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Human vs. robot baristas during the COVID-19 pandemic: Effects of masks and vaccines on perceived safety and visit intention

Abstract

Purpose: This study aims to (1) compare the effect of barista type (human vs. robot) on perceived safety and (2) examine the role of two moderators (mask-wearing and Coronavirus vaccination) on the effects of barista type on perceived safety and visit intention.

Design/methodology/approach: The research design consists of three studies. Three experiments were sequentially designed and conducted to address research questions.

Findings: Study 1 found that perceived safety mediates the effect of barista type on customers' visit intention. Study 2 revealed that the mask-wearing of human baristas and robot baristas differently influences perceived safety. Study 3 showed that customers, especially where robot baristas are used, perceive the effect of mask-wearing differently depending on their coronavirus vaccination status.

Research limitations/implications: Given that the levels of restrictions vary worldwide, together with the extent of countries' vaccination rollouts, caution is required when generalising the research findings.

Practical implications: Findings have practical implications for the hospitality industry, where the roles of face masks and coronavirus vaccines in shaping consumer psychology and behaviour have been underexplored.

Originality/value: Coronavirus vaccination is considered one of the most important driving forces for the recovery of hospitality businesses. As a heuristic-systematic model postulated, this study identified that vaccination status (fully vaccinated vs. not vaccinated) changes the level of involvement when customers assess the level of risk in service environments. By pinpointing the function of service robots in safeguarding customers from the potential spread of the disease, this study broadens the scope of human-robot interaction research in hospitality.

Keywords. Service robot, safety, visit intention, vaccination, mask, barista type, COVID-19, human-robot interaction

Introduction

With the rapid development of artificial intelligence (AI), automation, and robotics, service robots are spotlighted as a future labor force in hospitality and tourism (McCartney and McCartney, 2020). After the outbreak of COVID-19, customers' risk perception of respiratory disease infection through human interactions has been intensified in service delivery environments (Choi and Choi, 2021). As the need for 'contactless service' has increased during the pandemic, many researchers and industry practitioners have explored the possibility of robots as an alternative service delivery mode in place of frontline human staff, with the hope of reducing the risk of spreading COVID-19 (Choi *et al.*, 2020; Hou *et al.*, 2021; Hwang *et al.*, 2021; Kim *et al.*, 2021). Hence, there is a growing consensus that the COVID-19 pandemic has accelerated the worldwide digitalization and diffusion of AI and service robots throughout the hospitality and tourism industries (Seyitoğlu and Ivanov, 2020).

One of the fastest transforming service environments that adopts robots is the restaurant and dining context. Service robots provide restaurant customers unique experiences of human-robot interaction (HRI) including greeting, ordering, serving, or making payment in ways that require no or reduced human interactions (Tuomi *et al.*, 2020). In recent years, various versions of service robots have been installed and commercialized, especially in bars and tea/coffee houses. For instance, Café X introduced a robot barista with a six-axis arm at the San Francisco International Airport (Bandoim, 2019). F&P Robotics in Swiss developed Barney, a fully automated robot bartender that mixes dozens of cocktails/mocktails (Revill and Wiegmann, 2021). In addition, KamChAI was developed as a specialized robot that makes Hong Kong-style milk tea using silk-stocking straining techniques (Lew, 2018). Likewise, the application of service robots is apparently an emerging trend in restaurants and coffee houses. However, it is

largely unknown whether service robots will be preferred over human staff and which kinds of service robots will be successful.

With the risk of COVID-19, safety has become a critical factor for customers visiting restaurants and coffee houses (Hwang *et al.*, 2021; Kim *et al.*, 2021). Given that one of the distinct changes post COVID-19 in restaurant businesses will be an increasing emphasis on safety, certain attributes of service robots, related to safety, are likely to be valued. To successfully adopt service robots in service delivery environments, it is important to understand what makes customers feel safer and how the perception of safety influences their behavior. In terms of robots' mechanical function and configuration, not only the technical aspects of service robots (what they can perform) but also the design aspects (what they look like) play an important role in enriching the experiential quality of HRI and enhancing perceptions of safety. Studies on HRI have applied and extended the 'computers are social actors' paradigm (CASA) to emphasize the importance of social affordances, which refer to the potential of service robots to communicate with users (Gambino *et al.*, 2020; Fox and Gambino, 2021). The fundamental assumption of CASA is that people tend to apply the same social rules and regulations we use in human relationships when we interact with computers, machines, or robots (Reeves and Nass, 1996). Anthropomorphic humanoids can be designed not only to reflect human appearance but also programmed to mimic human gestures and behaviors (Bailenson and Yee, 2005). However, there is a lack of empirical studies examining how restaurant customers perceive the services delivered by human staff and humanoids.

Recently, there have been significant numbers of studies on service robots in the hospitality and tourism domain. Conceptual works have provided theoretical foundations for the distinct characteristics of service robots (Murphy *et al.*, 2019) and described the transfer of robot

applications into hospitality settings (Manthiou *et al.*, 2021). Empirical studies have been conducted to examine the impact of service robots on brand perception (Hwang *et al.*, 2021) and guest experience (Choi *et al.*, 2021). Also, by comparing how customers perceive the quality of services provided by human staff and by service robots, researchers have attempted to identify and examine the key attributes and moderators that can lead customers to prefer robots over humans (Ho *et al.*, 2020; Hou *et al.*, 2021; Hu *et al.*, 2021; Kim *et al.*, 2021).

However, less attention has been paid to the linkage between service robots and safety. It is still uncertain whether service robots are perceived as safer than human staff. Moreover, scarce study has attempted to account for the role of the situational factors of the COVID-19 pandemic. For instance, since the outbreak of COVID-19, one of the biggest changes in our daily life is mask-wearing, which presumably influences customers' perceptions of safety. Similarly, there could be a difference in the perception of safety between customers who are fully vaccinated and those who are not. Thus, in the context of comparing customers' preference for human or robot baristas during the pandemic, this study raised three major research questions (RQs).

RQ1: What is the effect of barista type (human vs. robot) on perceived safety and visit intention?

RQ2: How would mask-wearing by baristas change the effect of barista type on perceived safety?

RQ3: What is the difference in the perceived safety of human and robot baristas between customers who are fully vaccinated and those who are not?

Responding to these RQs, this study aims to compare the effect of barista type (human vs. robot) on perceived safety and examine the role of two moderators (i.e., mask-wearing and vaccination) on the effects of barista type on perceived safety and visit intention. As shown in Figure 1, three experiments were sequentially designed and conducted to address RQ1, RQ2, and RQ3.

