#### Robots Make Me Feel More Like A Human! Investigating How Employee-Robot Engagement Reduces Workplace Depersonalization

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#### Abstract

Recent research has begun to investigate employee-robot interactions, but the impact of employee-robot engagement in the workplace still requires further exploration. This research adopted a perspective of psychological empowerment to uncover the mechanisms and boundary conditions between employee-robot engagement and workplace depersonalization. A mixed-method research design with three studies was conducted. Study 1 involved a qualitative research approach and developed a theoretical model of employee-robot engagement under robot-related psychological empowerment, which includes meaning, competence, self-determination, and impact. Study 2 consisted of an online experiment, and the results revealed that employee-robot engagement can significantly reduce the presence of depersonalization. Study 3 employed a questionnaire survey and demonstrated that employee-robot engagement, through robot-related psychological empowerment, reduced depersonalization, with developmental HR practices playing a moderating role. Our research expands human-robot interaction theories, and offers practical guidance for the adoption of service robots in the tourism and hospitality organizations.

**Keywords**: Service robots; Employee-robot engagement; Workplace depersonalization; Psychological empowerment; developmental HR practices.

#### 1. Introduction

Service robots are autonomous devices that incorporate artificial intelligence (AI) technologies, often with physical embodiments, that perform programmed routines while adapting to diverse environments and tasks, interacting with humans to deliver effective services across various fields (IFR, 2019; Wirtz et al., 2018). In recent years, the integration of service robots into the tourism and hospitality industries has marked a paradigm shift in how organizations operate and deliver services (Ladeira et al., 2023; Liang et al., 2022; Mukherjee et al., 2023). This transformative trend has sparked significant interest among researchers and practitioners to better understand the dynamics and characteristics of humanrobot interaction (Kim et al., 2022; Li et al., 2019; Seyitoğlu & Ivanov, 2023). For instance, hotel employees use robots to accurately fulfill customer requests by delivering items directly to designated rooms, enhancing both work efficiency and the customer experience. At tourist attractions, especially during peak periods, staff deploys robots to handle tasks like check-in, ensuring consistent service quality. As tourism and hospitality businesses continue transitioning towards more automated and technologically integrated environments, understanding the impact of service robots on employees becomes increasingly important.

Previous studies have mainly focused on employee-robot interaction, such as the impact of robotic characteristics on acceptance, satisfaction, and engagement (Fang et al., 2023; Ladeira et al., 2023; Yin et al., 2023; Zhang et al., 2024). Research on employee-robot interaction is noticeably limited. Specifically, while earlier studies suggested that service robots would replace employees, leading to negative consequences such as resignations and passive work attitudes (Fu et al., 2022; Liu et al., 2019; Pan et al., 2025), more recent research indicates that employees are beginning to recognize the empowering effects of AI technology and experience more job benefits through the interactions with service robots (Decker et al., 2017; Liu et al., 2024; Yang & Gao, 2023; Yu et al., 2022). Despite these insights, the effects of employee-robot engagement on employees' subsequent experiences are still not well understood, representing a significant research gap.

Employee-robot engagement can be defined as positive, fulfilling state of mind that employees experience when working with service robots, drawing from work engagement theory and robotics literature (Hyun et al., 2022; Khosla et al., 2017; Paluch et al., 2022; Schaufeli et al., 2006). It is a state that is characterized by three dimensions (Schaufeli et al., 2006): vigor (high levels of energy and mental resilience in robot interactions), dedication (strong involvement and sense of significance in working with robots), and absorption (full concentration and happy engrossment in robot-assisted tasks). Previous research has shown that such engagement manifests through employees' active cooperation with robots in service delivery processes (Bankins & Formosa, 2020; Ding, 2021). Understanding the outcomes of employee-robot engagement, particularly its impact on employee psychological states (i.e. psychological empowerment and workplace depersonalization), is important. Firstly, empowerment is considered one of the most effective employee management strategies for tourism and hospitality organizations (Liu et al., 2024). Secondly, given the industry characteristics of high turnover rates and high levels of emotional exhaustion (Baker & Kim, 2021; Liu et al., 2020), the issue of workplace depersonalization in a digital technologydriven work environment should be given adequate attention. Exploring these aspects can help encourage employees to use robotic technology to empower themselves, while

alleviating psychological and emotional stress, improving service efficiency, and promoting the sustainable operation.

This research aims to investigate the impact of employee-robot engagement on employee psychological empowerment and workplace depersonalization. We propose that employeerobot engagement enhances employee psychological empowerment, and alleviates workplace depersonalization. According to empowerment theory (Zimmerman et al., 1992), empowerment is the degree to which individuals feel they can master and control their work environment during an event/process, and the corresponding perception and understanding can effectively guide subsequent work behaviors Through the process of employee-robot engagement, employees undergo psychological reactions, manifested in several aspects: (1) discovering a deeper level of work meaning, (2) improving operational skills in digital technology, (3) being given more managerial authority, and (4) promoting increased selfdetermination (Kong et al., 2016; Speer et al., 2013; Vatan & Dogan, 2021; Song et al., 2022; Xu et al., 2020; Yang & Gao, 2023). Furthermore, psychological empowerment grants individuals more autonomy and a sense of responsibility, reducing the likelihood of viewing their work as simple labor (i.e., depersonalization). Additionally, we identified boundary conditions of the effect of employee-robot engagement and proposed that developmental human resource (HR) practices could serve as a potential moderating variable. Empowerment theory posits that an individual's level of psychological empowerment is influenced by various environmental factors (Seibert et al., 2011; Zimmerman et al., 1992). In organizations with a high level of developmental HR practices, the positive impact of employee-robot engagement on psychological empowerment will be enhanced.

Therefore, our research questions are threefold: (1) Does employee-robot engagement reduce workplace depersonalization? (2) Does psychological empowerment play a mediating role in this process? (3) Does developmental HR practice play a boundary role in this process? To investigate these questions, we conducted three empirical studies. Since the relationship between employee-robot interaction and psychological empowerment has not been examined by prior research, a qualitative exploratory study (Study 1) was conducted first to establish a conceptual model of robot-related psychological empowerment. Subsequently, experiments (Study 2) and surveys (Study 3) were used to further explore the potential mediating effects and boundary conditions. The theoretical contributions lie in proposing a robot-related psychological empowerment model to explain the causal mechanism between human-robot engagement and workplace depersonalization, and further identifying the boundary conditions within it. Our research enriches the research of the consequences of human-robot engagement while expanding the application scope of psychological empowerment theory, providing new theoretical insights for the literature on service robots. Practically, this research can help organizations better manage the integration of robots into their workforce, ensuring a more harmonious and productive work environment, and ultimately improving service quality and employee well-being (Vatan & Dogan, 2021).

# 2. Theoretical background, literature review and research model 2.1. Service robot research and human-robot engagement

Service robots have become a prominent research topic in the tourism and hospitality area (Kim et al., 2022; Liu et al., 2024; Pan et al., 2025). Empirical research on service robots

can be broadly divided into three categories. The first category investigates their impact on operational management. Scholars view the integration of service robots as a significant digital innovation driven by advancements in service operations technology, aimed at enhancing operational efficiency and reducing service-related costs (Lee et al., 2020; Noone & Coulter, 2012). Tuomi et al. (2021) have highlighted the transformative role of service robots, emphasizing their ability to autonomously perform routine tasks, thus freeing up human labor for more complex and dynamic work, and in some cases, even replacing human employees in certain business functions. Similarly, Chiang and Trimi (2020) have pointed out the operational benefits of service robots, particularly for contactless service delivery in hotels during the COVID-19 pandemic, while also acknowledging potential downsides, such as decreased personalization and warmth in customer interactions (Ivanov & Webster, 2019).

The second category of research centers on the impact of service robots on customers, which has been the most extensively studied. Existing studies have explored various factors, including robot design elements, differences in tourist characteristics, and service environment conditions, to understand their effects on customer willingness to use robots, hotel stay intentions, satisfaction, and service evaluations (Jia et al., 2022; Hu et al., 2021). Additionally, scholars have delved into recovery strategies for robot service failures, such as using different language styles for apologies or employing alternative service agents for remediation (Hu et al., 2021; Ho et al., 2020).

