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Are we behaviorally immune to COVID-19 through robots?

Xiling Xiong, IpKin Anthony Wong, Fiona X. Yang

A School of Tourism Management, Sun Yat-Sen University, Tangzhou Rd. 1, Zhuhai, China
B Faculty of Business Administration, University of Macau, Macau, China

Abstract

In the context of the health risks of the COVID-19 pandemic, tourists’ choices have shifted to reflect a subconscious psychological mechanism – the behavioral immune system – that facilitates human organisms to better identify plausible threats to one’s health through environment cues. This research draws upon this theoretical lens to assess tourists’ pre-trip hotel evaluation in two 2 × 2 between-subject experiments. Experiment 1 (robot vs. human) tested the service provider’s effect on hotel selection evaluation through the mediation of sense of control and the moderation of pandemic risk. Experiment 2 examined this chain of relationship through the moderation of hotel type. This research contributes to the literature by underscoring the pathogen-avoidance mechanism in tourist evaluation and the peril of robotization.

Keywords: Robot, Behavioral immune system, Hotel evaluation, COVID

Introduction

For years, tourism scholars have endeavored to understand how perceived risk has inhibited tourists’ travel decisions and behaviors (Aliperti et al., 2019). Anxiety and psychological apprehension render as a powerful hindrance that could compromise efforts and initiatives from destinations and tourism providers to attract tourists (Wong & Yang, 2020). Duress imposed from the COVID-19 outbreak has exacerbated such apprehensions, creating both health risks and extenuating circumstances for international travel (Qiu, Park, Li, & Song, 2020). Yet, the COVID pandemic affords an excellent opportunity to further investigate the underlying psychological mechanism of risk perception and its role in tourism product evaluation, an area that has received cursory attention in the tourism literature.

This research draws on the behavioral immune system theory (Schaller, 2006) to identity the pathogen-avoidance process that underpines risk perceptions during one’s excursion in the context of hotel evaluation. The behavioral immune system provides a holistic picture of how humans subconsciously respond to the threat of disease by stigmatizing other human beings as a behavioral defense (Park, Faulkner, & Schaller, 2003). This logic has relevance for the present inquiry by illustrating a process in which tourists’ product selection is subconsciously affected during physical interactions with the service provider depending on environmental cues (Murray & Schaller, 2016). In other words, health risks are entwined with tourist services in touristic evaluation, such that preferences for human (vs. humanless/robotic) services are conditioned on a higher level of situational contingencies.

In essence, this research takes a step forward to identify an important theoretical underpinning germane to the behavioral immune system theory, and to synthesize a series of moderated mediation relationships that could better explain tourist evaluation of choices in the context of accommodations. Based on two 2 × 2 between-subject experiments, authors of this research seek to answer four questions: How does robotic (vs. human) service influence tourist product selection evaluation? What is the role of sense of control in the evaluation process? How does travel risk superimposed onto a destination impact tourist evalua-
tion? And do different service standards (full-service vs. economy) condition the role of robotic (vs. human) service? To answer the aforementioned questions, Experiment 1 tested the effect of service provider type (robot vs. human) on hotel selection evaluation through the mediation of sense of control and the moderation of pandemic risk. Experiment 2 examined this chain of relationship through the moderation of hotel type (full-service vs. economy).

In summary, this investigation works to prime situations with perceptual cues that could activate or inactivate the behavioral immune system. To fulfill this objective, we develop a nomological network to assess how different service providers would influence travelers’ choice evaluations through their sense of control, which plays a central role in people’s preferences and approach-avoidance behaviors (Namasivayam & Hinkin, 2003). Activation of one’s behavioral immune system is accomplished through priming cues germane to the severity of the pandemic risk and type of accommodation, which are rightly important travel information in this COVID era (Wong & Yang, 2020). These two environmental cues work as boundary conditions that could moderate the proposed relationship, as Fig. 1 illustrates.

This research aims to advance the literature by underscoring the pathogen-avoidance mechanism in evaluating tourism products with or without activation of the behavioral immune system. It further acknowledges the peril of robotization as a one-size-fits-all antidote for all tourism products and situations to illustrate that robotic services are preferable only subject to tourists’ perceptual cues from the immediate environment with salient connotations to the self. This research takes a psychological science perspective to rediscover the benefits of robotization and humanless service in extenuating circumstances, while acknowledging a behavioral avoidance tendency (Mortensen, Becker, Ackerman, Neuberg, & Kenrick, 2010) to demonstrate how activation of the behavioral immune system could diminish tourists’ sense of control based upon multiple heuristic cues from the micro and macro environments.

Theoretical background

Robotic services in hotels

Service robots are one of the emerging game changers in human society, playing a vital part in different business operations and increasingly gaining influence on consumer experiences (Davenport, Guha, Grewal, & Bressgott, 2020). Global sales of service robots for personal and domestic use rocketed by 34% to 23.2 million units in 2019 (Robotics, 2020). In particular, in the tourism industry, the rapid advancement of cutting-edge technologies has catalyzed robotization in different hotel service scenarios—for example, reception, check-in, delivery, and in-room services (Tuomi, Tussyadiah, & Stienmetz, 2020). Robotic services have permeated the hospitality industry in the past decade and the trend has taken hold worldwide (Tung & Au, 2018).

Robotization in hotel services does not necessarily bring happy customers, as some tourists fail to adapt to the technology (Woods et al., 2007). Previous tourism and hospitality research has predominantly adopted the technology acceptance model (TAM) as a theoretical underpinning to explore technology acceptance factors of robotic services (Tuomi et al., 2020). The tenets of the TAM model postulate that users’ acceptance of technology mainly depends on two influential beliefs, namely the perceived ease of use (PEOU) and the perceived usefulness (PU) (Davis, 1989). This model has been further expanded by incorporating social influence and cognitive aspects. Taken together, users’ acceptance of robotic hotel services has been extensively studied as a result of their cognitive beliefs, social pressure, PU and PEOU of this new technology (Tussyadiah, 2020).