[Insert Figure 1]

Literature review

Perceived safety of human and robot barista during the COVID-19 pandemic

The outbreak of COVID-19 and the resultant restrictions in many countries have had an adverse impact on the hospitality industry. For example, major stakeholders have predicted significant financial fragility, temporary closures and employment issues totaling approximately 50 million job losses globally (Choi and Choi, 2021; Jiang and Wen, 2020). Experts and scholars have opined that the global pandemic has been a major disruption not only to the finances of hospitality businesses but also to their operations and management (Jiang and Wen, 2020).

Previously (i.e., in the pre-COVID-19 era), close interpersonal contact between guests, service staff and other clients was the usual practice in hospitality establishments, whereas these practices are currently disrupted by the COVID-19 pandemic. The majority of hospitality service providers are obliged to deliver ‘contactless services’ to their guests as part of national safety measures (Jiang and Wen, 2020; Shin and Kang, 2020). The impact of the pandemic has permeated the industry, meaning that hospitality managers and guests alike have become more cautious, paving the way for the institution of stringent safety and protective measures (Gössling *et al.*, 2020). Within various establishments, managers have focused on enhancing safety, hygiene, and cleanliness by using contactless technologies, self-check-in/check-out devices and using service robots for various tasks, including cleaning and disinfecting (Li *et al.*, 2021; Gursoy and Chi, 2020). Researchers have suggested that robot baristas, robot receptionists, robot concierge assistants, facial scan check-ins, voice-activated guest control, and other contactless

services will begin to replace person-to-person contact services in hospitality facilities in the immediate future (Gursoy and Chi, 2020).

Meanwhile, consumers' preferences for staff type (e.g., human or robot) and willingness to use them have been mediated by growing concerns regarding perceived safety during the COVID-19 pandemic. Scholars advocate that technological innovations such as service robots and AI substantially enhance perceived safety by lowering health risks, leading to increased visit intention and willingness to use and pay more when such facilities are available (Chuah *et al.*, 2022; Shin and Kang, 2020). For example, consumers show a higher level of positive attitude towards robots than to human staff in the hotel business when COVID-19 infection rates peak (Kim *et al.*, 2021). Findings also suggest that consumers' attitudes toward and preferences for robot staff differ significantly depending on the perceived risk of COVID-19 (e.g., high vs. low). Similarly, Li *et al.* (2021) found that AI contactless service influenced consumers' perceptions of safety, values, and service quality in the hospitality business during the COVID-19 pandemic. More specifically, it was found that consumers' perceived safety was mediated by three facets of contactless user experience with AI ('sensory properties', 'interactivity', and 'responsiveness') and service quality. These findings are not consistent with previous studies (e.g., Choi *et al.*, 2020), which presented a pre-COVID-19 pandemic consumer preference for human staff over robot staff. This suggests that the unprecedented global pandemic and long-lasting concerns about safety have substantially influenced consumer perceptions of service robots in business settings (Kim *et al.*, 2021). Thus, a hypothesis was developed as follows:

H1: Perceived safety mediates the effect of barista type (human vs. robot) on visit intention.

Moderating role of masks

The majority of the world's population lives in countries that mandate the use of masks. This is the 'new normal' in public situations during the COVID-19 pandemic (Liu and Zhang, 2020; Rab *et al.*, 2020). Face masks have been used as a public and private health care measure against the spread of SARS-CoV-2. On the recommendation of both health experts and political authorities, masks are being used as personal protective equipment (PPE) to limit the spread of the virus (Hu *et al.*, 2021; Liu and Zhang, 2020). Mask-wearing is regulated for hospitality businesses as well. For example, it is mandatory for staff and passengers to wear masks in multi-use facilities, such as airport terminals and during flights (Elachola *et al.*, 2020). Hotels and restaurants also practice mask-wearing policies and vigilance in adhering to what is considered a safe distance between seats, and it is recommended to keep an appropriate safe distance while interacting with masked staff (Jiang and Wen, 2020).

Although there are some differences between countries, depending on vaccination rates and other safety measures, in most countries, both staff and guests are obliged to wear masks when using indoor commercial facilities (Rab *et al.*, 2020; Shin and Kang, 2020). Thus, consumers feel comfortable and safe when masked staff provide services (Jiang and Wen, 2020). The mask not only has 'utilitarian function' in providing safety measures but also 'symbolic function' in enhancing the perception of safety among service providers and consumers during the COVID-19 pandemic. In service environments, mask-wearing by service providers can function as a visual cue that delivers certain types of heuristics, such as perceived safety and perceived risk.

Researchers have also found that enhanced safety regulations (e.g., a mask wearing-policy during service delivery, regular cleaning, and disinfection of high-contact surfaces) at

hospitality businesses influence consumers' perceived safety, resulting in increased visit intention (Choi and Choi, 2021; Jiang and Wen, 2020). Hospitality businesses have prioritized establishing upgraded standards for hygiene and cleanliness, and strengthening disinfection systems during the COVID-19 pandemic so that consumers using them can feel safe and comfortable (Choi and Choi, 2021; Jiang and Wen, 2020). Consumers have pointed out that the presence of well-equipped safety, sanitation and disinfection systems is a major factor influencing their intention to visit.

The adoption of self-service kiosk devices and service robots has substantially increased in hospitality businesses during the COVID-19 pandemic. It is not uncommon for consumers to encounter service robots such as 'Pepper' (a semi-humanoid) and 'Nao' (an autonomous and programmable humanoid) in hospitality outlets (Seyitoğlu and Ivanov, 2020). Unlike human staff, robot staff, particularly humanoids, do not wear a mask; however, in the presence of such a robot, neither consumers nor human staff feel uncomfortable and/or insecure. This is due to the fundamental properties of service robots. Robot staff have utilitarian and symbolic value and are seen as protection against the spread of SARS-CoV-2 and as an effective way to improve safety and hygiene (Hwang *et al.*, 2021). There is a strong perception among consumers that robot staff are safe and that the risk of transmission of the virus from them to consumers is extremely low (Seyitoğlu and Ivanov, 2020).

When facing risk, people tend to focus more on utilitarian values than on hedonic and symbolic values (Sperling, 2021; Vearrier and Henderson, 2021). Utilitarian value, also known as functional value, influences consumer satisfaction and behavioral intentions (Lee and Kim, 2018) and also contributes to building consumer trust in objects/services by lowering perceived risk and enhancing perceived safety (Han *et al.*, 2018). Since the utilitarian value and symbolic

value of masks do not play a prime role for robot staff (vs. human staff), consumers may have a higher level of perceived safety when dealing with robot staff without a mask (vs. with a mask). Robot staff wearing a mask can actually create or exaggerate anxiety in consumers, resulting in a reduced level of perceived safety. The moderating role of masks in the effect of staff type (human vs. robot) on consumers' perceived safety has been under-researched and requires further investigation. Thus, we posit the following hypothesis:

H2. There is a two-way interaction effect of barista type (human vs. robot) and mask-wearing (absence vs. presence) on perceived safety. More specifically, mask-wearing will produce more positive effects for human baristas (vs robot baristas) but more negative effects for robot baristas (vs human baristas).