The third category focuses on the influence of service robots on frontline employees. Initially, research in this area primarily addressed the negative impacts, such as job insecurity and perceived threats (Fu et al., 2022; Koo et al., 2021; Li et al., 2019; Modliński et al., 2023; Pan et al., 2025). However, as robots have become more integrated into workplaces, attention has shifted towards their potential to strengthen, support, and empower service employees (Song et al., 2022). Some studies have also noted the double-edged sword effect, where, for instance, Liang et al. (2022) found that awareness of artificial intelligence can simultaneously foster and hinder employee innovation.

Most research on human-robot engagement has focused on customers, examining factors influencing customer engagement from social (e.g., COVID-19, Kim et al., 2021), organizational (e.g., competitive climate, Li et al., 2019), technological (e.g., perceived intelligence, Kim et al., 2022), and individual perspectives (e.g., technology readiness). Only a few studies have explored employee-robot engagement. Building on our conceptualization of employee-robot engagement as a positive, fulfilling state of mind, previous research has examined how this state manifests in workplace settings. For example, Ding (2021) found that employees' perceptions of robot-related stress can significantly influence their engagement levels. Rather than a momentary response to specific robot interactions, employee-robot engagement represents a more persistent and pervasive affective-cognitive state that shapes how employees approach their technology-enhanced work environment (Bankins & Formosa, 2020). However, the outcomes of employee-robot engagement, particularly its impact on employees' psychological states and workplace attitudes, remain largely unexplored. The current research seeks to deepen the understanding of how this engagement state influences employee psychological empowerment and workplace depersonalization.

#### 2.2. Employee-robot engagement and workplace depersonalization

Workplace depersonalization refers to an organizational approach in the work environment that excessively emphasizes mechanization, indifference, and standardization in dealing with employees or work tasks, neglecting individual personalities and emotional needs (Baker & Kim, 2021; De Clercq et al., 2020; Lee et al., 2018). This leads to employees reacting with indifference, negativity, or apathy towards themselves and their surroundings (Baker & Kim, 2021; Söderlund, 2017). Employees in the tourism and hospitality sector often work in highly repetitive and low-status environments, making workplace depersonalization a common issue that has attracted considerable attention from researchers. Workplace depersonalization can result in negative work experiences and outcomes, such as job dissatisfaction, emotional burnout, and reduced service quality (Baker & Kim, 2021; De Clercq et al., 2020). Regarding its antecedents, existing studies have explored the causes of workplace depersonalization from various perspectives, including organizational factors (e.g., emotional labor strategies, Lee et al., 2018), colleague-related factors (e.g., coworker support, Baker & Kim, 2021), and customer-related factors (e.g., incivility, Baker & Kim, 2021). However, little research has examined the relationship between robotics-related factors and the mitigation of employee depersonalization, representing a theoretical gap.

Drawing on work engagement theory (Schaufeli et al., 2006) and socio-technical systems perspective, we propose that employee-robot engagement reduces workplace depersonalization. When employees experience a state of vigor, dedication, and absorption in their robot-assisted work, they are more likely to maintain meaningful connections with their work role and environment. Specifically, vigor enables employees to maintain high energy levels and resilience in facing technological challenges, counteracting the emotional detachment characteristic of depersonalization (Baker & Kim, 2021). Dedication, manifested as strong involvement and sense of significance in robot collaboration, helps employees maintain personal investment in their work rather than treating it mechanically (De Clercq et al., 2020). Absorption in robot-assisted tasks promotes active engagement rather than the detached, impersonal approach typical of depersonalization (Söderlund, 2017).

Empirical evidence supports proposed theoretical relationship. For instance, Liu et al. (2024) found that engaged collaboration with robots enhances employees' goal clarity and personal connection to their work. Similarly, Paluch et al. (2022) demonstrated that positive interaction with robots helps employees maintain more meaningful connections with their work environment. When employees are vigorously engaged with robots, they are more likely to view technology as enhancing rather than dehumanizing their work (Yang & Gao, 2023). This engaged state enables employees to focus on more meaningful aspects of their work while robots handle routine tasks (Vatan & Dogan, 2021; Guan et al., 2024), thereby potentially reducing the sense of depersonalization that often stems from repetitive, mechanized work environments (Baker & Kim, 2021). Based on this, we propose that:

**Hypothesis 1:** Employee-robot engagement significantly reduces workplace depersonalization.

#### 2.3. Employee-robot engagement and psychological empowerment

Psychological empowerment refers to a series of mental states and motivational processes that reflect employees' positive positioning of their roles in the work environment (Kim et al., 2012; Spreitzer, 1995a; Thomas & Velthouse, 1990). Spreitzer (1995b) pointed out that psychological empowerment includes the meaning of work (employees value their

work), competence (employees believe in their ability to use skills to complete work-related tasks), self-determination (employees feel they have some degree of choice), and impact (employees believe that achieving task goals will lead to positive outcomes).

Drawing from engagement theory (Schaufeli et al., 2006), we propose that employeerobot engagement, characterized by vigor, dedication, and absorption, enhances psychological empowerment. In the robotics-embedded service scenarios, engaged employees experience a positive, fulfilling state of mind that enables them to leverage cutting-edge technology (artificial intelligence and robots) to complete tasks more effectively (Song et al., 2022; Liu et al., 2024). During this state of engagement, employees gain technological empowerment and control through multiple pathways (Paluch et al., 2022). First, the vigor dimension of engagement, manifested as high energy and mental resilience in robot interactions, enhances employees' competence and self-determination by enabling them to actively master new technological processes (Liu et al., 2024). Second, dedication, characterized by strong involvement and sense of significance, helps employees discover deeper meaning in their work as they engage in more sophisticated tasks while robots handle routine operations (Song et al., 2022). Third, absorption in robot collaboration increases employees' perceived impact as they become fully immersed in using technology to achieve service outcomes (Guan et al., 2024; Qiu et al., 2022).

Empirical evidence supports these relationships. When employees are vigorously engaged with robots, they demonstrate enhanced technological efficacy and decision-making capabilities (Le et al., 2024; Yang & Cao, 2023). Their dedicated involvement leads to greater perceived work meaning and purpose (Song et al., 2022), while absorbed engagement in robot collaboration increases their sense of impact on service outcomes (Liu et al., 2024). Combining existing literature, employee-robot engagement enhances all four dimensions of psychological empowerment: meaning (Song et al., 2022), competence (Guan et al., 2024; Qiu et al., 2022), self-determination (Le et al., 2024; Yang & Cao, 2023), and impact (Liu et al., 2024). As such, we propose that:

**Hypothesis 2:** Employee-robot engagement is positively related to psychological empowerment.

#### 2.4. The mediating role of psychological empowerment

According to empowerment theory, psychological empowerment is an important mechanism that explains individuals' positive work behaviors and outcomes in specific events or environments (Gregory et al., 2010; Liden et al., 2000). Within the framework of environment-perception-feedback, psychological empowerment triggered by employee-robot engagement can alleviate workplace depersonalization through multiple mechanisms.

The theoretical mechanisms operate through each dimension of empowerment. From the perspective of work meaning, when employees believe their work is meaningful and contributes to organizational goals, they are more likely to perceive work as a positive experience, reducing indifference and rigid responses (Abhicharttibutra & Tungpunkom, 2019). In terms of competence and self-determination, when employees feel capable of completing work tasks and have autonomy in decision-making (Guan et al., 2024), they experience a greater sense of achievement and self-worth, which alleviates emotional exhaustion and prevents workplace depersonalization (Mardani & Mardani, 2014). Regarding

impact, when employees believe their work can positively influence the organization, they are more likely to view work as a mission rather than just a means of livelihood, further reducing workplace depersonalization (Abhicharttibutra & Tungpunkom, 2019; Liu et al., 2024).