![Fig. 1. Conceptual framework. Note: dash lines indicate mediations.](image-url)
In addition to TAM and its extended models, previous research has also built on other theories and identified a broad spectrum of factors that influence acceptance of robots—for instance, anthropomorphism (Kim, Schmitt, & Thalmann, 2019) and customers’ individual differences (Longoni, Bonezzi, & Morewedge, 2019). Although these studies are insightful, they mainly focus on the characteristics of robots or customers, ignoring that customers’ acceptance of robots may also hinge on situational factors. With the COVID outbreak taken into account, several scholars have acknowledged the invaluable role of robotic services. Zeng, Chen, and Lew (2020) argue that tourism researchers should seize the opportunity to explore applications of robots to enhance tourist experience. Furthermore, a recent study conducted by Kim, Kim, Badu-Baiden, Giroux, and Choi (2021) suggests that robotic service is preferable and hence, more popular among customers than human servers since the COVID outbreak. The present research aims to bring forth a granular understanding of robotization by exploring the impact of robotic hotel services under different situations. Specifically, we will consider the interactions of pandemic risk, hotel types and service providers on customers’ hotel evaluation in light of sense of control.

Behavioral immune system

Epidemics and deadly variants of influenza pose enormous threats to humans and are one of the most important sources of pressure for human evolution (Tybur & Lieberman, 2016). To fight against pathogen invasions, humans have developed a comprehensive physiological immune system with rich antibodies. However, this system is merely reactive and a lagging response per se—trigged only after the virus has invaded the body (Duncan, 2009). Thus, there has evolved a sophisticated suite of proactive behavioral mechanisms—the behavioral immune system—that is complementary to the physiological system (Schaller, 2006).

The behavioral immune system differs from the passive physiological immune system in that it is a preventive response. When an individual perceives risk of virus/bacteria (e.g., smelling a disgusting odor), the individual will show reactive avoidance behaviors, such as paying more attention to hygiene (Puterman, Delongis, Lee-Baggley, & Greenglass, 2009).

The behavioral immune system is of great value to travelers. When people travel, they are exposed to a slew of unfamiliar germs that often pose a greater threat than the germs to which they have adapted in their long-term residence (Harvey et al., 2013). The behavioral immune system is an effective mechanism that can respond to this threat. In the field of tourism, empirical evidence suggests that during an epidemic, the behavioral immune system reinforces tourists’ group travel preferences because the familiarity of an in-group feeling can evoke a sense of security that reduces the perception of travel-related risks (Kock, Nørfelt, Jøs iassen, Assaf, & Tsonias, 2020). However, for strangers, the activation of the behavioral immune system leads to xenophobia toward out-group members (Kock, Jøs iassen, & Assaf, 2019).

The behavioral immune system is not without its imperfections despite the various health benefits; it engenders a potential cost of missing valuable opportunities or overly consuming resources. Therefore, as an active defense strategy, the behavioral immune system allows functional flexibility to maximize the benefits and minimize the cost. That is, the behavioral immune system is not always activated. Only when environmental clues suggest great threats to health, such as extremely dirty environments or areas with high rates of infection from epidemics, would individuals be attentive to the situational cues and activate their behavioral immune system (Murray & Schaller, 2016). The behavioral immune system provides solid ground for studying customer responses to COVID-19. In this vein, people’s attitudes and response toward different forms of services amid the COVID-19 pandemic may also be subject to situational factors. This research will explore the impact of different environmental cues on the behavioral immune system and their moderating effects on hotel evaluation in the context of robotic service.

It is worth noting that although consumers’ risk-reduction strategies can also lead to disease-risk avoidance behavior (Lo, Cheung, & Law, 2011), the behavioral immune system is a more appropriate theoretical focus for this research. First, risk-reduction strategies are general risk-avoidance behaviors that encompass a wide range of physical and social risks (Mitchell & McGoldrick, 1996), whereas the behavioral immune system specifically addresses reactive behaviors in pathogenic risks. In addition, unlike other socially learned motivations germane to risk reduction, the behavioral immune system informs basic human physiological needs that are rooted in our evolutionary instincts that comprehensively explain how ailment-related cues can activate human defensive behaviors and their consequences. Thus, it not only explains traveler behaviors during epidemics, but also helps tourism practitioners to better forecast these behaviors.

Sense of control

Sense of control is one of the universal psychological needs of human beings (Averill, 1973). To this end, human beings strive to continuously enhance their abilities to attain a cognitive mastery of the external world (De Charms, 1978). Having a sense of control makes people feel good and allows them to adapt better to a social environment (Ng, Sorensen, & Eby, 2006). By contrast, deprivation of control is often accompanied by anxiety, depression, and other mental problems (Cheng, Cheung, Chio, & Chan, 2013).

The body of literature has provided empirical evidence showing that sense of control affects consumers’ choices of products and services. For example, consumers with a high sense of control have a more favorable brand evaluation and demonstrate more positive attitudes toward a firm (Li, Wei, & Laufer, 2019). Another example shows that individuals deprived of control prefer commodities with precise design contours, believing that such designs can simplify and arrange their life events in a more orderly fashion (Cutright, 2012). In the context of hotel service, researchers indicate that customers are more satisfied when they feel an enhanced sense of control (Namasivayam & Hinkin, 2003). In particular, increasing customers’ sense of control in online services can improve their overall satisfaction with the service experience (Chang, 2008).
The COVID-19 pandemic has presented individuals with unprecedented challenges for health and security (Wong & Yang, 2020), remarkably jeopardizing their sense of control. In this circumstance, whether hotel services can evoke tourists’ sense of control is crucial for their evaluation of the hotel. This study will resort to sense of control as a mediator to compare robot services provided by different types of hotels on customer experiences amid the COVID-19 pandemic.