Moderating role of the COVID-19 vaccine

As of 29 September 2021, 33 vaccines, including Pfizer/BioNTech, Moderna, Oxford-AstraZeneca, and Sinopharm-BBIBP, have been approved for emergency or full use by the World Health Organization (World Health Organization, n.d.). The medical community anticipates that these COVID-19 vaccines will play a key role in reducing the likelihood of infection in individuals who lack immunity, by building 'herd immunity', which is a form of indirect protection from infectious disease (Li *et al.*, 2020; Mullard, 2020). There is also growing consensus that the increasing rollout of COVID-19 vaccines contributes to alleviating individuals' anxiety and perceived risk relating to the COVID-19 pandemic and creating the possibility of a return to normal life (Wang *et al.*, 2022).

Research has shown that COVID-19 vaccines significantly increase perceived safety relating to the spread of SARS-CoV-2 when interacting with service providers and consumers in the tourism and hospitality industry (Wang *et al.*, 2022). Similarly, where COVID-19 vaccines

are unavailable, consumers hesitate to dine-in at restaurants, preferring to engage in at-home consumption (Kim *et al.*, 2021). The underlying value of the COVID-19 vaccine is the trust and belief that it will play a critical role in protecting individuals, local communities, and nations worldwide (Li *et al.*, 2020; Wang *et al.*, 2022). According to the Centers for Disease Control and Prevention (CDC), individuals who are not vaccinated are 11 times more likely to die from the Delta variant (Dyer, 2021). Reducing cases and deaths by way of vaccination demonstrates the function and effectiveness of COVID-19 vaccines (Wise, 2021). This shows that the utilitarian and symbolic values of the COVID-19 vaccine are protective, which is considered as important as the value of masks.

The medical community expects that vaccination will have an enormous impact on the current 'new normal' lifestyle and subsequent consumption patterns (Mullard, 2020; Wise, 2021). For example, as vaccination rates increase, some countries have begun to adopt a 'vaccine passport' (also known as a 'vaccine pass') as a transitional step to return to normal life and for the purpose of tourism recovery (Gursoy *et al.*, 2021; Wang *et al.*, 2022). In Israel, which has the highest vaccination rate for COVID-19, a 'Green Pass' (formally called Green Passport) is issued in the form of an app on mobile devices to those who have completed the second vaccination. People with this 'Green Pass' are free from all quarantine conditions and can use restaurants, movie theatres and sports venues without restrictions. Gursoy *et al.* (2021) also found that the impact of COVID-19 vaccination on travel intention gradually increased during the rollout of the vaccination. These certificates are expected to boost the economy by easing travel restrictions and reinstating tourist confidence (Wang *et al.*, 2022).

Furthermore, given that the effectiveness and symbolic protective meaning of COVID-19 vaccines are significant (Gursoy *et al.*, 2021; Li *et al.*, 2020; Mullard, 2020; Wise, 2021),

consumers' perceived safety, preferences for staff type (human vs. robot), and the use of masks (absence vs. presence) as safety measures is likely to be influenced by individual COVID-19 vaccination status. In particular, we propose that consumers have different levels of perceived safety when dealing with robot baristas with/without masks, depending on individual COVID-19 vaccination status (full vaccination vs. not vaccinated). Robot staff and self-kiosk devices have been deployed by hospitality firms as a means of contactless service, ensuring high standards of hygiene and sanitation, which consumers have shown marked preferences for due to the fear of infection during the COVID-19 pandemic (Gursoy *et al.*, 2020; Seyitoğlu and Ivanov, 2020).

Given the nature of robot baristas, consumers maintain a certain level of perceived safety towards robot staff 'without a mask' regardless of their COVID-19 vaccination status. However, we assume that there may be differences in consumers' perceived safety of masked robot baristas depending on the customer's COVID-19 vaccination status (fully vaccinated vs. not vaccinated) because unvaccinated consumers may have a lower perception of safety regarding masked robot staff compared with fully vaccinated consumers. People tend to focus on the utilitarian value (e.g., function and performance) of objects when they face perceived risk in business activities (Sperling, 2021; Han *et al.*, 2018; Vearrier and Henderson, 2021). Unvaccinated consumers are more vulnerable to infection with SARS-CoV-2 and have a higher risk of death from the Delta variant (Dyer, 2021). Thus, the combination of functionless masks (e.g., not functional to robot staff) and robot staff may trigger risk or anxiety heuristics, resulting in lower perceived safety compared with robot staff without a mask. In contrast, vaccinated consumers who are less vulnerable to the SARS-CoV-2 and the risk of death from the Delta variant (Dyer, 2021) may focus on the symbolic value of the mask rather than the utilitarian value, which may lead to heightened levels of perceived safety compared with unvaccinated consumers.

In addition, we propose that consumers may maintain perceived levels of safety with regard to masked human staff, regardless of their COVID-19 vaccination status. In addition to the rollout of COVID-19 vaccines, the mask-wearing policy remains a safety measure widely and continuously implemented worldwide during the COVID-19 pandemic (Liu and Zhang, 2020; Rab et al., 2020). The utilitarian value (e.g., function and performance) and symbolic value (e.g., symbolic meaning of protection) of mask wearing is effective and applicable to humans (e.g., consumers). Thus, consumers may react to the perceived values of masks, resulting in perceived safety, regardless of their COVID-19 vaccination status. However, it is also anticipated that consumers who are not fully vaccinated (vs. fully vaccinated) will have the lowest perceived safety when dealing with unmasked human staff (vs. robot staff) due to the absence of safety measures. Synthesizing these justifications, the following hypothesis is proposed:

H3-1: There is a three-way interaction effect of vaccination (fully vaccinated vs. not fully vaccinated), barista type (human vs. robot), and mask-wearing (absence vs. presence) on perceived safety. More specifically, mask-wearing will produce more positive effect on perceived safety for human baristas (vs robot baristas) in groups of both fully vaccinated and not fully vaccinated customers.

H3-2: For robot baristas, mask-wearing will produce a negative effect on perceived safety only in customers who are not fully vaccinated.

Study 1 – Mediating role of perceived safety (RQ1)

Study 1 was conducted to 1) examine the main effect of barista type on consumers' visit intentions and 2) test the mediating role of perceived safety.

