

Working with a Service Robot – Case “Kalle” the Robot in Hotel Hanaholmen

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Abstract

This study employs a case study approach and qualitative methods to explore performance outcomes and factors influencing the effectiveness of service robots in room-service delivery. Conducting 22 interviews with employees of Hotel Hanaholmen that experimented with a service robot, we identified key subjective and taskwork outcomes of human-robot collaboration. The study links task-technology fit with performance impacts in human-robot interactions, enhancing the literature on service robots by offering qualitative insights and understanding employee reactions to working with these robots. Practically, it provides valuable insights for integrating service robots, emphasizing feasibility requirements for optimal use.

Keywords: Service robot, Case study, Technology-to-Performance Chain model, performance outcomes.

1. Introduction

Artificial intelligence (AI) applications, including robots, are transforming work tasks by complementing and enhancing human performance (Coombs et al., 2020). In organizations, AI-enabled technologies are increasingly used to work alongside humans (You & Robert, 2023), performing tasks that range from simple mechanical to complex empathetic functions (Huang & Rust, 2018). Deploying AI in organizational service processes is expected to significantly impact service economies by increasing productivity (Decker et al., 2017; Paluch et al., 2022; Wirtz et al., 2018; Xiao & Kumar, 2021).

Robots, as intelligent systems with virtual or physical embodiments, can learn and adapt to new environments, interact with humans, and perform tasks autonomously (Groom & Nass, 2007; Wirtz et al., 2018). Organizations employ robots to improve efficiency, precision, and innovation while addressing labor shortages (Smids et al., 2020). Initially used in industrial settings, robots now assist in various sectors such as transportation, hospitality, and medicine (International Federation of Robotics, 2022).

Robots are increasingly seen as collaborative technologies working towards common goals with

humans (Ma et al., 2018). Collaborative service robots, equipped with AI and autonomy, work with employees to co-create service delivery (Paluch et al., 2022). Prevailing studies have largely focused on the customer perspective of service robots, while research on employee-robot collaboration remains less explored, necessitating further investigation (De Keyser & Kunz, 2022).

In this study we investigate the collaboration between hotel employees and a mobile service robot delivering room service orders. The study aims to explore performance outcomes and factors influencing collaboration effectiveness in human-robot teams. By assessing task performance through various metrics such as time, speed, workload, and reliability (Singer & Akin, 2011), the research seeks to identify factors that facilitate better human-robot collaboration.

Performance is defined as “observable things people do (i.e., behaviors) that are relevant for the goals of the organization” (Campbell et al., 1990). Team performance includes both behaviors and outcomes, with effectiveness reflecting the end results of actions (Campbell et al., 1990; Mathieu et al., 2008). In human-robot collaboration, performance can be evaluated in terms of system, operator, or robot performance, focusing on collaborative task outcomes (Gervasi et al., 2020; You & Robert, 2018).

This study aims to enhance the understanding of effective robot deployment in the service industry by identifying the factors that affect human-robot collaboration performance and outcomes. Specifically, our research addresses the following questions: 1) What are the performance outcomes of human-robot collaboration in a service work context? and 2) What factors influence the effectiveness of employing a service robot for room service delivery at a hotel?

2. Earlier research into robots

Robots are artificially intelligent systems capable of performing actions autonomously, with varying levels of autonomy enabling them to perceive environments and make decisions independently (Paluch et al., 2022; Smids et al., 2020). Robots are categorized into industrial and service robots.

Industrial robots, primarily used in factories, perform automated tasks without direct human interaction (Thrun, 2004; Xiao & Kumar, 2021). As technology advances, service robots – both virtual and embodied - are increasingly integrated into various sectors, performing diverse tasks in non-standardized environments (Coombs et al., 2020; Decker et al., 2017; Huang & Rust, 2018). Service robots, defined as autonomous interfaces interacting with customers and employees, can be professional or personal (Thrun, 2004; Wirtz et al., 2018). Professional service robots assist in specialized tasks like medical services or in hazardous environments, while personal service robots support domestic and recreational activities (Thrun, 2004).

Human-robot collaboration is expected to enhance performance by combining the strengths of both robots and humans. This collaboration ranges from coexistence and cooperation to direct physical interaction in shared tasks (De Simone et al., 2022; Gervasi et al., 2020). Collaborative robots are designed to work alongside human employees, performing similar service roles (Paluch et al., 2022). Embodied robots, which operate in physical environments, evoke emotional responses and social interactions, often being perceived as social actors (Dourish, 2001; Groom & Nass, 2007).

Human-robot collaboration has been an important theme in the human-robot interaction (HRI) research. For HRI, human-robot collaboration is a research “branch that explores the interaction between a human and a robot acting like a team in reaching a common goal” (Semeraro et al. 2023, p. 1). This stream of research has mainly focused on manufacturing tasks (for a review, see Semeraro et al. 2023), rather than on service business, which is the focus of this study.

3. Theoretical grounding

The theoretical basis of this study draws from the Technology-to-Performance Chain (TPC) model (Goodhue & Thompson, 1995). The TPC model posits that information technology impacts individuals' performance positively when the technology is utilized, and its functionalities align with the user's task requirements (Goodhue & Thompson, 1995). Within the TPC model, utilization is influenced by user attitudes and beliefs, with increased use often resulting in positive performance impacts.