The current theoretical framework

Impact of robotic service on customers’ hotel evaluation under adversity

The adversity faced during the course of the pandemic has created feelings of uncertainty and risk from health and safety hazards (Wong & Yang, 2020). The outbreak of COVID-19 has triggered people’s behavioral immune system as the first line of defense, which tunes them to change the way they live and behave. Examples include wearing a mask when going out (Cheng, Lam, & Leung, 2020), keeping a distance from others (Lewnard & Lo, 2020), and minimizing direct physical contact with strangers (Romania, 2020).

Activation of the behavioral immune system during COVID-19 may put people in the uncomfortable situation of being wary of strangers (Aarøe, Osmundsen, & Petersen, 2016), which throws down great challenges to hotel services. Unavoidable physical contact between customers and service personnel—such as during check-in and room services—may raise customers’ worries about virus infections and undo their pleasant travel experiences (Shin & Kang, 2020). Meanwhile, technology advancement has brought the age of robotic services ever nearer for the lodging industry. Hotels practically manned by robots hold an advantage in providing contactless services that are able to stem the spread of the disease, which may eliminate customers’ concerns about virus infections (Kim et al., 2021).

Customer evaluation of robotic services was fairly diverse and inconclusive before the outbreak of COVID-19 (Gnams & Appel, 2019). On one hand, people tend to trust robots’ strengths in computation and rationality and are willing to trust their abilities in non-social interactions, such as disaster warning (Robinette, Li, Allen, Howard, & Wagner, 2016) and path selection (Robinette et al., 2016). This stream of research often demonstrates people’s positive attitude toward robots. On the other hand, people show dissatisfaction with robots’ performance when it comes to human–robot interactions. For example, robotic services may insufficiently attend to customers’ specific needs (Granulo, Fuchs, & Puntoni, 2020) and make guests feel alienated (Kim et al., 2019). However, under the current pandemic, the activation of the behavioral immune system may shift tourists’ greatest concerns to safety and health. It is in this circumstance that robotic services have gained a competitive edge over human-centered interactions. It is worth noting that the behavioral immune system will only be activated in the presence of environmental cues of the menace of virus/bacteria (Murray & Schaller, 2016). Therefore, the advantages of robotic services may only unfold in high-risk areas. Given the above rationale, the following hypothesis was proposed:

Hypothesis 1a. The relationship between service provider and hotel evaluation is moderated by pandemic risk, such that under a high-risk situation, hotel guests who receive robotic services have higher hotel evaluations than those who receive human services.

In spite of hotels’ endeavors to implement robotization amid COVID-19 (Kim et al., 2021), there is still a paucity of exploration into the inner psychological mechanism of why would people prefer robot services in the pandemic. Such a favorable robot-induced hotel evaluation could be possibly explained by an increased sense of control—a psychological advantage of robotic services. When the pandemic risk is high, the activation of the behavioral immune system evokes sensitivity to virus/bacteria information about the environment, as customers feel more uncertain about contacts with strangers. An increased feeling of uncertainty would weaken or even deprive their sense of control (Chae & Zhu, 2014). As such, individuals would strive to reassert their abilities to control the environment by different means (Chen, Lee, & Yap, 2017). Robot-facilitated, contactless experiences may reduce their uncertainty over contacts with strangers, thereby replenishing their sense of control and hence, promoting favorable evaluation of the service provider. Accordingly, the following hypothesis was proposed:

Hypothesis 1b. The relationship between service provider and hotel evaluation is mediated by sense of control, such that hotel guests who receive robotic services have higher hotel evaluations through higher sense of control.

Interaction between hotel type and robotic service on customer experience

Activation of behavioral immune system is not only affected by macro environmental cues, but also by immediate environmental cues (Murray & Schaller, 2016). This dynamic may help us to re-examine the first hypothesis, which postulates that in high-risk areas, people would have more positive feelings about robotic service due to activation of the behavioral immune system. Going a further step, there may exist some reassuring safe harbors that would inactivate the behavioral immune system, even in a high-risk zone for COVID-19 infections.

Such reassuring factors may include the types of accommodation services. Previous studies have indicated that people are more willing to choose full-service hotels during the pandemic for high standards of hygiene (Kourgiantakis, Apostolakis, & Dimou, 2020). During their stay at such a premium hotel with high quality assurance, patrons’ behavioral immune system may not be triggered, as they have confidence in the hotel’s safety, health, and hygiene standards. This situation resonates with the
quality halo effect (Kim, Choi, & Martin, 2020), in which high-end services often connote superior sanitation and hence, a safety net that can keep the virus at bay. Therefore, the influence of the behavioral immune system on tourists’ experiences would be minimal. As it is the behavioral immune system that directs customers’ preference toward robotic services, the inactive status of the behavioral immune system at a full-service hotel will marginalize the advantage of robotic services, even in high-risk areas. Accordingly, the following hypothesis was proposed:

**Hypothesis 2a.** Under high risk of pandemic, the relationship between service provider and hotel evaluation is moderated by hotel type, such that only for economy hotels, guests who receive robotic services would give a higher hotel evaluation than those who receive human services.