Existing research suggests that psychological empowerment contributes to the establishment of more positive teamwork and interpersonal relationships (Liden et al., 2000; Yang & Choi, 2009). By giving employees more responsibility and autonomy, organizations encourage them to collaborate better in employee-robot engagement and work together to achieve goals (Guan et al., 2024; Liu et al., 2024; Song et al., 2022). Good interpersonal relationships (e.g., assisting employees or proactively serving customers) help create a more collegial work environment, thus alleviating workplace indifference and depersonalization tendencies. Moreover, empirical studies support the mediating role of psychological empowerment in various workplace contexts. For example, Huertas-Valdivia et al. (2019) explored how different leadership styles influence employees' job performance via psychological empowerment. Building on this evidence and our previous hypothesis that employee-robot engagement enhances psychological empowerment (H2), we propose that psychological empowerment serves as a mediator between employee-robot engagement and workplace depersonalization. Therefore:

**Hypothesis 3:** Psychological empowerment mediates the relationship between employee-robot engagement and workplace depersonalization.

#### 2.5. The moderating role of developmental HR practices

Developmental HR practices refer to the supportive strategies and management approaches that organizations invest in to meet employees' developmental needs, including dimensions such as career development, training opportunities, and performance assessments (Jung & Takeuchi, 2018; Kuvaas, 2008). Traditional human resource management practices emphasize control and rigid systems. Kuvaas (2008) first introduced the concept of developmental HR practices, indicating that HR practices should meet employee needs, foster positive attitudes and behaviors, and ultimately enable mutual development and value creation between employees and organizations. Developmental HR practices have three main features: (a) Employee-oriented, focusing on employee development; (b) Incentivizing, stimulating employees' growth motivation, encouraging them to strive for higher goals rather than maintaining the status quo; and (c) Building a community by tapping into employee potential to gain human resource advantages, promoting organizational sustainable development, and ultimately achieving mutual growth (Kooij et al., 2010).

Research has shown that employees working with digital technology may experience psychological stress, emotional exhaustion, and increased turnover intentions (Koo et al., 2021; Li et al., 2019). However, organizational interventions can help buffer these negative effects. Specifically, organizational support, positive leadership, and a supportive climate can significantly mitigate negative reactions to technological change and employee-robot engagement (Koo et al., 2021; Li et al., 2019; Yu et al., 2022). Training and development initiatives have also proven effective in reducing technological anxiety (Kim, 2022). Building on these findings, we propose developmental HR practices moderate the relationship between employee-robot engagement and psychological empowerment.

Specifically, developmental HR practices work in three main ways to support employees to collaborate with robots. First, they give employees specific training and hands-on experience that builds their skills and confidence with robots, enhancing their technological self-efficacy and self-assessment capabilities (Jung & Takeuchi, 2008; Kuvaas, 2008; Li et al., 2019). Second, they provide career advice and mentoring that helps employees view robot collaboration as a path to professional development rather than a threat, which strengthens their technology adaptation (Karaevli & Hall, 2006; Zacher & Griffin, 2015; Song et al., 2022). Third, they create systematic feedback mechanisms that help employees evaluate and improve their technological competencies, while offering incentives that enhance work meaningfulness, job autonomy, and creative potential (Maddux & Kleiman, 2016). Therefore, when organizations implement strong developmental HR practices, employees are more likely to perceive robot engagement as an opportunity for demonstrating competence and exercising meaningful control over their work environment, i.e., enhanced psychological empowerment (Kooij et al., 2010). In contrast, when developmental HR practices are insufficient, employees may lack the necessary resources to effectively interpret and respond to robot engagement, potentially perceiving it as a threat to their autonomy and competence (Li et al., 2019; Yu et al., 2022). Thus,

**Hypothesis 4:** Developmental HR practices positively moderate the relationship between employee-robot engagement and psychological empowerment, such that the effect of employee-robot engagement on psychological empowerment is stronger when there are more developmental HR practices in place (vs. less).

This moderating effect also influences the mediated relationship between robot engagement and workplace depersonalization through psychological empowerment. Strong developmental HR practices create conditions where enhanced psychological empowerment can more effectively translate robot engagement into positive workplace outcomes, reducing depersonalization. Thus,,

**Hypothesis 5:** Developmental HR practices moderate the mediating effect of psychological empowerment between employee-robot engagement and workplace depersonalization, such that the mediating effect is stronger when there are more developmental HR practices in place (vs. less).

<Insert Figure 2 about here>

#### 3. Research overview

This research employs a mixed-method approach, consisting of a qualitative interview (Study 1), an experiment (Study 2), and a questionnaire survey (Study 3). Study 1 helps us identify the main research variables and establishes a theoretical framework through exploratory theme analysis. Subsequently, Study 2 explores the main effects of the research model, clarifying the causal relationship between employee-robot engagement, psychological empowerment and workplace depersonalization. Finally, Study 3, a questionnaire survey combining online and offline methods, further examines the moderating effects and moderated mediation effects after the second validation of the main and mediating effects. The three studies build upon each other in a progressive manner, with mutual support. The combination of qualitative and quantitative approaches strengthens the research's internal and external validity, ensuring the scientific nature (Liu-Lastres et al., 2024; Peng et al., 2022).

#### 4. Study 1: An exploratory research framework

Study 1 aimed to explore the characteristics of human-robot interaction and their potential impacts from the employee's perspective, and establish a conceptual framework of psychological empowerment related to the application of service robots.

#### 4.1. Data collection

We recruited 23 employees from tourism and hospitality companies through convenience sampling and snowball sampling for in-depth interviews, focusing on topics such as employee-robot interaction features, employee psychological feedback, and business management and operations (see Appendix 1 for the interview questions). Participants were required to work in environments where service robots were already in use, and they had some interaction experience with robots in the workplace. Face-to-face and telephone interviews were conducted, with each interview lasting between 20-30 minutes, and participants received a \$5 reward afterward. Demographic information is presented in Table 1. About 86% of participants were between 18-45 years old, with males accounting for 40.9%. Over 90% of interviewees came from the restaurant and hotel industry, and all participants worked in frontline departments, including the front desk, guest rooms, and bars.

<Insert Table 1 about here>

#### 4.2. Data analysis

We followed the steps proposed by Braun and Clarke (2006) to conduct a thematic analysis based on the 150,000 words of content from the 23 interviewees. First, two researchers reviewed all interview content, ensuring a comprehensive understanding of the data. Next, we performed line-by-line coding, creating an initial list of codes. Based on these codes, the researchers identified, reviewed, discussed, and confirmed themes. We then defined and named the refined list of themes. Finally, the main themes were created and reported, forming the research framework for our subsequent studies.

To ensure the validity of the qualitative findings, we employed a data triangulation strategy (Guion et al., 2011). We recorded notes and timely transcriptions after each interview, and multiple researchers collaborated to identify codes and themes. The diverse characteristics of the sample also contributed to data triangulation. Ultimately, we validated the findings of the qualitative study through subsequent quantitative research, aligning with the principles of methodological triangulation (Guion et al., 2011).

#### 4.3. Findings

Through the above analysis, we derived four themes: emotional responses to working with robots, psychological empowerment through human-robot interaction, transformative impact of service robots on employee experiences, and the importance of developmental HR practices for effective human-robot integration in the workplace.

#### 4.3.1. Emotional responses to working with robots

The interviews reveal a spectrum of engagement and disengagement, with some employees forming deep emotional bonds with their robotic counterparts, while others grapple with feelings of unease and disconnection. On the engaged end of the spectrum, employees develop strong attachments to their robotic co-workers, viewing them as reliable partners and integral parts of their work life. This emotional connection is vividly portrayed by R2, a female employee, who affectionately refers to the robot as "Xiaozhi" and shares, "*It is my reliable work partner, and we all call it Xiaozhi. Our work is inseparable from it.*" The use of a personalized name and the description of the robot as a "reliable work partner" illustrates the depth of the emotional bond formed. R2 further expresses the team's longing for the robot during its absence due to repairs, stating, "*Last week, it was recalled to the robot company for repairs due to some issues. During that week when it wasn't here, we actually missed it a lot.*" This sentiment highlights the emotional attachment and reliance employee, emphasizes the inseparable nature of her work with the robot, expressing, "*Nowadays, my daily work is inseparable from it. It's as if it has become a part of my work, just like my colleagues. I really hope it continues this way.*" The comparison of the robot to colleagues underscores the emotional significance of the human-robot collaboration and the desire for its continuity.

