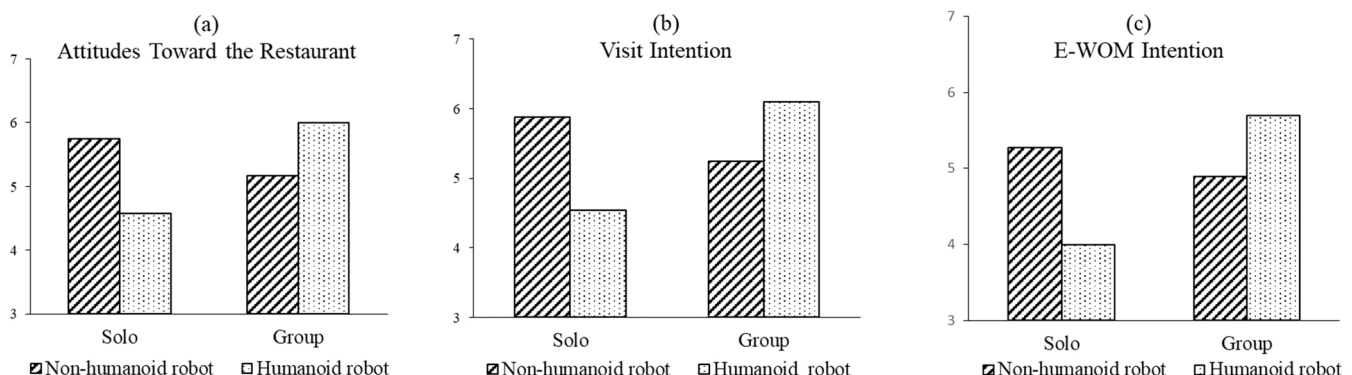


Fig. 2. The effects of robot type and diner type on (a) attitudes toward the restaurant, (b) visit intention, and (c) e-WOM intention.

entered robot type as the independent variable, diner type as the moderator, anticipated psychological comfort as the mediator, and attitudes toward the restaurant as the dependent variable. Results indicated a significant moderated mediation process through anticipated psychological comfort (index of moderated mediation = -0.684 , 95% CI = $[-1.0517, -0.3817]$), such that anticipated psychological comfort mediated the impact of robot type on attitudes toward the restaurant in both the solo condition (indirect effect = 0.4553 , 95% CI = $[0.2159, 0.7405]$) and the group condition (indirect effect = -0.2287 , 95% CI = $[-0.4114, -0.0690]$).

In the moderated mediation model testing H3b, we entered visit intention as the dependent variable, the independent variable, moderator, and the mediator were the same as the previous moderated mediation analysis. Results indicated a significant moderated mediation process through anticipated psychological comfort (index of moderated mediation = -0.7367 , 95% CI = $[-1.1092, -0.4021]$), such that anticipated psychological comfort mediated the impact of robot type on visit intention in both the solo condition (indirect effect = 0.4904 , 95% CI = $[0.2324, 0.7835]$) and the group condition (indirect effect = -0.2463 , 95% CI = $[-0.4321, -0.0715]$).

In the moderated mediation model testing H3c, we used e-WOM intention as the dependent variable, the independent variable, moderator, and the mediator were the same as the previous moderated mediation analysis. Results indicated a significant moderated mediation process through anticipated psychological comfort (index of moderated mediation = -0.6862 , 95% CI = $[-1.0314, -0.3668]$), such that anticipated psychological comfort mediated the impact of robot type on e-WOM intention in both the solo condition (indirect effect = 0.4568 , 95% CI = $[0.2168, 0.7295]$) and the group condition (indirect effect = -0.2294 , 95% CI = $[-0.4131, -0.0648]$).