In addition, although robotization can evoke people’s sense of control during the pandemic through contactless services, it still has its imperfections, in that robots can hardly satisfy complicated needs for empathetic interactions (Granulo et al., 2020; Longoni et al., 2019). Full-service/luxury hotels are met with a long list of customers’ high expectations of service quality (Zhang, Ye, & Law, 2011), especially for personalization and empathy (Yu & Timmerman, 2014). This demand would eclipse the advantages of service robots because such a high-standard environment often entails rigorous containment measures that could instill guests’ confidence and hence, a greater sense of control (i.e., a sense that the virus is at bay) (Jiang & Wen, 2020). A high level of service quality can also mitigate patrons’ anxiety during their hotel stay, resulting in more favorable guest responses (Wong & Yang, 2020). Accordingly, offering robotic services in such settings, however, may restrict the technology’s ability to improve tourists’ sense of control and hence, their hotel evaluations. By contrast, tourists at economy hotels are generally not fastidious about service quality (Zhang et al., 2011). Compared with the need for empathetic interactions, they are inclined to place more emphasis on the quality of hotel hardware and hygiene standards (Zhang et al., 2011). Therefore, the advantages of robotic services during the pandemic may only become prominent for economy hotels, leading to the last hypothesis:

**Hypothesis 2b.** The relationship between service provider and hotel evaluation is conditionally mediated by sense of control, such that only for economy hotels, guests who receive robotic services would give a higher hotel evaluation when they have a higher sense of control.

**Experiment 1**

The objective of this experiment was to examine individuals’ preference for service provider (human service vs. robot service) under different exposure to pandemic risk (high vs. low) in the hotel setting. In our study, we compared robotic and human services to examine the effectiveness of the behavioral immune system in the tourism setting. The benefits of this comparison are twofold. First, unlike organisms, robots cannot actively spread germs through the respiratory system; yet they are able to interact with humans, making them an excellent control group. Second, while people’s social acquisition of interaction with robots is still limited, robotic services are particularly welcoming during the pandemic (Kim et al., 2021). Therefore, people’s current risk judgments are more likely to rely on the behavioral immune system than on their risk-reduction strategies.

**Method**

A total of 225 participants (39.5% female, mean age = 31.53) were randomly recruited through the Wenjuanxing platform, a Chinese online survey platform that functions similarly to Amazon Mechanical Turk (Cao, Wang, & Wang, 2020). Wenjuanxing comprises 2.6 million Chinese members from diverse demographic and socioeconomic backgrounds (Zheng & Zheng, 2014). Experiment 1 is a between-subject design in which participants were randomly assigned to one of four conditions in a 2 (service provider: human vs. robot) × 2 (pandemic risk: high vs. low) setting. First, participants were asked to read a scenario with pictures of a hotel and to imagine being in the following situations with four different scenarios with the statement “The current outbreak of COVID-19 is becoming more devastating worldwide. The World Health Organization (WHO) has assessed the risk level according to the pandemic situation in different regions.” The following statements were served as stimuli to guide respondents:

*Please imagine that you are going to visit a destination with high risk (vs. low risk) of the pandemic. The hotel you plan to stay in is shown in the pictures. The hotel is currently open, and all service staff are on duty (vs. all service staff are replaced by robots).*

To strengthen participants’ attention to the stimuli, we adopted the method from Oishi, Miao, Koo, Kisling, and Ratliff (2012) to ask participants to briefly write down the description of a specific interaction with hotel service (e.g., check-in, request for delivery, etc.). In order to mitigate the ineffectiveness of a manipulation check, which may “alerts participants to the purpose of the manipulation” (Ejelov & Luke, 2020, p. 5), we used an open-ended account of their description and then coded the frequency of the keywords relevant to the epidemic risk/robotic services as an indirect manipulation check (see Appendix A for details of the manipulation).

Next, participants rated their sense of control using three items (At the moment, I feel helpless/powerless/lack of control) on a 5-point anchor ranging from 1 (not at all) to 5 (very much) (α = 0.826), adopted from Fritsche, Jonas, and Fankhanel (2008). The Chinese version was validated by Liu, Wang, and He (2014). Following the suggestion from Liu et al. (2014), we reversed the
score to get the customer’s positively ranked sense of control. Customer’s evaluation of hotel (or “hotel evaluation” for short) was assessed using four items (e.g., How well the hotel satisfied my needs) adopted from Kim, Zhang, and Li (2008). The Chinese version was validated by (Yang & Zhu, 2016). Details for each scale item can be found in Appendix C. Each item was evaluated with a 7-point anchor ranging from 1 (not at all) to 7 (very much) (α = 0.845). All analyses for both Experiments 1 and 2 were conducted using SPSS 22.0.

Finally, we recruited another 108 participants (63% female, mean age = 32.67) from the same subject pool to conduct a separate experiment as an independent manipulation check and realism check. This approach followed the suggestions from Hauser, Ellsworth, and Gonzalez (2018) to ensure the directness and avoid the interference of the manipulation/realism check. We asked the participants, “What is your perceived risk of an outbreak in the scenario? (from 1 = very low risk to 10 = very high risk)” and “What do you perceive as the main employees to provide the service in the scenario? (from 1 = mainly human server to 10 = mainly robotic server).” For realism check, we used three items (e.g. I find the scenario for this hotel to be realistic) (α = 0.771) adopted from Gao, Zhang, and Mittal (2017). The translation procedure followed a translation-back translation process (Cheng, Zhou, Guo, & Yang, 2020) to ensure accuracy.

**Results**

**Manipulation check**

First, to check the effectiveness of our experimental manipulation, we coded participants’ descriptions of the expected experience of the hotel service acceptance. For participants in the high pandemic risk condition, 45.3% mentioned keywords such as “mask,” “disinfect,” and “infection risk” more than those in low pandemic risk condition (32.8%), χ²(1, 224) = 3.70, p = .054. For participants in the robot service condition, 69.2% clearly mentioned keywords such as “robot” and “artificial intelligence,” more than those in the human service condition (1.0%), χ²(1, 224) = 111.38, p < .001. Second, in an independent manipulation check, the participants in the high-risk condition perceived higher risks (M = 7.60, SD = 2.07) than those in the low-risk condition (M = 4.60, SD = 2.61), F(1, 107) = 43.839, p < .001. The participants in the robotic condition perceived that the service was mainly provided by robots (M = 9.45, SD = 1.01), in contrast to those in the human condition (M = 1.27, SD = 0.60), F(1, 107) = 43.839, p < .001. Therefore, our manipulation was effective.