Method

By manipulating two types of baristas (human or robot), a one-factor between-subject experiment was designed. For each human or robot barista condition, a set of three images were created: a) a coffee-making scene involving the barista; b) a coffee-serving scene involving the barista; and c) a cup of coffee served (Figure 2). All information was the same in the two conditions, with the exception of the barista figure. A pilot test with 30 undergraduate students was conducted to check whether they recognized the type of barista. All participants identified the correct type of barista in the given human or robot condition.

[Insert Figure 2]

In the main study, 150 participants were recruited from Amazon MTurk in September 2020 and randomly assigned to one of two conditions. Here, only participants who 1) currently live in the US and 2) drink coffee were invited to participate. A total of 135 responses were used for analysis after excluding 15 responses that failed the attention check using the following questions.

- According to the scenario, which one is newly opened in your town? a) hotel, b) recreation center, c) coffee house, and d) theme park.
- Did you carefully examine the photo and read all the text above? a) yes, b) no.

Of the respondents, males (n=87, 64.4%) were more numerous than females (47, 34.8%). More than half of them were married (n=93, 68.9%) and in the age range of 20-29 years (n=59,

43.7%) or 30-39 years (n=28, 20.7%). Most participants had either a bachelor's (n=79, 58.5%) or a master's degree (n=27, 20.0%). The highest number of participants had an annual household income range of US\$ 50,001 - US\$ 75,000 (n=52, 38.4%), followed by US\$ 25,001 - US\$ 50,000 (n=37, 27.4%) and US\$ 75,001 - US\$ 100,000 (n=24, 17.8%). All participants who consented to participate in this survey were instructed to read the following scenario carefully.

Imagine that you are going out for coffee to start your morning, or to keep on pushing into the afternoon. You decide to try a new coffee house in your town. Because the coffee house has only recently opened, you have not visited it yet. This coffee house has been serving only take-away items during the COVID-19 pandemic, so you decide to order a Latte to go.

Then, participants were informed that they would see three photos of the new coffee house, showing the process of brewing and serving and the menu image of a latte. For each condition, the three photos in Figure 2 were presented one by one, for at least 5 seconds. After being exposed to all three photos, the participants were asked to complete a questionnaire. Manipulation was checked with one item: "According to the scenario, I am certain that the barista is a robot" (1 = very uncertain, 7 = very certain). Three items were adapted from a study by Karmarkar and Tormala (2010), which measured visit intention as follows: "I would visit the coffee house"; "I would seek more information about the coffee house"; and "I am interested in visiting the coffee house". Perceived safety was measured using three items derived and modified from Moon, Yoon, and Han (2017) and operationalized as: "I think that this coffee house is safe"; "I would feel safe while staying at this coffee house"; and "I would feel comfortable in this coffee house". Because the experiment was based on hypothetical scenarios and 3D images of the barista robot were created for the experiment, participants' responses may have been influenced by how they perceived the realism of the given scenario. Thus, perceived realism was measured as a covariate using three items (Ho et al., 2020; Wirtz et al., 2013)

operationalized as: “It is easy to imagine being in the situation described in this study”; “The scenario is realistic”; and “Something like this situation can happen”.

Results

With regard to the manipulation check, the participants in the robot barista condition ($n = 67$, $M_{\text{robot}} = 6.40$, $t = -11.59$, $p < .01$) felt more confident that the barista was a robot than those in the human barista ($n = 68$, $M_{\text{human}} = 6.40$) condition. Given that perceived realism was included as a covariate, one-way ANCOVAs were performed to compare the means of perceived safety and visit intention between the two conditions (Table 1). Perceived safety was higher in the robot barista condition ($M_{\text{robot}} = 5.81$, $F = 16.13$, $p < .01$) than in the human barista condition ($M_{\text{human}} = 4.96$). Similarly, intention to visit the coffee house was also higher in the robot barista condition ($M_{\text{robot}} = 5.75$, $t = 13.34$, $p < .01$) than in the human barista condition ($M_{\text{human}} = 4.78$). The effect of perceived realism was significant on both perceived safety and visit intention.

[Insert Table 1]

To examine the mediating role of perceived safety, the bootstrapping approach of Hayes (2018, Model = 4, bias-corrected bootstrap = 5,000) was adopted (Table 2). The mediation model specified barista type as the independent variable (X), perceived safety as the mediator (M), visit intention as the dependent variable (Y), and perceived realism as the covariate (S). As shown in Table 3, the results supported the proposition that perceived safety mediated the effect of barista type on visit intention (indirect effect = 0.84; 95% CI = 0.4340 to 1.2882), supporting H1.

[Insert Tables 2 & 3]

Study 2 – Moderating role of mask (RQ2)

The findings of Study 1 supported the proposition that robot baristas, compared to human baristas, increased customers' visit intention via their perception of safety. As the utilitarian and symbolic functions of masks were postulated earlier, Study 2 was conducted to examine the moderating role of masks for human and robot baristas.

Method

A 2 (barista type: human or robot) x 2 (mask: absence or presence) between-subject experiment was conducted. For the absence of mask conditions, the same stimuli as those in Study 1 were used. Additional photos were created and used for the presence of mask conditions (Figure 3).

To implement Study 2, 300 participants were recruited from Amazon MTurk in September 2020.

In addition to the screening criteria of Study 1, only the participants who did not participate in Study 1 were invited to complete the questionnaire. Using the same attention check questions, 37 participants were excluded from further analysis. The participants' profiles were similar to those of Study 1. More respondents were males (n=154, 58.6%), married (n=208, 79.1%), and were in the age categories of 20-29 years (n=124, 47.1%) or 30-39 years (n=59, 22.4%). Most participants had either a bachelor's (n=147, 55.9%) or a master's degree (n=59, 22.4%).

Regarding annual household income, the highest percentages were found in the category of US\$ 50,001 - US\$ 75,000 (n=91, 34.6%), followed by US\$ 25,001 - US\$ 50,000 (n=58, 22.1%), and US\$ 75,001 - US\$ 100,000 (n=50, 19.0%).

[Insert Figure 3]

As shown in Table 4, the participants were randomly assigned into one of the four conditions (C1 = human with no mask, C2 = robot with no mask, C3 = human with mask, C4 =

robot with mask). The same instructions and scenario that were provided in Study 1 were given to all participants in Study 2. Also, the measures were the same in the questionnaire apart from one additional manipulation check question (“According to the scenario, I am certain that the barista is wearing a face mask”).

[Insert Table 4]

Results

In response to the manipulation check questions, participants in the robot barista conditions ($M_{\text{robot}} = 6.49$, $t = -15.43$, $p < .01$) answered that the barista was a robot more frequently than participants in the human barista conditions ($M_{\text{robot}} = 3.10$). Also, the participants in the ‘presence of mask’ conditions ($M_{\text{robot}} = 6.63$, $t = -13.17$, $p < .01$) indicated that the barista was wearing a mask more frequently than those in the absence of mask conditions ($M_{\text{robot}} = 3.36$). Hence, the manipulation checks were successful.