On the contrary, a minority of employees have expressed alienation and struggle. R14, a male employee, mentioned, "*I feel the robot is just a gimmick; many times people exaggerate its capabilities, which leaves me quite speechless, so now I rarely use it.*" R22, a female employee, mentioned her anxiety about using the robot, "*Many times the robot does the work, and I feel at a loss, feeling that with this trend, I don't know when I might be eliminated.*" We summarize this category under the sub-theme of employee-robot disengagement.

#### 4.3.2. Psychological empowerment through human-robot interaction:

The interviews reveal that collaborating with robots leads to a sense of empowerment among employees, which manifests in four key dimensions: meaning, competence, selfdetermination, and impact.

First, employees find that working with robots allows them to engage in more specialized and meaningful work. R5, a male employee, shares, "*In the past, we were more involved in repetitive physical labor. Now, with it, we can also engage in more specialized and meaningful work. For example, we can promote our company's innovative culture to customers interested in robots.*" This quote highlights how robots enable employees to move beyond repetitive tasks and contribute to higher-level, purpose-driven activities, such as promoting the company's innovative culture.

Second, competence is evident in employees' acquisition of new skills and knowledge related to AI and robotics. R7, another male employee, states, "*I have now learned a lot about AI-related knowledge and some basic robot operation knowledge. This is a kind of growth, or you can say, a kind of skill improvement.*" This quote illustrates how collaborating with robots provides opportunities for employees to expand their skill sets and experience personal growth, enhancing their sense of competence and self-efficacy.

Self-determination, the third dimension of psychological empowerment, is reflected in employees' increased flexibility and control over their work. R16, a female employee, shares, "*The current job is more flexible. I can have the robot help me with some basic tasks, giving me more time to deal with communication-related matters.*" This demonstrates how robots

empower employees to have greater autonomy in managing their workload and allocating their time to higher-value tasks, such as communication and interpersonal interactions.

Lastly, the impact is evident in employees' enhanced authority and ability to influence customer experiences. R2, a female employee, enthusiastically shares, "Now, the job gives me more authority. I can control the robot. Some parents with children are eager to see the robot delivering items, and I can demonstrate it to them. I can also make the robot perform some shows, and everyone is quite happy." This highlights how employees feel empowered to create positive customer experiences through their control over the robot, leading to a sense of impact and influence in their work.

This theme shows that positive human-robot interactions go beyond mere task assistance and have profound psychological implications for employees. By collaborating with robots, employees experience a sense of empowerment that encompasses meaning, competence, selfdetermination, and impact. On the contrary, employees who are not in sync with the robot may exhibit a lower level of empowerment. R4, a female employee, said, "*There are also some colleagues who may think that the robot is not of much practical use and are not very willing to interact with the robot. These colleagues are like being in a cage themselves, and there is not much breakthrough in their skills and performance at work.*" Robot-related psychological empowerment not only enhances employees' well-being but also contributes to their overall job satisfaction and motivation.

#### 4.3.3. Transformative impact of service robots on employee experiences

The interviews reveal that over 90% of employees believe that working with service robots elevates their job status, increases self-esteem, enhances job satisfaction, and reduces workplace depersonalization.

One of the key transformative impacts is the reduction of repetitive and mundane tasks. R21, a male employee, shares, "*In the past, I was like a porter, repeating my work over and over. Now, the robot helps me with these repetitive tasks.*" This illustrates how service robots alleviate employees from the burden of monotonous and physically demanding work, allowing them to focus on more engaging and meaningful responsibilities.

Moreover, the presence of service robots facilitates increased human-to-human interactions between employees and customers. R18, another male employee, recounts, "Previously, many customers didn't bother talking to us at all. But since the robot arrived, they also engaged in conversations with us intentionally or unintentionally, even though most of the time, it's about inquiring about the robot's equipment. However, sometimes they talk about other things. Yesterday, a customer asked if having a robot makes our job less tiring than before." This highlights how service robots act as a catalyst for social interaction, breaking down barriers between employees and customers and fostering more personalized and meaningful exchanges.

The transformative impact of service robots on employee experiences extends beyond task reduction and enhanced social interaction. R2, a female employee, powerfully articulates the psychological shift she experienced: "*The robot has liberated my hands, and its presence makes me feel like I'm not a machine, but a human.*" This encapsulates the profound impact service robots can have on employees' self-perception and sense of self-worth. By taking

over repetitive and mechanical tasks, robots enable employees to engage in more uniquely human activities, affirming their value and identity as individuals.

This theme challenges the notion that the introduction of service robots in the workplace leads solely to negative outcomes, such as job displacement and dehumanization. Instead, it reveals a transformative potential that elevates employees' experiences, fosters meaningful interactions, and enhances their sense of self.

#### 4.3.4. Developmental HR practices for human-robot integration

The interviews underscore the importance of adopting a developmental approach that prioritizes employee orientation, employee development, and collaborative goals to foster successful human-robot integration.

One key aspect of developmental HR practices is the provision of training and knowledge-sharing opportunities. R17, a male employee, shares, "*Our organization also considers our growth needs, such as arranging many AI knowledge seminars, allowing senior employees to teach others how to use service robots for work, and so on.*" This quote highlights how organizations can support employees' growth and adaptability by offering targeted training programs and facilitating knowledge transfer among employees. By investing in employee development, organizations demonstrate their commitment to empowering their workforce to thrive in the era of human-robot collaboration.

Another critical element of developmental HR practices is the communication of a clear and supportive organizational stance on human-robot collaboration. R10, a female employee, recounts, "*Our leaders tell us that robots cannot replace human employees, but humans can make good use of robots to excel in their work.*" This quote illustrates how organizations can alleviate employees' concerns about job displacement by emphasizing the complementary nature of human-robot collaboration. By framing robots as tools to augment and enhance human capabilities, rather than replace them, organizations can foster a positive and inclusive mindset among employees.

This theme also highlights the importance of employee-centric practices in the context of human-robot integration. The interviews reveal that organizations that prioritize employee well-being, engagement, and development are better positioned to create a positive and productive human-robot collaborative environment. R13, a female employee, shares, "*Compared to being replaced, I think the hotel helps us to acquire new skills, such as how to learn and apply robotics and artificial intelligence technology.*" By actively seeking employee input, addressing their concerns, and providing ongoing support, organizations can demonstrate their commitment to employee welfare in the face of technological change.

#### <Insert Figure 1 about here>

Based on the four aforementioned themes, we further explored the potential relationships among them and subsequently developed a theoretical framework for employee-robot engagement and psychological empowerment, as depicted in Figure 1. Specifically, employee-robot engagement is expected to influence psychological empowerment and enhance the work experience by alleviating workplace depersonalization. In this process, developmental HR practices can further assist in advancing human-robot collaboration and promoting sustainable development between the two. Building upon this foundation, the next two studies aim to further investigate the relationships between these core variables through experiments and surveys.

#### 5. Study 2: Experiment 5.1. Stimulus materials, procedure, and sampling

An online scenario-based experiment was conducted to examine the main and mediating effects with a between-subject design (H1-H3). Participants were assigned at random to one of the two designed groups (employee-robot engagement vs. employee-robot disengagement). The experimental stimuli were designed on the basis of qualitative findings and the concept of employee-robot engagement. The scenarios described a series of interactions between employees and robots in the workplace. In the employee-robot engagement group, we described employees' interaction with robots in the workplace as vigor, dedication, and absorption. In the disengagement group, we described it as anxiety, burnout, and threat. Participants were instructed to thoroughly review the narrative and immerse themselves in the role of the employee depicted within the scenario.