**Realism check**

One sample t-tests indicated that each of the conditions was more realistic than the scale’s midpoint (high-risk, human service: 6.12 vs. 3.5, t[24] = 24.50, p < .001; high-risk, robotic service: 5.53 vs. 3.5, t[29] = 9.36, p < .001; low-risk, human service: 6.07 vs. 3.5, t[26] = 18.94, p < .001; low-risk, robotic service: 5.67 vs. 3.5, t[29] = 13.62, p < .001). Thus, the realism of our scenario was acceptable.

**Sense of control**

We find a main effect of pandemic risk on sense of control, F(1, 224) = 5.497, p = .020, but no main effect of service provider, F(1, 224) = 0.459, p = .499. Importantly, the interaction of pandemic risk and service provider was significant, F(1,221) = 4.388, p = .037. When participants were situated in a high pandemic risk context, their level of sense of control on robotic services was higher (M = 3.87, SD = 0.91) than when the services were provided by regular employees (M = 3.55, SD = 1.06), F(1, 104) = 2.797, p = .097, with a marginally significant effect. However, when participants were situated in a low pandemic risk context, there was no significant difference on sense of control for robotic services (M = 3.90, SD = 0.74) and employee services (M = 4.06, SD = 0.75), F(1, 117) = 1.441, p = .232. (see Fig. 2 for graphical illustrations).

![Fig. 2. Interaction effect between pandemic risk and service provider on sense of control.](image-url)
Hotel evaluation

We did not find any main effect of pandemic risk on hotel evaluation ($F_{1,221} = 0.390$, $p = .533$), but a marginally significant main effect of service provider ($F_{1, 221} = 3.675$, $p = .057$). Importantly, the interaction between pandemic risk and service provider was significant ($F_{1, 221} = 6.668$, $p = .010$). When participants were situated in a high-risk circumstance, individuals who were served by robots recorded a higher level of hotel evaluation ($M = 5.88$, $SD = 0.77$) than those who were served by human employees ($M = 5.39$, $SD = 1.20$), $F_{1, 104} = 6.560$, $p = .012$, with a significant effect. However, when participants were placed in a low-risk situation, there was no significant difference for robotic services ($M = 5.67$, $SD = 0.66$) and services from human employees ($M = 5.74$, $SD = 0.60$), $F_{1, 117} = 0.389$, $p = .534$. Thus, $H_1a$ was supported (see graphical illustrations in Fig. 3).

It is important to note that a preliminary analysis revealed neither direct nor interaction effect of gender and age on the dependent measures. Inclusion of these variables did not affect the results and hence, they were not included in the analysis for parsimony.

Mediation effect

The mediating role of sense of control was explored through a bootstrapping model (Hayes, 2017). The present study hypothesized that the interaction effect between pandemic risk and service provider would indirectly affect hotel evaluation through sense of control. Thus, we used the PROCESS macro model 8 to verify the moderated mediation of sense of control between service provider and hotel evaluation. A 95% CI of the parameter estimates was obtained by running the samples 5000 times. Results for the overall model are shown in Table 1. Sense of control mediated the effect of service provider on hotel evaluation (CI = 0.01 to 0.53). The direct effect of service provider on hotel evaluation was present only in the high-risk condition (CI = 0.06 to 0.60), but not in the low-risk condition (CI = −0.24 to 0.26). Thus, $H_1b$ was warranted.

Discussion

Results from Experiment 1 supported our hypotheses in that the relationship between service provider and hotel evaluation was moderated by pandemic risk. Specifically, only under the high-risk pandemic situation did customers give higher hotel evaluations for robot service than human service. Importantly, robotic service improved customers' hotel evaluation through an improved sense of control. Although Experiment 1 showed that there was significant interaction between pandemic risk and service provider, it is unclear whether the results are consistent across different types of hotels. According to previous studies, people’s expectations of services in different types of hotels varies greatly (Ariffin & Maghzi, 2012) and hence, the impact of different types of hotels providing robot services is also worthy of further research. In order to address this limitation, Experiment 2 explored the impact of robot service provided by full-service hotels (vs. economy hotels).

Experiment 2

The objective of this experiment was to examine individuals’ preference for the hotel service provider (human service vs. robotic service) under different hotel categories (full-service hotel vs. economy hotel) in a destination with high pandemic risk.

Method

The data collection procedure of Study 2 was the same as the first study. A total of 254 participants (35.8% female, mean age = 30.98) were recruited through Wenjuanxing. This study utilized a between-subject design in which participants were randomly assigned to one of four conditions in a 2 (service provider: human vs. robot) × 2 (hotel type: full-service vs. economy) setting.

![Fig. 3. Interaction effect between pandemic risk and service provider on hotel evaluation.](image-url)
The experimental procedure began by asking participants to read a scenario with pictures of a hotel and to imagine being in the following situations. In particular, participants read one of four scenarios with the statement that began with “The current COVID-19 outbreak is becoming more devastating worldwide. The World Health Organization has assessed the risk level according to the pandemic situation in different regions.”

Please imagine that you are going to a destination with a high risk of pandemic. The hotel you plan to stay in, a [full-service (vs. economy)] hotel, is shown in the figures below. The hotel is currently open, and all service staff are on duty (vs. all service staff are replaced by the robot) to provide services to guests.

To strengthen participants’ attention to the stimuli and as a manipulation check, we adopted the same writing task as experiment 1 (see Appendix B for details of the manipulation). Next, participants rated their sense of control using a three-item scale ranging from 1 (not at all) to 7 (very much) (α = 0.856) adopted from Fritsche et al. (2008). Items were reverse-scored to record the customer’s positive sense of control. Hotel evaluation was assessed by four items on a 7-point anchor ranging from 1 (not at all) to 5 (very much) (α = 0.858). The scale was adapted from Kim et al. (2008).