To examine the interaction effect of barista type and mask on perceived safety and visit intention, two-way ANCOVAs were conducted by including a covariate: perceived realism. As shown in Table 5, barista type ($F(1, 258) = 17.85$, $p < 0.01$) and mask ($F(1, 258) = 4.33$, $p < 0.05$) had significant main effects on perceived safety. More importantly, the interaction effect of barista type and mask on perceived safety was statistically significant ($F(1, 258) = 17.46$, $p < 0.01$). In particular, participants perceived human baristas as safer when wearing a mask ($M_{\text{human with mask}} = 5.70$) than when wearing no mask ($M_{\text{human without mask}} = 4.82$). In contrast, robot baristas without a mask ($M_{\text{robot without mask}} = 5.86$) produced a higher level of perceived safety than robot baristas with a mask ($M_{\text{robot with mask}} = 5.52$). With regard to visit intention, the interaction effect of barista type and mask was not significant ($F(1, 258) = 3.19$, $p = .08$). The effect of perceived

realism was significant on both perceived safety ($F(1,258) = 17.46$) and visit intention ($F(1,258) = 24.20$).

[Insert Table 5]

To test the indirect effect of perceived safety and the moderating role of masks, we conducted a moderated mediation analysis using the bootstrapping approach of Hayes (2018, Model = 7, bias-corrected bootstrap = 5,000). Mask was specified as a moderator (W) in the moderated mediation model. Perceived safety positively influenced visit intention when controlling for perceived realism (effect = .61, $p < .01$; see Table 2). The index of moderated mediation was significant (-.62, $p < .05$; see Table 3), indicating that the magnitude of the indirect effect differed depending on the absence or presence of a mask. In particular, the conditional indirect effect on visit intention was significant in the absence of mask condition (effect = .66, 95% CI = .38 to .98), while it was not significant in the presence of mask condition (effect = .04, 95% CI = -.15 to .26).

The findings of Study 2 supported the moderating role of masks (H2 was supported). That is, mask-wearing by human baristas produced a positive effect on perceived safety, whereas mask-wearing by robot baristas negatively influenced perceived safety. Masks as a visual cue induced certain types of heuristics that differently affected customers' perceptions of safety. Particularly for robot baristas, customers seemed to consider the utilitarian function of masks for protection because they are vulnerable to health risks. However, we postulated that customers would focus on the symbolic function of masks if they were fully vaccinated. Thus, a follow-up study was conducted to capture the effect of vaccination status.

Study 3 – Moderating role of vaccine (RQ3)

To examine the moderating role of vaccination, we collected additional data in Study 3 in June 2021, after COVID-19 vaccines were developed and deployed, and a substantial number of people were vaccinated. To investigate how barista type and mask differently influence the perception of safety and visit intention for customers who are ‘fully vaccinated’ and ‘not fully vaccinated’, newly collected data in Study 3 were combined with the data collected in Study 2.

Method

A 2 (barista type: human or robot) x 2 (mask: absence or presence) x 2 (vaccine: not fully vaccinated or fully vaccinated) between-subjects experiment was conducted. For Study 3, an additional 300 participants were recruited from Amazon MTurk. Applying the same screening criteria used in the previous experiments, only participants who did not participate in Study 1 or Study 2 were invited to complete the questionnaire. One more screening question was added (“Are you fully vaccinated? a = yes, b = no) and only fully vaccinated participants were invited to proceed. After applying the same attention check questions used in the previous studies, a total of 269 participants completed Study 3. Using the same stimuli in Study 2, the participants were randomly assigned to one of the four conditions (C5 = human with no mask, C6 = robot with no mask, C7 = human with mask, C8 = robot with mask; see Table 3).

The participants’ profile was similar to those in Study 1 and Study 2. There were more male participants (169, 62.8%) than female (99, 36.8%). Most of them were married (197, 73.2%) and in the age ranges of 20-29 years (120, 44.6%) or 30-39 years (61, 22.7%). Most participants had either a bachelor's (156, 58.0%) or a master’s degree (49, 18.2%). The highest number of participants had an annual household income range of US\$ 50,001 - US\$ 75,000 (79,

29.4%), followed by US\$ 25,001 - US\$ 50,000 (69, 25.7%), and US\$ 75,001 - US\$ 100,000 (59, 21.9%). The same scenarios and instructions used in Study 2 were given to the participants in Study 3. Measures used in the questionnaire were also the same as those used in Study 2. To examine the moderating effect of vaccination, the data collected in Study 2 (not fully vaccinated participants) were combined with the data collected in Study 3 (fully vaccinated participants). In total, 570 data points were used in the analysis.

Results

The manipulations were checked for the participants who were fully vaccinated (C5 – C8). The participants in the robot barista conditions ($M_{\text{robot}} = 6.09$, $t = -18.68$, $p < .01$) answered that the barista was a robot more frequently than those in the human barista conditions ($M_{\text{robot}} = 2.28$). Also, the participants in the presence of mask conditions ($M_{\text{robot}} = 6.33$, $t = -16.01$, $p < .01$) thought that the barista was wearing a mask more frequently than those in the absence of mask conditions ($M_{\text{robot}} = 2.84$). Thus, the manipulations were successful.

To examine the interaction effect of barista type, mask, and vaccination on perceived safety and visit intention, three-way ANCOVAs on perceived safety and visit intention were conducted by including a covariate: perceived realism (Table 6). The results showed that the three-way interaction effect of barista type, mask, and vaccine on perceived safety was statistically significant ($F(1, 521) = 4.36$, $p < 0.05$). As presented in Study 2, the interaction of barista type and mask was significant for the participants who were not fully vaccinated (Figure 4). For those who were fully vaccinated, the interaction of barista type and mask was marginally significant ($F(1,265) = 2.94$, $p < .10$). The pattern of interaction was the opposite for robot baristas. For fully vaccinated participants, a robot barista with a mask ($M_{\text{robot with mask}} = 5.89$)

produced a higher level of perceived safety than a robot barista without a mask ($M_{\text{robot without mask}} = 5.61$). A similar effect of masks was shown for human baristas ($M_{\text{human with mask}} = 5.57$; $M_{\text{human without mask}} = 5.04$). For visit intention, the interaction effect was not significant ($F(1, 521) = 2.37$, $p = .08$). The effect of perceived realism was significant at the level of .01 on both perceived safety ($F(1, 521) = 86.57$) and visit intention ($F(1, 258) = 137.42$).