After reading the scenarios, participants were asked to answer questions related to the independent variables, mediating variables, and outcome variables. Three items from Schaufeli et al.'s (2006) work were adopted to measure employee-robot engagement. The mediating variable's measurement utilized four items from Spreitzer's (1995a, 1995b) scale for psychological empowerment. These four items covered dimensions of meaning, self-determination, competence, and impact, and were applicable to the current context. To validate the scenario-based experiment's efficacy, participants were asked to indicate their perceived realism of the scenarios (M= 6.12, SD= 0.92), clarity (M= 6.24, SD= 0.86), and comprehensibility (M= 6.23, SD= 0.80). Apart from demographic information, a 7-point Likert scale was utilized for the assessments (see Appendix 2 and 3 for the scenarios and all measurement items).

We conducted a pre-test with 40 full-time employees working in the tourism and hospitality sector. The ANOVA findings indicated a significant difference in employee-robot engagement scores between the two groups ( $M_{engagement}$ = 6.25,  $M_{disengagement}$ = 1.97,  $F_{(1, 38)}$ = 161.91, p< 0.001), confirming the manipulation was effective. Following this, we moved forward to the formal experiment.

Study 2 recruited 248 full-time employees from the tourism and hospitality sector in China via Credamo. Credamo is a comprehensive data collection platform that can survey tourism and hospitality workers (e.g., Hu et al., 2022). Only the individuals who have had experience working with robots were invited to participate. We paid an average of 1 US dollar after they completed the survey. A total of 197 participants successfully completed the survey, with males constituting 38.6%. Their average age was 31.7 years, ranging from 18 to 59, accompanied by a SD value of 9.00. Their educational backgrounds were as follows: high school or lower (10.2%), college (16.8%), undergraduate (61.4%), and master or higher (11.7%). Participants mainly came from the hotel sector (55.8%) and the restaurant sector (35.5%).

#### 5.2. Manipulation check

To evaluate the manipulation effectiveness, an ANOVA analysis was performed and the findings indicated that participants showed significant differences in their assessments of employee-robot engagement ( $M_{\text{engagement}}$ = 6.13,  $M_{\text{disengagement}}$ = 2.11,  $F_{(1, 195)}$ = 633.06, p < 0.001). This confirmed the success of our manipulation.

#### 5.3. Hypothesis testing

*Main effect analysis.* As shown in Figure 3, the ANOVA analysis revealed a significant effect between the employee-robot engagement in both psychological empowerment  $(M_{engagement}=5.91, M_{disengagement}=4.30, F(1, 195)=82.78, p<0.001)$  and workplace depersonalization  $(M_{engagement}=2.32, M_{disengagement}=4.10, F(1, 195)=95.24, p<0.001)$ . Therefore, H1 and H2 were supported.

*Mediation effect analysis.* To examine the mediating effect of psychological empowerment, a bootstrapping mediation with 5,000 samples was performed (Hayes, 2013; 95% *CI*, Model 4 in PROCESS). The results indicated that psychological empowerment mediated the effect of employee-robot engagement on workplace depersonalization ( $\beta$ = 0.36, *SE*= 0.08, 95 % *CI* [0.2191, 0.5159]). So H3 were verified.

#### <insert Figure 3 about here>

Study 2 expanded on the conceptual framework established in Study 1 by conducting an experiment to investigate the direct effect of employee-robot engagement on workplace depersonalization and the mediating role of psychological empowerment. The experimental results supported the hypothesized effect, confirming that employee-robot engagement reduces workplace depersonalization and that psychological empowerment mediates this relationship. However, the experimental design had limitations, such as potential concerns regarding the realism of the experimental simulation and the external validity of the findings. Additionally, Study 2 focused solely on testing the direct and mediating effects, without exploring potential moderating factors that could influence these relationships.

To address these limitations and further investigate the research questions, Study 3 employed a large-scale survey distributed through multiple channels. It aimed to replicate the direct effect and mediating effect found in Study 2 while also expanding the scope of the research by examining the moderating role of developmental HR management practices. By utilizing a survey method and a larger, more diverse sample, Study 3 sought to enhance the generalizability of the findings and provide a more comprehensive understanding of the relationships between employee-robot engagement, psychological empowerment, workplace depersonalization, and the moderating effect of developmental HR management practices.

#### 6. Study 3: Survey 6.1. Samples and procedure

This study employed convenience sampling and utilized both online and offline channels to collect data from two countries, China and the United States. For offline channels, we selected a local hotel group in China that is undergoing a digital transformation and has recently introduced AI smart devices and service robots in their daily operations. We conducted on-site research in four hotels in the southern region of China (Shenzhen, Ganzhou, Jiujiang, and Nanchang) from May to September 2023.

To ensure external validity, additional data was collected from participants in the US through Mturk, from October 2023 to December 2023. The criteria for participating in this research included: (1) employees from the tourism and hospitality sector (e.g., hotels, tourist attractions, travel agencies, and tourism-related retail malls), (2) must have experience using service robots in their organizations. At the beginning of the survey, online participants were first requested to recall scenarios of their interactions with robots at work and provide a brief description of that scenario, in order to engage them in the research context. We conducted a pilot survey by inviting experts and research subjects from both China and US to review the survey and provide their feedback accordingly.

In both the online and offline surveys, we incorporated attention check questions to filter out invalid data. All individuals successfully participating in the survey received compensation (\$0.8-1.5 USD). A total of 853 participants' responses were collected (China: 403; US: 450), and 168 invalid responses (China: 74; US: 94) were removed for not meeting conditions or failing attention tests. After screening for ineffective data, 685 valid responses were obtained (China: 329; US: 356), resulting in an effective rate of 80.3%.

The characteristics of the surveyed sample are detailed in Table 2, with 53.7% being male and 46.3% female. Participants were mainly distributed across three age groups: 18-25 years (23.4%), 26-35 years (43.9%), and 36-45 years (21.5%). Regarding education, individuals with a bachelor's degree predominated at 43.2%. The majority of respondents held frontline positions (87.2%). The highest proportions of participants had 1-3 years and 4-6 years of work experience, accounting for 33.7% and 33.6%, respectively. In terms of industry type, 78.7% of respondents were from hotels/resorts/lodging, and 12% were from restaurants/bars/catering/food & beverage. The ethnicities of the respondents mainly included Asian (49.9%), Black/African (12.3%), Caucasian (26.1%), and Native American (11.5%).

<Insert Table 2 about here>

#### 6.2. Measurement

All measurement scales were adapted from previous research with necessary translation/back-translation procedures. Two members of the research team were invited to cross-validate the measurement scale and make appropriate adjustments to the measurement context of the scales. All measurements were self-reported, employing a 7-point Likert scale with 1 denoting "strongly disagree" to 7 indicating "strongly agree". Employee-robot engagement was measured with six items adapted from Schaufeli et al. (2006), covering three dimensions: vigor, dedication, and absorption. Workplace depersonalization was measured with a four-item scale developed by Shih et al. (2013). Psychological empowerment was measured with 12 items from Spreitzer (1995a, 1995b), including four dimensions: meaning, self-determination, competence, and impact, each measured with three items. Furthermore, a six-item scale from Kuvaas (2008) was employed to measure developmental HR practices. Specific details of variable measurements are provided in Appendix 3. Additionally, demographic variables of employees (gender, age, education, position, experience, and frequency of interaction with robots) were included as control variables.