Finally, we followed the same procedure as in Experiment 1 and recruited another 100 participants (57% female, mean age = 31.46) from the same subject pool to conduct a separate experiment as an independent manipulation check and realism check. For the manipulation check, we asked the participants, “What type of hotel do you think the hotel in the scenario is more likely to belong to? (from 1 = definitely economy hotel to 10 = definitely full-service hotel)” and “What do you perceive as the main employees to provide services in the scenario? (from 1 = mainly human server to 10 = mainly robotic server).” For the realism check, we used the same three items as in Experiment 1 adopted from Gao et al., 2017 (α = 0.707).

Results

Manipulation check

In order to diagnose the effectiveness of our experimental manipulation, we first coded participants’ descriptions of the experience of different types of hotel services. For participants in the robot service condition, 74.8% described their experience with keywords such as "robot" and "artificial intelligence," more than those in the human service condition (0.8%). \( \chi^2 (1, 253) = 149.82, p < .001 \). To examine participants’ perceptions of different types of hotels, we also added an item to ask participants to estimate the hotel price. Participants in the full-service hotel condition estimated a higher price (\( M = 295.15, SD = 74.73 \)) than those in the economy hotel condition (\( M = 233.00, SD = 60.38 \)), \( F(1, 253) = 45.085, p < .001 \). In addition, the independent manipulation check revealed that the participants in the full-service condition were more likely to perceive their accommodation as a full-service hotel (\( M = 9.04, SD = 1.36 \)) than those in the low-risk condition (\( M = 4.04, SD = 2.97 \)), \( F(1, 99) = 119.077, p < .001 \). The participants in the robotic condition perceived that the service is mainly provided by robots (\( M = 9.42, SD = 1.01 \)), in contrast to those in the human condition (\( M = 1.50, SD = 0.89 \)), \( F(1, 99) = 1732.696, p < .001 \). Therefore, our manipulation was effective.

Table 1

| Predictor variables \( R^2 = 0.04, F(3,221) = 3.06, p = .029 \) | Mediating variable (sense of control) | Dependent variable (hotel evaluation) |
|------------------|----------------------------------------|----------------------------------------|
| \( \beta \) | SE | \( t \) | \( p \) | Cohen’s d | \( \beta \) | SE | \( t \) | \( p \) | Cohen’s d |
| Constant | 4.06 | 0.11 | 37.54 | \(<.001\) | Constant | 3.74 | 0.23 | 15.92 | \(<.001\) |
| Service type (human vs. robot) | -0.16 | 0.16 | -1.04 | 0.298 | Sense of control | 0.49 | 0.05 | 9.20 | \(<.001\) |
| Epidemic risk (low vs. high) | -0.52 | 0.17 | 3.01 | 0.002 | Service type × Epidemic risk | 0.49 | 0.23 | -2.10 | 0.037 |
| Service type × Epidemic risk | 0.49 | 0.23 | -2.10 | 0.037 |

| \( \beta \) | SE | \( t \) | \( p \) | Cohen’s d |
|------------------|----------------------------------------|----------------------------------------|
| \( \beta \) | SE | \( t \) | \( p \) | Cohen’s d |
| Conditional direct effects of X on Y at values of the moderator | Epidemic risk | \( \beta \) | SE | LLCI | ULCI |
| Epidemic risk | Low | 0.01 | 0.13 | -0.24 | 0.26 |
| High | 0.33 | 0.14 | 0.06 | 0.60 |
| Sense of control | \( \beta \) | SE | LLCI | ULCI |
| Epidemic risk | Low | -0.08 | 0.13 | -0.23 | 0.05 |
| High | 0.16 | 0.14 | -0.03 | 0.40 |
| Mediator | Index of moderated mediation | Sense of control | \( \beta \) | SE | LLCI | ULCI |
| Sense of control | 0.24 | 0.14 | 0.01 | 0.53 |
Realism check

One sample t-tests indicated that each of the conditions was more realistic than the scale’s midpoint (full-service hotel, human service: 5.99 vs. 3.5, \(t_{24} = 15.39, p < .001\); full-service hotel, robotic service: 6.08 vs. 3.5, \(t_{25} = 19.88, p < .001\); economy hotel, human service: 6.13 vs. 3.5, \(t_{24} = 18.62, p < .001\); economy hotel, robotic service: 5.67 vs. 3.5, \(t_{23} = 11.71, p < .001\)). Thus, the realism of our scenario was acceptable.

Sense of control

We find neither a main effect of hotel type (\(F_{1, 254} = 0.025, p = .874\)), nor a main effect of service provider on sense of control (\(F_{1, 254} = 1.056, p = .305\)). Importantly, the interaction of hotel type and service provider was marginally significant (\(F_{1, 250} = 3.807, p = .052\)). When participants were staying in an economy hotel, their sense of control was significantly higher for robotic services (\(M = 4.03, SD = 0.75\)) than for human employee services (\(M = 3.69, SD = 1.01\), \(F_{1, 123} = 4.524, p = .035\). However, when participants were placed in a full-service hotel, there was no significant difference between the two types of services (\(M_{\text{robot}} = 3.79, SD = 0.96\) vs. \(M_{\text{human}} = 3.89, SD = 0.89\), \(F_{1, 127} = 0.419, p = .518\) (see Fig. 4 for graphical illustration).

Hotel evaluation

We find a marginally significant main effect of hotel type on hotel evaluation (\(F_{1, 253} = 3.678, p = .056\), which implies that the evaluation of the full-service hotel (\(M = 5.77, SD = 0.89\)) was better than that of the economy hotel (\(M = 5.55, SD = 0.90\)). We also find a marginally significant main effect of service provider (\(F_{1, 253} = 3.445, p = .065\), which suggests that the evaluation of the robotic service-oriented hotel (\(M = 5.77, SD = 0.86\)) was better than that of the regular employee service-oriented hotel (\(M = 5.56, SD = 0.93\)).