[Insert Table 6 & Figure 4]

The indirect effect was tested using the bootstrapping approach of Hayes (2018, Model = 11, bias-corrected bootstrap = 5,000). Two moderators were specified for mask (W) and vaccine (Z) in the moderated mediation model. Perceived safety positively influenced visit intention when controlling for perceived realism (effect = .59, $p < .01$; see Table 2). The index of moderated mediation was significant (.74, $p < .05$; see Table 3), indicating the magnitude of the indirect effect differed, based on vaccination and mask. In particular, the conditional indirect effect on visit intention was significant for both vaccine groups. For those who were not fully vaccinated, the indirect effect was only significant in the absence of mask condition.

Discussion

Given that barista robots have become popular in restaurants and bars worldwide, this study compared how customers perceived the services delivered by human baristas and robot baristas. Particularly during the COVID-19 pandemic, this study postulated that perceived safety is the key to understanding customers' preferences for barista type. Study 1 supported the hypothesis that perceived safety mediates the effect of barista type on customers' visit intentions. This study also identified and examined the effect of two moderators, associated with service providers and customers, which change the effect of barista type on perceived safety. In Study 2, the findings

indicated that mask-wearing by human baristas and robot baristas influenced perceived safety differently. Study 3 indicated that customers, especially in robot barista conditions, perceived the effect of mask-wearing differently depending on their vaccination status.

Theoretical contributions

The study findings provide meaningful contributions to the literature on hospitality and HRI. First of all, by examining the mediating role of perceived safety in the effect of barista type on visit intention, this study showed that perceived safety is a key factor in understanding why customers prefer robot baristas over human baristas. Previous studies have identified several factors, including perceived innovativeness, novelty, and interesting experiences, that influence consumers' preferences for and positive attitudes towards service robots (Ivanov *et al.*, 2018; Tung and Au, 2018). The influence of recent technological advances has influenced customers' quests for novel experiences with service robots, as they seek to showcase their robot experiences to others (Mende *et al.*, 2019).

Also, the increasing demand for service robots has been informed by a changing demographic, which paves the way for a more sophisticated, technologically savvy consumer segment that has an affinity for state-of-the-art products (Choi *et al.*, 2020; Rodriguez-Lizundia *et al.*, 2015). Although the pace and trend towards the adoption of service robots in the hospitality industry differs worldwide, previous studies have argued that in general, human staff tended to be preferred prior to the outbreak of the COVID-19 pandemic. However, the current pandemic is not only a crisis but also a turning point in the significance of health and safety in hospitality and restaurant businesses (Choi and Choi, 2021). Given that safety has become the first priority during the pandemic, all three experiments in this study showed a consistent pattern

in which robot baristas were perceived as safer than human baristas. By pinpointing the function of service robots in safeguarding customers from the potential spread of the disease, this study broadens the scope of HRI research in hospitality.

In addition, this study offers a new theoretical and methodological approach to better understanding an unprecedented situational factor during the pandemic by delving into customers' psychological responses to mask-wearing. To the best of our knowledge, this study is the first attempt to empirically test how customers perceive safety by assessing the effect of mask-wearing in two types of service provider: human and robot. Although previous studies on service robots mainly focused on the design aspects of anthropomorphism, this study investigated a barista robot's behavioral aspect in mimicking human behavior, in the form of mask-wearing.

As postulated in media equation theory (Reeves and Nass, 1996) and the MAIN model (Sundar, 2008), the study also showed that customers easily recognize masks as a visual cue, which produces certain types of heuristics. Interestingly, mask-wearing produced seemingly opposite types of heuristics (e.g., safety and risk) for human baristas and robot baristas. This is in line with previous studies (Choi *et al.*, 2021; Moody *et al.*, 2014) in the sense that the same visual cue is able to produce multiple heuristics and the effect of those heuristics can be contradictory. The moderating role of masks can be interpreted by separating their functions: utilitarian and symbolic. Where the utilitarian function of a mask is compatible with human baristas, customers seem to perceive the mask as a sign of protection and prevention. For robot baristas, however, the utilitarian function of a mask is questionable, so the mask produces its prime effect as a warning sign for the possible risk of infection.

Lastly, this study provides meaningful contributions to the hospitality literature by investigating how vaccination affects customers' psychological perceptions of service environments. Vaccination rate is considered one of the most important driving forces for the recovery of hospitality businesses (Choi and Choi, 2021). As a heuristic-systematic model (Chaiken, 1980) postulated, this study implied that vaccination status changes the level of involvement when customers assess the level of risk in service environments. More specifically, the findings showed that the effect of certain heuristics produced by mask-wearing by human or robot baristas can be intensified or mitigated. For human baristas, the effect of mask-wearing was consistent regardless of customers' vaccination status, because the utilitarian function of a mask is compatible with human baristas. In contrast, for robot baristas, the effect of mask-wearing differed with customers' vaccination status. Although fully vaccinated customers tend to make a quick decision by relying on visual cue-induced heuristics, customers who are not fully vaccinated go through a systematic process of assessing the symbolic function of the mask.

Managerial implications

Our findings have practical implications for the hospitality industry, where the roles of face masks and vaccines in shaping consumer psychology and behaviour have been underexplored. First, regardless of national vaccination rates, owners, and managers of small and medium-sized enterprises (SMEs) that do not use service robots are recommended to continue using human staff equipped with appropriate PPE for service delivery. During the COVID-19 pandemic, most SMEs—especially small hotels and restaurants—have relied on human staff, due to a lack of digital skills and the enormous financial resources required to operate service robots. In contrast, multinational enterprises (MNEs) such as Marriott International, Inc. have increasingly adopted service robots (OECD, 2021). Our study revealed that both vaccinated and unvaccinated

consumers perceive that interactions with masked human staff are safer than interactions with unmasked human staff. Thus, we recommend that hospitality enterprises that are operated exclusively by human staff continue to mandate the use of appropriate PPE by their staff when tending to consumers.

Second, MNEs that have adopted robot staff can further enhance their service quality by decorating their robots to resemble human staff equipped with PPE. Our findings reveal that vaccinated consumers experience higher levels of perceived safety when interacting with masked robot staff than with unmasked robot staff. Given that vaccinated populations are increasing worldwide (Li *et al.*, 2020), the use of robot staff decorated with face masks and other PPE can be an effective management strategy for ensuring that consumers perceive that their interactions with service robots are safe, thereby encouraging consumption.

Limitations and suggestions for future research

There are several limitations to this study. First, given that the levels of restrictions vary worldwide, together with the extent of countries' vaccination rollouts (Li *et al.*, 2020), caution is required when generalising the research findings. Future research incorporating multiple case studies that account for the progress of vaccination programmes would therefore extend the present inquiry. Second, this study investigated the moderating role of vaccines by comparing two groups (fully vaccinated vs. not fully vaccinated) without distinguishing those who had received only the first dose of a vaccine from those who had received a second dose. In addition, consumers' levels of emotional comfort may vary according to the relative efficacy and side effects of the vaccines they have received. Therefore, future studies accounting for consumers who have received only their first dose of a vaccine, and the type of vaccine they have received,

may deepen understanding of the impact of vaccinations on consumers' perceptions of safety and their behavioural intentions with regard to hospitality businesses.