5. Discussions

An increasing number of restaurants around the world have adopted service robots to enhance cost efficiency as well as to attract consumers (Akdin et al., 2021; Lu et al., 2021). The trend of adopting service robots in restaurants has been accelerated by the outbreak of the COVID-19 pandemic, where restaurateurs aim to boost restaurant visits by offering a safer dining environment and lowering the risk of human-to-human transmission of the virus (Wan et al., 2020). Unlike robots in the back-of-house, service robots (i.e., robots in the front-of-house) need to communicate with consumers in service delivery processes and significantly affect consumers' service evaluations and experiences (Wirtz et al., 2018). Due to the critical and unique role of service robots, a growing number of studies have emerged to understand consumers' evaluations and reactions toward service robots (Kim et al., 2019; Lu et al., 2021; Pinxteren et al., 2019; Qiu et al., 2020; Yogananthan et al., 2021). In contrast with prior studies emphasizing the merits of humanoid service robots (Li et al., 2010; Pinxteren et al., 2019; Qiu et al., 2020), we explore a boundary situation in which humanoid service robots can backfire and are less appealing than non-humanoid service robots from the diner type perspective. Specifically, in the online reservation context, we investigate the joint effects of robot type (non-humanoid vs. humanoid) and diner type (solo vs. group) on consumers' (a) attitudes toward the restaurant, (b) visit intention, and (c) e-WOM intention. Results show that while group diners exhibit more favorable responses toward restaurants featuring humanoid (vs. non-humanoid) service robots, solo diners prefer restaurants featuring non-humanoid (vs. humanoid) service robots. The moderated mediation analysis further indicates that anticipated psychological comfort mediates the influence of robot type and diner type on consumer responses.

5.1. Theoretical implications

The theoretical implications of this research are notable. First, this work contributes to the hospitality marketing literature on robot

innovations by examining the relative effectiveness of humanoid vs. non-humanoid service robots in attracting consumers to visit restaurants. Despite the increasing research attention in understanding consumer evaluations of service robots, prior research has largely centered on human-robot interaction processes and examined consumer responses during consumption (Lu et al., 2021; Qiu et al., 2020). There is evidence showing that service robots could be an effective marketing tool that attracts consumers and boosts businesses (Shin and Kang, 2020; Wan et al., 2020). Contributing to this line of research, this work focuses on the pre-consumption stage and explores whether and how knowing robot type influences consumers' decision-making. In the online reservation context, our findings show that robot type can affect consumers' attitudes toward the restaurant, visit intention, and e-WOM intention. These findings are particularly important in today's digital world that people gradually get used to checking restaurant information online before visiting it. Moreover, these findings also add to prior research investigating the role of service robots' appearance in consumer responses (Li et al., 2010; Pinxteren et al., 2019; Qiu et al., 2020) and offer valuable insights to robot designers and researchers in robotics.

Second, we extend the hospitality literature on service robots by examining the congruency effect between robot type and diner type. While prior research demonstrates that humanoid service robots tend to induce more favorable consumer responses than non-humanoid service robots (Li et al., 2010; Pinxteren et al., 2019; Qiu et al., 2020), these studies have largely restricted the investigation to group consumers, with strikingly little attention devoted to solo consumers. In the current research, we shed light on the potential backlash of humanoid service robots and identify a situation where they become less appealing than non-humanoid service robots by taking both group diners and solo diners into consideration. Our findings show that group diners indicate more favorable responses toward restaurants featuring humanoid (vs. non-humanoid) service robots, which is consistent with prior studies building on the anthropomorphism theory, which posits that human-like features can motivate consumers to apply knowledge about humans to service robots and increase their receptivity to robotic services (Pinxteren et al., 2019; Qiu et al., 2020). However, our findings also show that featuring non-humanoid rather than humanoid service robots is more effective in attracting solo diners who tend to have a people-avoidance motive. These findings also deepen our understanding of solo diners, echoing prior research that calls for factors affecting solo diners' decision-making (Brown et al., 2020; Choi et al., 2020).

Finally, we identified anticipated psychological comfort as the mechanism underlying the congruency effect of robot type and diner type. Consumers tend to seek a comfortable dining experience. Prior research suggests that before visiting the restaurant, consumers often anticipate their dining experience based on surrounding online cues, such as the appearance of human service providers (Koernig and Page, 2002; Li et al., 2019). While recent hospitality research suggests that humanoid service robots positively influence consumers' psychological comfort of service experience (Nakanishi et al., 2018; Qiu et al., 2020), these studies have mostly focused on group consumers. Extending this stream of research, this work reveals that consumers' anticipated psychological comfort can be enhanced when robot type "matches" diner type. Specifically, our findings show that group diners anticipate greater psychological comfort if the restaurant features humanoid (vs. non-humanoid) service robots. In contrast, solo diners believe that they would feel more comfortable if they could dine out at a restaurant featuring non-humanoid (vs. humanoid) service robots, which is congruent with the view that people tend to feel uncomfortable with the presence of others when dining out alone at restaurants (Brown et al., 2020; Her and Seo, 2018). Furthermore, our findings show that the enhanced anticipated psychological comfort leads to a series of positive downstream consequences, including attitudes toward the restaurant, visit intention, and e-WOM intention. Therefore, this work also enriches the emerging research emphasizing the importance of the anticipated psychological comfort in consumers' decision-making (Brown et al.,