Importantly, the interaction of hotel type and service provider was marginally significant (\(F_{1, 250} = 2.938, p = .088\)). When participants were situated in an economy hotel, they recorded a significantly higher evaluation of the hotel with robotic services (\(M = 5.76, SD = 0.80\)) than of the hotel with human employee services (\(M = 5.36, SD = 0.95\), \(F_{1, 123} = 6.309, p = .013\). However, when participants were situated in a full-service hotel, no difference was found between the robotic service group (\(M = 5.78, SD = 0.92\)) and human employee service group (\(M = 5.77, SD = 0.87\), \(F_{1, 127} = 0.010, p = .920\). Thus, \(H2a\) was supported, and these results are depicted in Fig. 5. It is important to note that we performed a preliminary analysis on the potential effect of gender and age on the dependent measures. Inclusion of these variables did not affect the results and hence, they were not included in the main study, for parsimony.

Mediation effect

The mediating role of sense of control was tested through the PROCESS procedure (Hayes, 2017). This study hypothesized that the interaction effects between hotel type and service provider would indirectly affect hotel evaluation through sense of control. Thus, we used Model 8 via PROCESS to verify this moderated mediation effect. A 95% CI of the parameter estimates was obtained by running the samples 5000 times. The results for the overall model can be seen in Table 2. Sense of control conditionally mediated the effect of service provider on hotel evaluation only for economy hotels (CI = 0.02 to 0.26), but not for full-service hotels (CI = −0.17 to 0.08). Thus, \(H2b\) was warranted.

Discussion

Experiment 2 revealed evidence that a positive effect of robotic service on hotel evaluation during the pandemic is only reflected in economy hotels and not in full-service hotels. In addition, this effect is conditionally mediated by sense of control such that only in economy hotels can robotic service improve tourists’ hotel evaluation through an improved sense of control.
The goal of this inquiry is to offer a granular understanding of how micro and macro situational factors could shape tourists' hotel evaluation in the midst of the COVID crisis. Specifically, this research examined the impact of robotic service on hotel selection evaluation based on two boundary conditions: pandemic risk perceptions and type of accommodation. The authors are particularly interested in answering questions pertaining to why in some situations robotization is preferable, while in other occasions it is less desirable. In answering this question, we draw on behavioral immune system theory, along with theories germane to sense of control, to unlock the mystique about robotic services that are devoid from human interactions. From two 2 × 2 between-subject experiments, the findings provide evidence that under high health risk of a pandemic, robotic service in economy hotels can significantly improve tourist evaluation through improved sense of control. These empirics inform several theoretical implications, as detailed below.

Thus far, research on the COVID-19 pandemic has laid an early foundation on how health and travel related risks could hinder destination choices and tourism product selection (Qiu et al., 2020). Yet, in general, the literature only pays cursory attention to the reason beneath risk perceptions on traveling. In particular, prior tourism literature commonly adopts risk-reduction strategies to explain risk-avoidance behaviors arising from a constellation of risk factors (e.g., political instability,

### Table 2

| Predictor variables $R^2 = 0.02$, $F (3,250) = 3.06, p = .189$ | Mediating variable (sense of control) | Dependent variable (hotel evaluation) |
|---------------------------------------------------------------|---------------------------------------|---------------------------------------|
| Constant                                                      | 3.69                                  | 3.98                                  |
| Service type (human vs. robot)                                | 0.34                                  | 0.33                                  |
| Hotel type (economy vs. full-service)                         | 0.21                                  | 0.33                                  |
| Service type × Hotel type                                     | −0.45                                 | −0.22                                 |
| Sense of control                                              | 0.37                                  | 0.27                                  |
| Service type (human vs. robot)                                | 0.06                                  | 0.06                                  |
| Hotel type (economy vs. full-service)                         | 0.15                                  | 0.15                                  |
| Service type × Hotel type                                     | −0.22                                 | −0.03                                 |
| Sense of control                                              | 0.13                                  | 0.01                                  |
| Mediator Conditional direct effects of X on Y at values of the moderator |
| Hotel type                                                    | 0.27                                  | 0.13                                  |
| Economy                                                       | 0.15                                  | 0.02                                  |
| Full-service                                                  | 0.06                                  | 0.02                                  |
| Sense of control                                              | 0.13                                  | 0.01                                  |
| Mediator Conditional indirect effects of X on Y at values of the moderator |
| Hotel type                                                    | 0.27                                  | 0.13                                  |
| Economy                                                       | 0.15                                  | 0.02                                  |
| Full-service                                                  | 0.06                                  | 0.02                                  |
| Sense of control                                              | 0.13                                  | 0.01                                  |
| Mediator Index of moderated mediation                         | 0.17                                  | 0.00                                  |

Fig. 5. Interaction effect between hotel type and service provider on hotel evaluation.
tension, disease, and cultural barriers, etc.) among international tourists (Lo et al., 2011). Risk-reduction approaches encompass a wide range of mental, physical, and social tactics (Mitchell & McGoldrick, 1996) that tourists consciously employ in order to alleviate dangers associated with travel (Kim, Lee, Petrick, & Kim, 2020). This research takes a step forward to identify an important theoretical underpinning from the behavioral immune system to synthesize a series of moderated mediation relationships that could better explain tourist choice. Importantly, the behavioral immune system provides a holistic picture of how the human organism subconsciously avoids health threats by discriminating against other human beings. This logic has transferred into the present inquiry to acknowledge a process in which tourists’ product selection subconsciously eschews possible interactions with service staff depending on the environmental cues. In other words, health risks and services are entwined in touristic evaluation to underscore why preference for human (vs. humanless) services are conditioned on a higher level of situational contingencies.