The TPC model acknowledges that predicting performance impacts based solely on utilization can be problematic, particularly in mandatory use scenarios where user attitudes may not predict utilization effectively (Goodhue & Thompson, 1995). Hence, the model integrates task-technology fit, suggesting that

performance impacts also depend on how well technology features align with task requirements, independent of utilization.

The constructs of the TPC model include task-technology fit, utilization, and performance impacts. Task-technology fit indicates the level of assistance technology provides for tasks, considering technology, task, and user characteristics. Utilization refers to the use of technology in task execution, influenced by beliefs, feelings, social norms, and facilitating conditions. Performance impacts relate to task execution quality, efficiency, and effectiveness. The TPC model also incorporates feedback mechanisms, highlighting the cyclical nature of technology use and performance improvement (Goodhue & Thompson, 1995).

Goodhue and Thompson (1995) proposed a simplified version of TPC known as the Task-Technology Fit (TTF) model. The TTF model directly links task-technology fit to utilization and performance impacts while excluding individual characteristics, utilization precursors, and feedback constructs. Recent research has applied the TTF model to the context of AI and robots, examining the fit between robotic process automation (RPA) and accounting tasks (Kokina & Blanchette, 2019), intelligent customer service adoption (Sheng et al., 2022), and AI-based chatbots for travel planning (Dhiman & Jamwal, 2023).

In this study, we build on the TPC model as a framework (see Figure 1) to structure our rich set of qualitative data and to guide us in coding. The aim was to build a nuanced picture of factors that each construct is composed of in the context of a service robot-human collaboration.

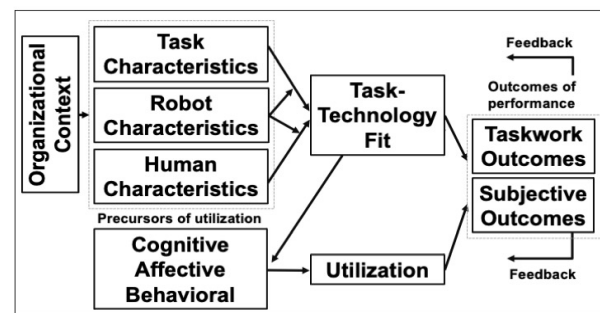


Figure 1. Research framework: Technology-to-Performance Chain model (adapted from Goodhue and Thompson, 1995)

We acknowledge the organizational context as a key enabler and driver for the utilization of a specific technology, a service robot in our case, and the critical role of task-technology fit in determining performance impacts. Inputs for the task-technology fit consist of

factors regarding task, robot, and human characteristics. In addition to task-technology fit and utilization, different cognitive, affective and behavioral factors are assumed to act as precursors.

4. Empirical study

4.1. Research methodology

In this study we investigate the performance outcomes of integrating a service robot into a work task and identify the factors that support or hinder the effectiveness of human-robot collaboration. Our investigation is based on a real-life experiment at Hotel Hanaholmen. Due to the real-world setting, the case study approach is chosen because it is suitable for investigating complex instances where inputs and outputs cannot be readily or accurately related to gain an understanding of the instance (Grosshans & Chelimsky, 1990).

4.2. Research setting

The Hanaholmen hotel that served as the environment for the robot room-service experiment is located in Southern Finland. This small hotel with 66 hotel rooms provides modern facilities for companies and other organizations to organize conferences and cultural events.

The robot used in the study is a mobile service robot (butler bot W3 by KEENON Robotics) whose main purpose was to deliver room service orders to hotel customers' rooms. The robot navigates its environment with cameras, a 120-degree sensor, and a pre-programmed map. It is partially autonomous: it could move from the standby position to the hotel rooms. Its integration with the hotel's elevator allowed it to order the elevator autonomously and to move between different floors.

Human employees were needed to receive the room-service delivery order, pack items inside the robot, and inform the robot of its destination room by using the robot interface. Once the robot arrived at the customer's hotel room door, it called the room's phone to notify the customer of its arrival. Additionally, the robot communicated with employees through phone calls when encountering issues while performing a task. When it received a task, arrived back to the standby position after delivery, or went to get charged, it notified the users by speaking with natural language. Additionally, the robot communicated via text on its interface. The robot has compartments on two levels, both covered with doors, that can be opened or closed by pressing buttons from its interface. Also, the door

closes automatically after a limited period. The hotel employees named the robot "Kalle," and stickers were attached on its sides to inform customers about its purpose, which was to deliver room-service orders available on the "robot menu".



Figure 2. The service robot ("Kalle")

While the robot was experimented with at the hotel, the employees performed their daily work tasks as usual. The main users of the robot were the employees working as waitstaff in the hotel restaurant. Because the restaurant employees were usually busy serving customers, when in need of help while performing the delivery task (e.g., a door on the aisle was closed, so the robot could not reach the destination hotel room), the robot called reception employees' phones. Other hotel employees did not collaborate with the robot but might have interacted with it as they worked in the shared environment.