2020; Her and Seo, 2018).

5.2. Managerial implications

The managerial implications of the current research are also notable. Based on our findings, restaurants planning to adopt service robots should ensure the robot type would be a good match for their target customers (i.e., solo and group diners). Humanoid service robots have been shown to bring more benefits to companies than non-humanoid service robots (Li et al., 2010; Pinxteren et al., 2019; Qiu et al., 2020). However, our findings revealed that while humanoid service robots are more effective in attracting group diners, non-humanoid service robots outperform in attracting solo diners. Therefore, for restaurants whose target customers are group diners, such as family-style restaurants, managers are suggested to adopt humanoid service robots. In contrast, it is better to adopt non-humanoid service robots when restaurants mainly target solo diners. For example, according to recent marketing research, solo diners account for 35% of restaurant visits in the U.S. in 2019, and more importantly, 89% of them eat meals at quick-service restaurants (QSR, 2020). Therefore, non-humanoid service robots might be a better choice for quick-service restaurants. These findings are particularly important after the COVID-19 outbreak, which has speeded up service robot integration in the restaurant industry (Wan et al., 2020). Furthermore, humanoid service robots are nearly four times as expensive as non-humanoid robots (Color Depot, 2021; eBay, 2021). Therefore, by choosing the right service robots, restaurants can not only maximize marketing benefits but also reduce unnecessary financial costs.

Our findings indirectly suggest that adding anthropomorphism cues to service robots can help attract group diners, whereas it is better to weaken such cues when targeting solo diners. Building on prior research on anthropomorphism (Aggarwal and McGill, 2007), we provide restaurants that already adopt service robots “mismatching” their target customers with strategies to utilize the existing service robots better to attract target customers. First, for restaurants targeting group diners but already adopting non-humanoid service robots, marketers might consider adding anthropomorphism cues through message framing in marketing. Prior research shows that providing a machine with a human name and describing it in the first person motivates consumers to anthropomorphize it, even though it does not have a human-like appearance (Aggarwal and McGill, 2007; Hur et al., 2015). Accordingly, marketers might include this type of description for non-humanoid service robots in advertisements by saying, “Hello, I am Allison. I am a service provider in this restaurant that helps take the order. I am looking forward to serving you!” In this case, group diners might imbue non-humanoid service robots with human-like attributes and subsequently exhibit favorable responses. Second, for restaurants aiming to attract solo diners but already adopt humanoid service robots, marketers may weaken anthropomorphism cues and emphasize their nature as machines instead. For example, in the online reservation platform, marketers might add the following: “Our restaurant uses robots to deliver services. These machines will provide a comfortable dining environment without human contact.” Using this approach might discourage solo diners from anthropomorphizing humanoid service robots and consequently motivate them to visit the restaurant.

The current research also reminds restaurant practitioners of the importance of consumers’ psychological need for a comfortable dining experience in decision-making. When developing marketing strategies, managers mostly focus on traditional and explicit factors that influence consumers’ decision-making, such as food quality (Bujsisic et al., 2014), price (Campbell et al., 2014), location (Kincaid et al., 2010). Our findings suggest that consumers will make evaluations and decisions based on their anticipation of whether or not the restaurant can provide a comfortable dining experience. Similar to the role of service providers’ appearance, the appearance of service robots (i.e., robot type) can affect consumers’ perceptions and their feelings of comfort about the robotic

service (Nakanishi et al., 2018; Qiu et al., 2020). Extending this view, we find that group diners anticipate greater comfort if the restaurant features humanoid service robots, whereas solo diners believe that they would feel more comfortable if the restaurant adopts non-humanoid service robots. Therefore, non-humanoid (humanoid) service robots are likely to provide a better service experience to solo (group) diners. However, for restaurants adopting humanoid service robots but serving solo diners, managers might consider minimizing the human-robot interaction to create a comfortable environment for them. On the contrary, for restaurants adopting non-humanoid service robots but serving group diners, managers might encourage consumers to think of these service robots in human terms so that they would feel more comfortable in human-robot interaction. For example, managers might introduce the service robot to consumers with a human name and first-person language when they have a seat in the restaurant.