Application of the behavioral immune system could help us pave the way to better explain tourists’ attitudes, perceptions, and behaviors that may seem peculiar or even bizarre in the face of extenuating circumstances such as the COVID pandemic. As people are vulnerable to disease, they are particularly sensitive to heuristic cues that connote viruses and infection and hence, they tend to act conservatively and be reticent regarding normal courses of action (Mortensen et al., 2010). Our findings supplement this line of logic by showcasing that when a health threat is made salient during an excursion, tourists raise a more stringent health and safety standard for tourism services. As a result, they impose stigmatization on service providers to engage in pathogen-avoidance behaviors (c.f. Park et al., 2003). This underlying reasoning may better explain why prejudice and discrimination against tourists are rather common in the midst of the COVID crisis (Yang & Wong, 2020). Such a disease-avoidance mechanism thrusts a dagger into the heart of human interactions, leading to an anti-social crisis that permeates around the globe, especially as social distancing measures often take central stage. While the social cost of the pandemic is paramount (Qiu et al., 2020), our findings reveal strategies that could remedy the social-avoidance tendency by endowing tourism services with means to ease tourists’ worries and apprehension.

Our research focuses on the impact of perceptual cues in the environment on tourist preference for humanless services. Our study found that disease-related cues in the macro environment (i.e., high-risk regions) can activate one’s behavioral immune system, leading to preference for robotic services. In addition, the immediate micro environment (full-service hotels vs. economy hotels) also plays a role in activating their behavioral immune system, as different types of service standards connote heuristic cues that can signify safety or danger from pathogenic sources. This research thus offers new nuances to behavioral immune system by showcasing how activation/inactivation of the behavioral immune system could impact service preference. Our findings suggested the behavioral immune system influences one’s hotel evaluation indirectly through a boundary conditioning mechanism. These findings are novel to the theoretical strand put forth by Schaller (2006), whose primary concern is the direct effect of the behavioral immune system. More importantly, they afford a synthesis between micro- and macro-environmental cues to juxtapose a moderated meditational mechanism. On one hand, health-related risk at the regional level undermines taken-for-granted humanized services while promoting robotization; on the other hand, a high-quality level of tourism product (i.e., full service hotel) is still quintessential as it renders as a buffer to de-humanization of services.

With respect to robotic research, previous tourism-hospitality studies focus mainly on characteristics of the robot itself and individual differences (Prentice, Weaven, & Wong, 2020). This line of inquiry certainly favors robotic services, while Chen, Chen, and Lew’s recent article further acknowledges a trend in which the COVID-19 pandemic has facilitated adoption of robots, and hence, tourism and hospitality services are switching from “high-touch to high-tech”. As a result, robotization seems to represent a perfect antidote in the COVID era, especially as humanless services align well with the behavioral avoidance tendency that underpins the behavioral immune system (Mortensen et al., 2010) when tourists are primed for risk exposure in a highly infectious situation. Yet, a careful examination of this rationale deserves further consideration, as findings of the present inquiry reveal environmental contingencies that are symbiotic with the taken-for-granted a priori assumption about robots.

Taking Schaller (2006)’s viewpoint in the light of empirics discerned from this research may offer new revelations to tourism services. On one hand, robots are not always an antidote in the COVID era despite people tending to prefer humanless service when ailment-related cues are amplified, which activate human defensive behaviors. However, a high level of service standard that connotes warmth and empathy is still essential in the tourism industry. The synthesis between micro and macro-environmental cues points to the peril of robotic (vs. human) services during extenuating circumstances. It thus points to a danger for tourism providers to prematurely compromise their service excellence and depart from the taken-for-granted service model. Yet, it also casts a need for operators to reframe their strategies to better consider contextual variations that are entwined in tourist evaluations.

With respect to sense of control, this research illustrates how it plays a role in service evaluation. As an important means to determine one’s life and decisions, sense of control research has been accentuated as a critical motivational factor that directs certain behaviors. Prior literature, however, commonly acknowledges that improving one’s sense of control is mainly achieved by giving the individual psychological empowerment (Wright, Newman, & Dennis, 2006), such as involving the person in co-creation activities (Füller, Mühlbacher, Matzler, & Jawecki, 2009). Yet, tourists’ sense of control plays an even more salient role when a destination’s pandemic risk is pronounced, due to activation of their behavioral immune system. Robots thus work as a critical conduit that could buffer risks associated with virus infection, but only in economy hotels. Interestingly, human services can still replenish/fortify tourists’ sense of control as a preference over robots in full-service accommodations. This duality of sense of control adds new nuances to the literature by showcasing a complex of situational boundary conditions among tourism products and services that could remedy the deterioration of control over one’s life and travel outcomes in places that are subject to pandemic duress and threats to health.
Limitations and future research

This research took an experimental design to assess the proposed model. However, several limitations remain. First, both studies utilized vignette experiments from online participants. Future studies may investigate the proposed effect in real hotel settings. Second, we explored the mediation of sense of control. Other possible mediating factors may include robot preference, performance of robotic services, and tourist service experience. Finally, our research was mainly carried out by randomly recruiting Chinese participants and only classified the epidemic risk as high or low in different areas following the Chinese travel guidelines (China, 2020). We encourage future research to extend the present inquiry by exploring cultural differences and individual differences.

Declaration of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could influence the work reported in this paper.

Acknowledgment

The present research was funded by the National Natural Science Foundation of China (72074230), Humanity and Social Science Foundation of Ministry of Education of China Grant (20YJCZH189), and China Postdoctoral Science Foundation (2020M672918).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.annals.2021.103312.

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Xiling Xiong is a post-doctoral fellow of School of Tourism Management at Sun Yat-sen University. His research focuses on consumer psychology.

Ipkin Anthony Wong is a professor at Sun Yat-Sen University. His research interests include tourism motivation, consumer behaviors, and research methods.

Fiona Xi Yang is an Assistant Professor at Faculty of Business Administration, University of Macau. Her research interests include tourism and hospitality marketing.