#### 6.3. Reliability and validity

This study utilized Mplus 8.0 software for confirmatory factor analysis (CFA) to assess variables' reliability as well as validity. Our results indicated that the Cronbach's  $\alpha$ 

coefficients for each variable were between 0.90 and 0.96, deeming the measurement scales reliable (see Table 3). All factor loadings were above 0.5 for the main variables, which was considered satisfactory, and no items were deleted. The assessment of convergent validity was conducted through the measurement of the AVE (average variance extracted) values and the CR (composite reliability) values. The CR scores were within the range of 0.92 to 0.97, and the AVE scores were from 0.57 to 0.88, above the threshold of 0.7 (Hair et al., 2013; Nunnally, 1978), and AVE surpassing 0.5 (Bagozzi & Yi, 1988). As indicated in Table 4, the square root of the AVE value for each variable was found to be higher than its inter-variable correlations. Further, the correlation matrix indicated that the maximum inter-variable correlation coefficient was 0.72, below the standard of 0.80 for high correlation (Anderson & Gerbing, 1988), indicating good discriminant validity.

<Insert Table 3 and Table 4 about here>

We also conducted CFA to compare the fit of different factor structures. The results indicated that the four-factor model fitted well ( $\chi^2(344)$ = 1376.83; *CFI*= 0.93; *TLI*= 0.92; *RMSEA*= 0.07), compared to the other three models (three-factor model,  $\chi^2(347)$ = 4318.63; *CFI*= 0.71; *TLI*= 0.693; *RMSEA*= 0.13; two-factor model,  $\chi^2(349)$ = 4794.02; *CFI*= 0.68; *TLI*= 0.65; *RMSEA*= 0.14; one-factor model,  $\chi^2(350)$ = 6082.69; *CFI*= 0.59; *TLI*= 0.56; *RMSEA*= 0.16), indicating good discriminant validity among variables. Additionally, we performed Harman's single-factor test, and found that the primary factor explained 19.6% of the variance, which is below the threshold of 50% of the total variance (64.4%) as per Podsakoff et al. (2003). This finding suggests that common method bias does not pose a significant concern in this research.

#### 6.4. Hypothesis testing

We utilized SPSS 23.0 and SPSS-PROCESS Macro (Hayes, 2013) to examine the main effect, mediating effect, moderating effect, and moderated mediation effect.

#### 6.4.1. The main effect

Hypothesis 1 proposed that employee-robot engagement will negatively affect workplace depersonalization. We conducted hierarchical regression. As depicted in Table 5, after including the control variables (gender, age, education, position, experience, and frequency of interaction with robots), employee-robot engagement was significantly and negatively associated with depersonalization (Model 5,  $\beta$ = -0.36, p< 0.001). Hypothesis 1 was supported.

< insert Table 5 about here >

Hypothesis 2 posited direct relationships between employee-robot engagement and psychological empowerment. As depicted in Table 5, employee-robot engagement was significantly and positively correlated with psychological empowerment (Model 2,  $\beta$ = 0.68, p< 0.001), controlling for demographic variables. This supported hypothesis 2.

#### 6.4.2. The mediating effect of psychological empowerment

Hypothesis 3 posited that employee-robot engagement affects workplace depersonalization through psychological empowerment. We used Model 4 in SPSS-PROCESS Macro to examine this relationship (Bootstrapping = 2,000). The findings (as depicted in Table 6) revealed that the confidence interval for the psychological empowerment mediation effect ( $\beta_{indirect effect}$ = -0.13, SE= 0.07, LLCI= -0.2717, ULCI= -0.0077) did not encompass 0, indicating statistical significance. Therefore, hypothesis 3 was supported. Psychological empowerment served as a partial mediator.

#### < Insert Table 6 about here >

#### 6.4.3. The moderating effect of developmental HR practices

Hypothesis 4 posited that developmental HR practices moderate the impact of employeerobot engagement on psychological empowerment. Our analysis showed that there was a significant interaction effect between employee-robot engagement and developmental HR practices on psychological empowerment (Model 3,  $\beta$ = 0.13, p< 0.001) (Table 5). Subsequently, we performed a simple slope analysis to test the moderating effect of developmental HR practices (mean value ± 1SD). In organizations with strong developmental HR practices, employee-robot engagement exhibits a more pronounced influence on psychological empowerment ( $\beta$ = 0.76, t= 18.71, p< 0.001) compared to those in organizations with lower developmental HR practices ( $\beta$ = 0.51, t= 14.12, p< 0.001) (Figure 4). Thus, H4 was supported.

< Insert Figure 4 about here >

#### 5.4.3. The moderated mediation effect

Hypothesis 5 proposed that developmental HR practices moderated the indirect effect of psychological empowerment. Adhering to the analytical structure of the moderated mediation model as outlined by Edwards and Lambert (2007), we proceeded with the execution of Model 7, utilizing 2000 bootstrap samples for the analysis. The findings revealed that the indirect effects of psychological empowerment ( $\beta_{indirect effect}$ = -0.10, *SE*= 0.05, *LLCI*= -0.2147, *ULCI*= -0.0059, the confidence interval excluded 0) reached significance at low levels of developmental HR practices. More importantly, at high levels of developmental HR practices, the mediating effect also attained significance, demonstrating a stronger impact ( $\beta_{indirect effect}$ = -0.15, *LLCI*= -0.2978, *ULCI*= -0.0091, the confidence interval excluded 0). As shown in Table 7, the mediating effect exhibited significant variations across the two levels (*Index*= -0.03, *SE*= 0.01, *LLCI*= -0.0653, *ULCI*= -0.0045). Thus, H5 was supported.

< Insert Table 7 about here >

#### 7. Discussion and conclusions

In this research, we investigate the impact of employee-robot engagement on workplace depersonalization, and uncover the mediating role of psychological empowerment and the moderating role of developmental HR practices. Through a mixed-methods approach involving interviews, experiments, and surveys, we find that employee-robot engagement significantly reduces workplace depersonalization, and that this relationship is mediated by psychological empowerment. Furthermore, we show that developmental HR practices positively moderate the impact of employee-robot engagement on psychological empowerment, such that the benefits of engagement are amplified in organizations with strong employee-centric HR policies. Our study makes important theoretical and practical contributions to the literature on service robotics and human resource management.

#### 7.1. Theoretical implications

This research contributes to the literature on the application of technology in the tourism and hospitality sectors in several aspects.

First, this research contributes to the literature on service robots by exploring the mechanisms of employee-robot interaction. While research on service robots has gained traction in recent years-expanding from initial discussions on customer-robot interactions to employee-robot interactions (Leung et al., 2023; Li et al., 2019; Lu et al., 2020; McCartney & McCartney, 2020)-previous studies have primarily focused on the negative effects of robotics on employees, such as job replacement and perceived threats (Koo et al., 2021; Li et al., 2019; Vatan & Dogan, 2021). Few have explored the potential positive effects of service robots on employees. This study addresses this research gap by examining how employeerobot engagement can help alleviate workplace depersonalization, drawing upon the socialtechnical systems theory to explain how the compatibility and cooperation between robotic technology and employees can lead to positive outcomes. Research on the antecedents of workplace depersonalization has mainly focused on factors related to organizations (e.g., emotional labor strategies), colleagues (e.g., coworker support), and customers (e.g., incivility) (Baker & Kim, 2021; Lee et al., 2018), with less emphasis on factors at the robot level. To the best of the authors' knowledge, this is the first empirical study to link service robots to workplace depersonalization. Our study not only enriches the research on the antecedents of depersonalization in the tourism and hospitality sector but also provides new insights into the development of emotional management theories from the perspective of human-robot interaction.

Second, we introduce a novel theoretical framework of robot-related psychological empowerment that connects employee-robot engagement with workplace depersonalization. This contribution also enhances the development of psychological empowerment theory in the tourism and hospitality sector. Psychological empowerment theory is one of the most effective theoretical tools in this field (Huertas-Valdivia et al., 2019; Usman et al., 2021). Against the backdrop of increasing research on transformative technologies such as artificial intelligence and service robots (Liu et al., 2024), our study integrates digital technology to further explore the theoretical core of psychological empowerment theory and effectively expands its scope of application. This research investigates a more positive psychological outcome - psychological empowerment - and demonstrates its importance as an underlying mechanism. Drawing upon Spreitzer's (1995a, 1995b) conceptualization of psychological empowerment, which includes meaning, competence, self-determination, and impact, the study shows that employee-robot engagement can enhance employees' sense of meaning, competence, self-determination and impact in their work, which in turn significantly reduces workplace depersonalization. This represents an important theoretical contribution, as it provides empirical evidence for the role of psychological empowerment in the roboticsembeded work context and extends the explanatory power of psychological empowerment theory to the domain of service robot research.