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Table 1. One-way ANCOVA on perceived safety and visit intention (Study 1)

Source	Type III Sum of Squares	df	Mean Square	<i>F</i>
Perceived Safety^a				
Intercept	36.85	1	36.85	17.13**
Total effects				
Barista Type (BT)	34.71	1	34.71	16.13**
Covariate				
Perceived Realism	12.54	1	12.54	5.83*
Error	284.02	132	2.15	
Total	4069.33	135		
Visit Intention^b				
Intercept	39.97	1	39.97	19.78**
Total effects				
Barista Type (BT)	26.96	1	26.96	13.34**
Covariate				
Perceived Realism	12.35	1	12.35	6.11*
Error	266.72	132	2.02	
Total	4222.00	135		

Note: ^aAdjusted R² = .122; ^bAdjusted R² = .108; *p<.05, **p<.01.

Table 2. Effect of barista type on perceived safety and visit intention

	M (Perceived Safety)			Y (Visit Intention)		
	Coeff.	SE	p-value	Coeff.	SE	p-value
Study 1 (Model 4)						
Constant	2.828	.826	< .01	.682	.434	.119
X (Barista Type)	1.017	.253	< .01	.053	.135	.697
M (Perceived Safety)	-	-	-	.829	.044	< .01
S (Perceived Realism)	.335	.139	< .05	.055	.071	.445
Study 2 (Model 7)						
Constant	3.000	.456	< .01	1.322	.353	< .01
X (Barista Type)	1.093	.189	< .01	.071	.104	.497
W (Mask)	.793	.193	< .01	-	-	-
X * W	-1.022	.272	< .01	-	-	-
M (Perceived Safety)	-	-	-	.608	.0434	< .01
S (Perceived Realism)	.315	.075	< .01	.153	.056	< .01
Study 3 (Model 11)						
Constant	3.332	.203	< .01	1.444	.173	< .01
X (Barista Type)	1.203	.176	< .01	.145	.068	< .05
W (Mask)	.819	.181	< .01	-	-	-
Z (Vaccine)	-.051	.177	.774	-	-	-
X * W	-1.103	.253	< .01	-	-	-
X * Z	-.509	.246	< .05	-	-	-
W * Z	-.240	.252	.342	-	-	-
X * W * Z	.742	.355	< .05	-	-	-
M (Perceived Safety)	-	-	-	.589	.031	< .01
S (Perceived Realism)	.300	.032	< .01	.152	.024	< .01

Note: X = independent variable; W = moderator; Z = moderator; M = mediator; Y = dependent variable.

Table 3. Indirect effects of barista type on visit intention through perceived safety

		Effect	95% CI	Index	95% CI
Study 1: Model 4					
		.84*	[.43, 1.29]		
Study 2: Model 7					
	No mask	.66*	[.38, .98]	-.62	[-1.00, -.28]
	With mask	.04	[-.15, .26]		
Study 3: Model 11^a					
Not fully vaccinated	No mask	.70*	[.47, .94]	-.65	[-.93, -.36]
	With Mask	.06	[-.12, .26]		
Fully vaccinated	No mask	.41*	[.19, .65]	-2.21	[-.51, .07]
	With Mask	.20*	[.02, .38]		

Note: * Significant conditional indirect effect; ^aIndex of moderated moderated mediation = .44, 95% CI = [.03, .84].

Table 4. Means and standard deviations of perceived safety and visit intention

Condition	Vaccine	Mask	Barista Type	N	Perceived Safety	Visit Intention
Data collected in Study 2						
C1	Not fully vaccinated	No mask	Human	67	4.82 (1.59)	5.14 (1.36)
C2	Not fully vaccinated	No mask	Robot	68	5.86 (.77)	5.74 (1.05)
C3	Not fully vaccinated	With mask	Human	60	5.70 (.94)	5.67 (.83)
C4	Not fully vaccinated	With mask	Robot	66	5.52 (.93)	5.63 (.98)
Data collected in Study 3						
C5	Fully vaccinated	No mask	Human	70	5.04 (1.41)	5.25 (1.33)
C6	Fully vaccinated	No mask	Robot	70	5.61 (.87)	5.56 (.96)
C7	Fully vaccinated	With mask	Human	65	5.57 (.98)	5.46 (.93)
C8	Fully vaccinated	With mask	Robot	64	5.86 (1.00)	5.88 (.89)

Note: Standard deviation in parentheses.

Table 5. Two-way ANCOVA on perceived safety and visit intention (Study 2)

Source	Type III Sum of Squares	df	Mean Square	<i>F</i>
Perceived Safety^a				
Intercept	88.54	1	88.54	73.99**
Total effects				
Barista Type (BT)	21.35	1	21.35	17.85**
Mask (M)	5.18	1	5.18	4.33*
BT x M	16.96	1	16.96	14.17**
Covariate				
Perceived Realism	20.89	1	20.89	17.46**
Error	308.73	258	1.20	
Total	8192.11	263		
Visit Intention^b				
Intercept	82.17	1	82.17	76.01**
Total effects				
Barista Type (BT)	11.57	1	11.57	10.70**
Mask (M)	3.84	1	3.84	3.56
BT x M	3.45	1	3.45	3.19
Covariate				
Perceived Realism	26.16	1	26.16	24.20**
Error	278.89	258	1.08	
Total	8361.44	262		

Note: ^aAdjusted R² = .152; ^bAdjusted R² = .113; *p<.05, **p<.01.

Table 6. Three-way ANCOVA on perceived safety and visit intention (Study 3)

Source	Type III Sum of Squares	df	Mean Square	<i>F</i>
Perceived Safety^a				
Intercept	544.06	1	544.06	523.80**
Total effects				
Barista Type (BT)	43.34	1	43.34	41.73**
Mask (M)	14.62	1	14.62	14.08**
Vaccine (V)	6.80	1	6.80	6.55*
BT x M	17.70	1	17.70	17.04**
BT x V	.62	1	.63	.61
M x V	.56	1	.56	.54
BT x M x V	4.53	1	4.53	4.36*
Covariate				
Perceived Realism	89.92	1	89.92	86.57**
Error	541.15	521	1.04	
Total	16682.22	530		
Visit Intention^b				
Intercept	484.68	1	484.68	540.89**
Total effects				
Barista Type (BT)	31.85	1	31.85	35.55**
Mask (M)	7.69	1	7.69	8.58**
Vaccine (V)	13.73	1	13.73	15.33**
BT x M	2.14	1	2.14	2.39
BT x V	.18	1	.18	.20
M x V	.15	1	.15	.16
BT x M x V	2.12	1	2.12	2.37
Covariate				
Perceived Realism	123.14	1	123.14	137.42**
Error	466.86	521	.90	
Total	16860.89	530		

Note. ^aAdjusted $R^2 = .212$; ^bAdjusted $R^2 = .234$; * $p < .05$, ** $p < .01$.