5.3. Limitations and future research

This present research has several limitations, opening new avenues of research. First, we utilized a scenario-based approach and collected data via an online experimental design. Future research might conduct a field study to add credibility to our findings. For example, researchers could pick restaurants adopting non-humanoid and humanoid service robots respectively and analyze the composition of solo and group diners from the online reservation data. Second, prior research suggests that solo consumers with a utilitarian (vs. hedonic) consumption motivation are less affected by others in the consumption context (Ratner and Hamilton, 2015). For example, solo diners who just want to have a quick lunch and get back to work (i.e., utilitarian motivations) might feel less uncomfortable than those who expect to have an enjoyable and relaxed dinner (i.e., hedonic motivations) in the restaurant. Therefore, it is possible that the backlash effects of humanoid service robots will be mitigated when solo diners have salient utilitarian motivations. Moreover, this study was conducted by focusing on casual dining restaurants. Future research should explore whether the type of restaurants (e.g., quick-service, casual dining, and fine dining restaurants) will influence the proposed effects. For example, consumers dining out in quick-service restaurants tend to have utilitarian motivations and expect to have few social interactions with service providers, whereas in casual dining or fine dining restaurants, customers might have hedonic motivations and expect to have many interactions with service providers (Hanks et al., 2017; Xu et al., 2020). Given that humanoid (vs. non-humanoid) service robots tend to be considered as more sociable and friendly (Kim et al., 2019; Pinxteren et al., 2019), it is possible humanoid service robots are more appropriate for casual dining and fine dining restaurants, whereas non-humanoid service robots are more suitable for quick-service restaurants.

Third, this study focused on humanoid service robots with moderately human-like features and non-humanoid service robots with machine-like appearances. Future research could expand our research by examining solo and group diners’ responses toward service robots that look like humans vs. animals. In addition, we restricted our investigation to robots in front-of-house. As consumers do not expect to interact with robots in back-of-house (e.g., robot chefs) (Ivanov and Webster, 2020; Wirtz et al., 2018), it is likely that solo diners and group diners will react indifferently to back-of-house robots with humanoid vs. non-humanoid appearances. Fourth, in the group condition manipulation, we only focused on the responses of consumers who search for restaurant information and make the group booking decision. But it remains an open question whether these consumers’ responses can be representative of the entire group, such as those who are not decision-makers. To test whether our proposed effects can be applied to all diners in a group, future research is warranted to capture the responses of consumers who receive a dinner invitation to the robotic restaurant from the decision-maker.

Another potential direction for future research is to examine whether

device type (e.g., personal computers vs. smartphones) used to access the booking information may influence the proposed effects. Prior research suggests that people tend to deliberate less and rely on feelings when making decisions through touch (vs. non-touch) devices (Shen et al., 2016). As smartphones (vs. PCs) often require much more direct and physical touch on their interfaces (Melumad et al., 2019; Melumad, Pham, 2020), people may be more likely to rely on feelings when using smartphones (vs. PCs) to process information and make decisions. As anticipated psychological comfort is the mechanism underlying the interaction between robot type and diner type, it is possible that such an interaction effect will be more salient when using smartphones (vs. PCs) for information processing and decision-making. In a similar vein, future research could examine the role of channel type, for example, an aggregator platform (e.g., Opentable) versus the restaurant's website. Prior research shows that channels used to present the booking

information can influence consumers' judgments and decision-making processes (Inversini, Masiero, 2014; Toh et al., 2011). It would be interesting to explore whether channel type will affect consumer responses to restaurants featuring humanoid vs. non-humanoid service robots.

Declarations of interest

None.

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Appendix A. Stimuli

Non-humanoid service robot condition.

Non-humanoid service robot condition



Humanoid service robot condition.

Humanoid service robot condition



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