Finally, our research contributes to the theoretical development of hospitality human resource management theories in the context of human-robot interaction. Specifically, the study identifies developmental HR practices as a key boundary condition shaping the impact of employee-robot engagement. While prior research suggests that the effects of robot technology on employees can be double-edged (Ding, 2021; Liang et al., 2022), most studies have examined potential moderators from an individual perspective, such as technological readiness, future orientation, and technology anxiety (Kim et al., 2022; Liang et al., 2022; Modliński et al., 2023). Far less attention has been paid to the role of management strategies and organizational factors. This study addresses this gap by introducing the construct of developmental HR practices, which refer to the supportive strategies and management approaches that organizations invest in to meet employees' developmental needs, including dimensions such as career development, training opportunities, and performance assessments (Jung & Takeuchi, 2018; Kuvaas, 2008). Drawing upon the empowerment theory, which suggests that positive organizational decision-making practices can promote employees' socialization processes (Ulukapı Yılmaz & Yılmaz, 2016; Zimmerman et al., 1992), the study shows how an employee-centric HR approach can amplify the positive impact of employeerobot engagement on psychological empowerment and mitigate workplace depersonalization. This finding expands existing research on boundary conditions in the employee-robot interaction literature and offers new avenues for human resource management theory in the context of robotic technology.

#### 7.2. Managerial implications

The findings of this study offer several important implications for managers in the tourism and hospitality industry looking to effectively integrate service robots and manage employee well-being in an increasingly technology-driven workplace.

First, the results suggest that managers should approach employee-robot engagement from a positive perspective and focus on cultivating constructive human-robot interactions. The study shows that when employees engage meaningfully with service robots, they are less likely to experience workplace depersonalization and more likely to feel valued as individuals rather than mere cogs in the machine. This insight provides a new lens for employee management in an industry where workers have traditionally struggled with issues of selfesteem, confidence, and social recognition. By promoting positive employee-robot engagement, managers can help mitigate these challenges and improve overall employee well-being. To foster positive employee-robot engagement, managers should carefully consider how to optimally integrate human and robotic labor. For instance, service robots could be assigned to perform highly repetitive tasks such as delivering items or serving meals, while employees could be engaged in meaningful and fulfilling service tasks such as resolving customer complaints. Rather than viewing robots as replacements for human workers, managers should deploy them strategically to complement and enhance employees' capabilities. This may involve identifying service processes that are particularly well-suited for human-robot collaboration and designing workflows that enable service robots to assist employees in delivering more efficient and effective service. Managers can also proactively engage employees in the robot integration process, for example by offering training sessions, workshops, and hands-on learning opportunities to help employees become more comfortable and proficient in working alongside robots.

Second, the study highlights the critical role of psychological empowerment in translating employee-robot engagement into reduced workplace depersonalization. Managers should therefore prioritize employees' psychological growth and development in the context of human-robot collaboration. This involves recognizing and valuing employees'

contributions, and actively encouraging them to leverage robotic technologies in ways that enhance their sense of meaning, competence, self-determination, and impact at work. By doing so, managers can help employees view robots as tools for personal and professional empowerment rather than as threats to their job security or self-worth. To foster psychological empowerment, managers can adopt a range of strategies. These include offering consistent feedback and recognition to acknowledge employees' contributions and achievements. Additionally, empowering employees by assigning them leadership roles over robotic systems can have a positive impact, making them feel a sense of authority and control. Furthermore, involving employees in the decision-making processes regarding the deployment and integration of robots can lead to increased engagement and a stronger sense of ownership. This participatory approach can also help in aligning technological advancements with the workforce's expectations and needs. Managers can also communicate a clear and compelling vision for how human-robot collaboration can enable employees to focus on higher-level, more fulfilling work tasks. By supporting employees' psychological empowerment, managers can not only improve individual well-being but also foster a more engaged and motivated workforce.

Finally, the study underscores the importance of adopting developmental HR practices to maximize the benefits of employee-robot engagement. Managers should take an employeecentric approach to HR, investing in practices that support employees' growth, development, and well-being in the context of technological change. This may include offering mentoring and coaching programs to help employees navigate the challenges and opportunities of human-robot collaboration, providing ongoing training and upskilling opportunities to keep pace with evolving robotic technologies, and designing reward and recognition systems that celebrate successful human-robot teamwork. Moreover, managers should strive to create a supportive and inclusive organizational culture where robotics and artificial intelligence technologies serve not only customers but also employees. For instance, managers can leverage Robotic Process Automation (RPA) technology in the human resources field for applications such as uncivilized behavior monitoring, job-candidate matching models, smart scheduling, and understanding employee welfare needs, thereby enhancing employee wellbeing and satisfaction. Additionally, managers should actively seek feedback from employees regarding their experiences with robotic technologies, address any concerns or anxieties they may have, and involve them in the co-creation of human-robot collaboration strategies. This participatory approach not only fosters a sense of ownership and trust among employees but also ensures that the implementation of such technologies is aligned with the workforce's needs and expectations. By adopting a developmental approach to HR, managers can not only enhance the positive impact of employee-robot engagement on psychological empowerment, but also build a more resilient and adaptable workforce in an age of rapid technological transformation.

#### 7.3. Limitations and future research directions

While this study contributes to our understanding of employee-robot engagement, psychological empowerment, and workplace depersonalization, it has limitations that suggest avenues for future research. First, the mixed-methods approach drew exclusively on qualitative and experimental data from participants in China, limiting generalizability. Future research should extend these components to other cultural contexts to assess variations in employee-robot engagement. Second, to enhance the test of causal relationships, future studies should employ longitudinal designs, objective data sources, or randomized controlled trials for stronger causal evidence. Furthermore, using multilevel modeling techniques could deepen the understanding of how developmental HR practices interact with individual and organizational factors. Third, the survey study included a limited set of control variables. While randomization and demographic controls were implemented, future research could incorporate a wider range of substantive controls, such as personality traits, task interdependence, and the robot integration stage. Finally, our survey utilized samples from China and the United States, but did not further explore the multi-group effects, and the aggregation issue at the data level may be a potential limitation. Several promising directions for future research include exploring the antecedents of employee-robot engagement from a multi-stakeholder perspective, examining additional outcomes, such as job performance and customer satisfaction, and investigating boundary conditions, such as the moderating roles of technology readiness and team dynamics.

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Figure 1 An exploratory framework for employee-robot engagement and psychological empowerment



Figure 2 Research model



Figure 3 Comparison results of mean values in the experiment



Figure 4 The moderating effect of developmental HR practices

Demographic information		Frequency (N)	Percentage (%)
Gender	Male	9	40.9
	Female	14	63.6
Age	18-25 years old	5	22.7
	26-35 years old	7	31.8
	36-45 years old	8	36.3
	More than 46 years old	3	13.6
Education	College or lower	4	17.4
	Undergraduate	16	69.6
	Master or higher	3	13.0
Industry	Hotels/resorts/lodging	14	63.6
	Restaurants/bars/catering/f ood & beverage	7	31.8
	Other tourism-related service industries	2	0.10
Interview type	Offline (face to face)	15	68.2
	Online (voice to voice)	8	36.4
Work experience with robots		23	100