Figure 1. Research model

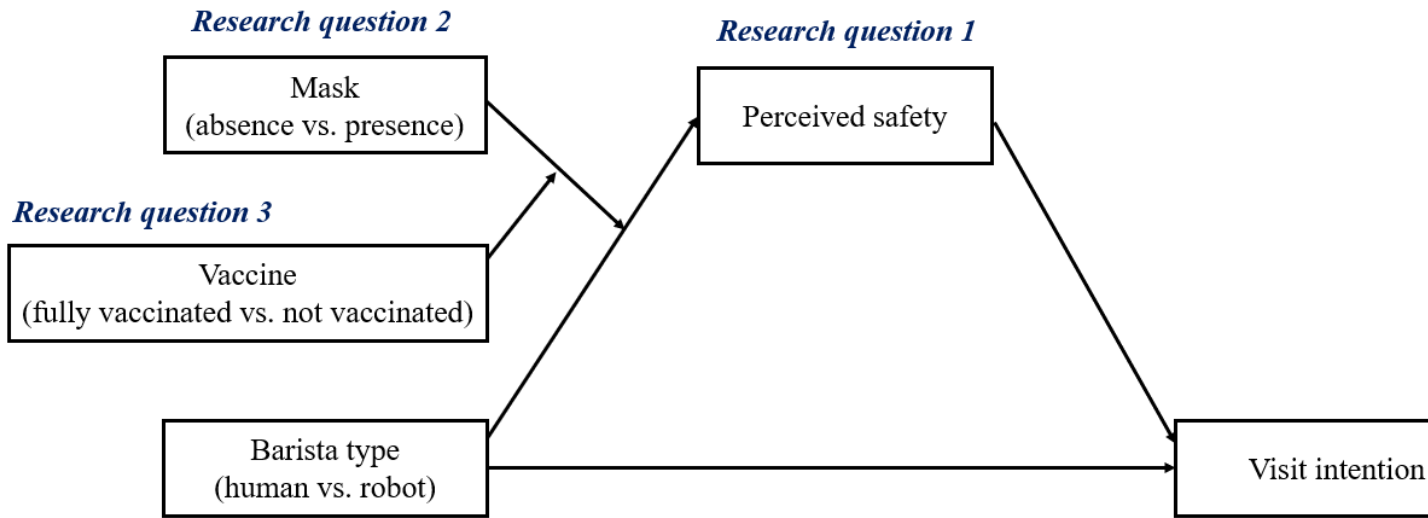


Figure 2. Stimuli images in Study 1

Top = human barista



Bottom = robot barista

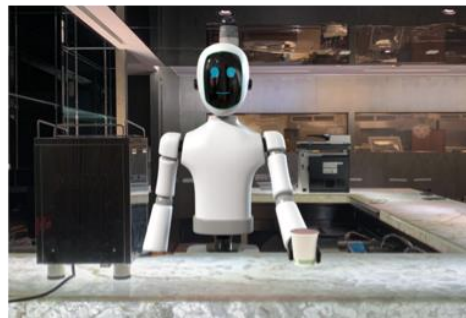


Figure 3. Stimuli images added in Study 2

Top = ‘mask-wearing’ human barista



Bottom = ‘mask-wearing’ robot barista

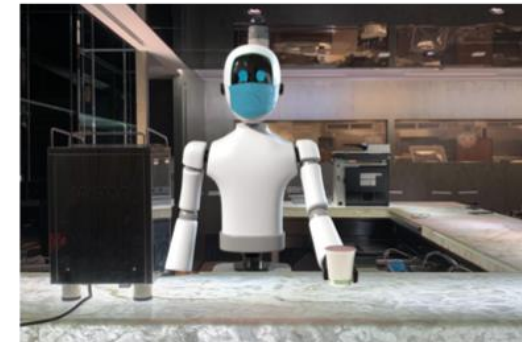
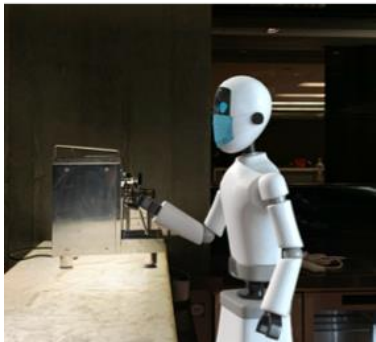
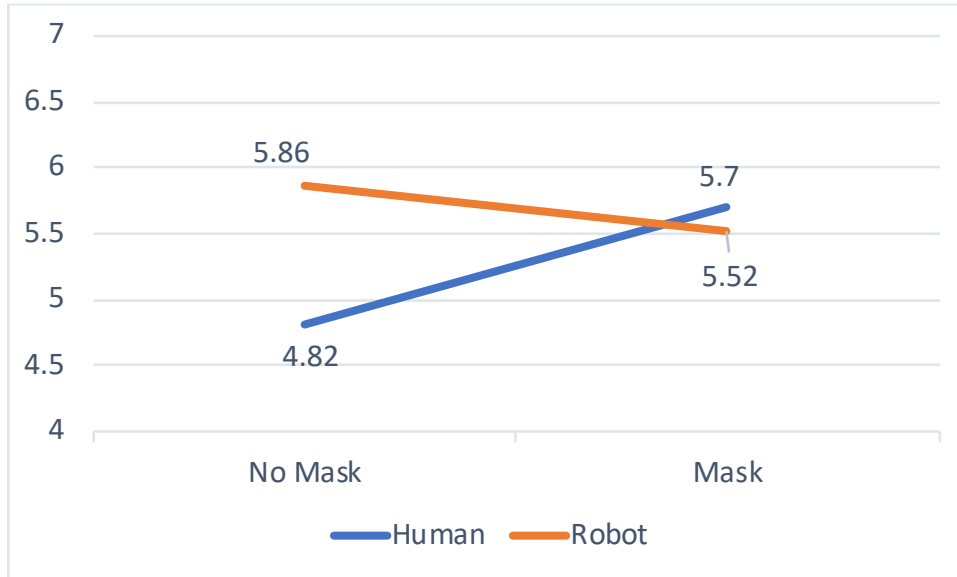


Figure 4. Three-way interaction on perceived safety

Vaccine = 0



Vaccine = 1