# Table 1. Sample profile in Study 1 (N=23)

Variables	Categories	Response	Percentage %
Gender	Male	368	53.7
	Famale	317	46.3
Age	18-25 years old	160	23.4
	26-35 years old	301	43.9
	36-45 years old	147	21.5
	46-55 years old	65	9.5
	More than 55 years old	12	1.8
Education	High school or lower	181	26.4
	College or associate degree	102	14.9
	Bachelor degree	296	43.2
	Master degree or higher	106	15.5
Position	Frontline employee	597	87.2
	Managers (senior and general-level)	88	12.8
Hotel work	Less than 1 year	67	9.8
experience	1-3 years	231	33.7
	4-6 years	251	36.6
	7-9 years	68	9.9
	More than 9 years	68	9.9
Industry	Hotels/resorts/lodging	539	78.7
	Restaurants/bars/catering/food &	82	12.0
	Other tourism-related service industries	64	9.3
Ethnicity	Asian	342	49.9
	Black/African	84	12.3
	Caucasian	179	26.1
	Native American/Pacific Islander	80	11.6

**Table 2.** Demographic information of Study 3 (N= 685,  $N_{CN}$ = 329,  $N_{US}$ = 356)

Variable	Label	Loading	α	CR	AVE
Employee-robot	ERE1	0.821	0.91	0.93	0.68
engagement	ERE2	0.866			
(ERE)	ERE3	0.833			
	ERE4	0.829			
	ERE5	0.822			
	ERE6	0.771			
Psychological	PE1	0.742	0.93	0.94	0.57
empowerment	PE2	0.773			
(PE)	PE3	0.792			
	PE4	0.730			
	PE5	0.721			
	PE6	0.695			
	PE7	0.780			
	PE8	0.783			
	PE9	0.787			
	PE10	0.751			
	PE11	0.767			
	PE12	0.756			
Workplace	WD1	0.929	0.96	0.97	0.88
depersonalization	WD2	0.958			
(ŴD)	WD3	0.932			
<b>`</b> ,	WD4	0.941			
Developmental	DHRP1	0.813	0.90	0.92	0.65
human resource	DHRP2	0.838			
practices (DHRP)	DHRP3	0.826			
- ` ` `	DHRP4	0.798			
	DHRP5	0.798			
	DHRP6	0.778			

**Table 3.** Factor loadings, Cronbach' s α, CR and AVEs

 Table 4. Descriptive statistics and validities of constructs

 Variables
 M+SD
 1
 2

Variables	M±SD	1	2	3	4
1.Employee-robot engagement	5.09±1.08	0.82			
2.Psychological empowerment	5.31±0.99	0.69**	0.75		
3. Workplace depersonalization	$3.31 \pm 1.90$	-0.17**	-0.19**	0.94	
4.Developmental HR practices	$5.25 \pm 1.02$	0.72**	0.55**	-0.21**	0.81

Note: N = 685; \*\*p < 0.01, \*p < 0.05. The bold numbers in the diagonal row are square roots of AVEs.

Dradiativa variablas	Psycholo	ogical empo	owerment	Workplace depersonalization		
Predictive variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	$4.10^{***}$	$4.90^{***}$	4.81***	3.52***	3.09***	3.01***
<b>Control variables</b>						
Gender	$0.16^{*}$	$0.11^{*}$	0.13*	-0.41**	-0.38**	-0.36*
Age	0.02	-0.01	-0.01	0.12	0.14	0.14
Education	0.03	-0.03	-0.02	0.33***	0.36**	0.36***
Position	0.04	0.06	0.06	0.12	0.10	0.12
Work experience	0.13**	$0.07^{*}$	$0.07^*$	-0.29***	-0.26**	-0.24**
Daily interaction	$0.11^{***}$	0.01	-0.00	-0.03	0.02	0.03
frequency						
Independent variable						
Employee-robot		$0.68^{***}$	$0.64^{***}$		-0.36***	-0.23*
engagement (ERE)						
Mediation variable						
Psychological						$-0.20^{*}$
empowerment						
Moderation variable						
Developmental HR			$0.14^{***}$			
practices (DHRP)						
Interaction variable						
ERE×DHRP			0.13***			
$\mathbf{p}^2$	0.07	0.50	0.50	0.07	0.10	0.11
$\mathbf{R}^2$	0.07	0.50	0.53	0.07	0.10	0.11
Adjusted R <sup>2</sup>	0.07	0.50	0.52	0.06	0.09	0.10
$\Delta K^2$	0.07	0.43	0.03	$0.0^{-7}$	0.03	0.01
F	8.93	96.70	83.88	8.03	10.61	9.82

 Table 5. Multiple regression results

Note: N = 685; \*\*p < 0.01, \*p < 0.05.

 Table 6. Bootstrapping outputs for indirect effects

Tuble 0. Dootstrupping outputs for manoer encets						
	Mediator	Effect	SE	t-value	p-value	Bootstrap 95% CI
Direct effect	-	-0.22	0.10	-2.28	0.02	[-0.4208,-0.0318]
Indirect effect	Psychological empowerment	-0.13	0.07	-	-	[-0.2717,-0.0077]

 Table 7. Bootstrapping outputs for moderated mediation effects

Moderated variable	Mediated variable	Moderated level	Indirect effect	SE	Bootstrap 95% CI
Developmental	Psychological	Low (-1SD)	-0.10	0.05	[-0.2147, -0.0059]
HR practices	empowerment	High (+1SD)	-0.15	0.07	[-0.2978, -0.0091]

#### **Appendix 1 Interview outline**

1. Please briefly describe the scenarios in which you work collaboratively with service robots.

2. How do you understand the role of employee-robot interaction in your work?

3. What impact do you think service robots have had on your job?

4. What differences and similarities do you see between service robots and human employees (yourself)?

5. What strategies do you think organizations can implement in managing both human employees and robots?

### **Appendix 2 Experimental material**

#### **Employee-robot engagement**

*Mr./Miss Allen is a frontline employee at a hotel. In recent years of work, Allen has gradually discovered that the level of synergy between robots and human employees exceeds expectations, allowing for efficient collaboration. In the dynamic setting of human-robot coexistence, Allen is full of vitality and willingly contributes to the organization. S/he actively provides services to customers at work, often receiving positive feedback. Allen quickly adapts to the robot's operational methods and is growing more fond of the current work environment. This state of alignment promotes overall teamwork, creating a relaxed working atmosphere.* 

#### **Employee-robot disengagement**

*Mr./Miss Allen is a frontline employee at a hotel. In recent years of work, Allen has gradually discovered that the level of synergy between robots and human employees falls below expectations, preventing efficient collaboration. In the dynamic setting of human-robot coexistence, Allen feels at a loss and is unwilling to contribute to the organization. S/he cannot provide proactive service to customers at work, sometimes even facing complaints. Allen feels unable to adapt to the robot's operational methods and is growing increasingly resentful of the current work environment. This state of misalignment hinders overall teamwork, creating a tense working atmosphere.* 

#### **Appendix 3 Research instrument**

#### **Employee-robot engagement**

When working with service robots, I feel bursting with energy.

When working with service robots, I feel strong and vigorous.

I am enthusiastic about working with service robots.\*

Working with service robots inspires me.

I feel happy when I am working with service robots.\*

I am immersed in working with service robots.\*

#### **Robot-related psychological empowerment**

During human-robot interaction, I realize.....

The work I do is meaningful to me.

My job activities are personally meaningful to me.

The work I do is very important to me.\*

I am confident about my ability to do my job.

I am self-assured about my capabilities to perform my work activities.

I have mastered the skills necessary for my job.\*

I have significant autonomy in determining how I do my job.\*

I can decide on my own how to go about doing my work.

I have considerable opportunity for independence and freedom in how I do my job.

I have a great deal of control over what happens in my department.

I have significant influence over what happens in my department.\*

My impact on what happens in my department is large.

#### **Employee depersonalization**

I have become more callous toward people since I took the job.\*

I worry that this job is hardening me emotionally.\*

I do not really care what happens to some customers.\*

I feel customers blame me for some of their problems.\*

#### **Developmental HR practices**

It seems like my organization really cares about my career opportunities.

This organization puts in a great deal of effort in organizing for internal career development.

Considering the work I do, the training and development I have received are sufficient.

I am satisfied with the training and development I have received.

The feedback I receive on how I do my job is highly relevant.

My organization seems more engaged in providing positive feedback for good performance than criticising poor performance.

\*Represents measurement items used for experimental research (Study 2)



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