4.3. Data collection

The qualitative approach was chosen because of the explorative nature of the study. We conducted semi-structured interviews which were recorded and transcribed. Altogether 22 individuals (15 women and 7 men) working in Hotel Hanaholmen were interviewed.

Ten of the interviewees work at the hotel's restaurant, one at the management level. This unit was responsible for sending the robotic room service delivery orders. Six interviewees (including one manager) work at the hotel's reception, the unit the robot phoned if it encountered any issues while performing its task.

To diversify the participant sample, we interviewed one employee from the technology and sales unit and one management-level personnel from each housekeeping, management, marketing, and sales department.

The semi-structured interviews lasted from 16 to 53 minutes, and the transcriptions totaled 222 pages.

The interviews followed an interview guide, tailored to suit the interviewees' roles and exposure to the robot. Only five of the 10 restaurant employees had directly used the robot to send an order a customer ordered, but all 22 hotel employees interviewed were at least aware of it. Some had used Kalle for other purposes, such as filming a marketing video or practicing using it in a group setting, or they had to return the robot to its standby position when it had deviated from its place.

The coding process followed a hybrid approach involving an inductive phase to identify themes and a deductive coding phase to organize the codes based on categories in the theoretical framework (Fereday & Muir-Cochrane, 2006). The entire coding process (using Atlas.ti software) consisted of multiple coding rounds. Specifically, once we had transcribed the interviews, we did the first round of coding to identify categories and themes from the data. Next, we reviewed and refined the codes to increase consistency across the emerged categories and their subcategories. Once we had identified the central themes in the interview data, we categorized the codes based on our theoretical framework and refined the lists of factors in the research framework accordingly.

Because using a theoretical framework may hinder the researcher's inductive reasoning (Garvey & Jones, 2021), we frequently reviewed our research questions and reflected on the findings.

5. Findings

We will next present the findings of the interviews. We begin with the organizational context, which enables and drives human-robot teamwork. Then, we will present the relevant input factors, including task, human, and robot characteristics, combinations of which influence task-technology fit and a set of precursors of utilization. Task-technology fit, and utilization then influence the outcomes of performance. The findings related to each are presented along with interview quotations and the development suggestions of interviewees. We believe it is useful to highlight these suggestions, as they accentuate the shortcomings of the service robot perceived by the users.

5.1. Organizational context

Organizational context is a focal external factor in a context where humans work with a robot, as it influences overall effectiveness by either supporting or hindering the provision of resources (You & Robert, 2017). Training, IT support, and incentives have been

identified as key drivers in the organizational context of human-robot teamwork (You & Robert, 2017).

The employees at Hanaholmen received two *training* sessions on using the robot. The first session demonstrated its functionalities, while the second involved practicing the delivery process. Some had missed the sessions due to scheduling conflicts and had to learn from colleagues. Although some suggested more extensive training would have been beneficial, the training provided was generally considered sufficient.

External *IT support* was available to address robot errors, but communication issues arose because hotel employees couldn't always identify or describe the problems accurately. Interviewee 5 mentioned, "*At some point in the morning, Kalle did not find a charger[...], so what do we do now? It was difficult to inform that Kalle is now acting strange because we didn't know exactly what he was doing wrong.*"

Hotel management had introduced the robot positively, and participants appreciated its media appeal and potential to attract new customers and increase public interest. Interviewees saw future *incentives* in alleviating labor shortages, addressing challenges in finding skilled workers, increasing efficiency, and enhancing customer satisfaction. As Interviewee 1 noted, "*Many customers have been interested in Kalle. They are like, wow, what is that? Then we tell them it's Kalle, and it delivers champagne to rooms. Then [customers] reply, 'How interesting, can I take a picture with Kalle?' [...] So, if Kalle is in the restaurant, I feel it can increase customer satisfaction.*"

5.2. Task characteristics

Task type, proximity to the robot, and task interdependence are characteristics of the task.

The types of tasks a robot can perform relate to the robot's functionality. Room service delivery is a standardized task, generally requiring that all items arrive together and that food items remain at an appropriate temperature until delivered. At Hanaholmen hotel, there is no dedicated room service staff in the restaurant. The employee who answers the phone call from the customer, prepares and delivers the order. This multitasking can be problematic, particularly during busy times, as employees must interrupt their current tasks to handle room service requests. Interviewees highlighted the burden this creates and noted that room service tasks are considered extra work to in-restaurant service.

The proximity of robots affects humans, primarily when they exist in the same physical space. The robot shared the restaurant space with employees, which

raised concerns about its location and impact on space utilization. While employees initially found the robot's location too central and intrusive, they adapted over time. The robot moved in aisles away from primary work areas, minimizing disruption. However, interviewees speculated that increased robot usage could lead to more frequent interactions with employees, particularly housekeeping staff.

Task interdependence is the cooperation and interaction in the actions of team members while they perform a task (Stewart & Barrick, 2000). In other words, it describes how one person's behavior affects another's performance (Zhao et al., 2020). Room service interrupts restaurant employees' tasks, particularly during peak dining hours. Even with robot assistance, human input is necessary for receiving and preparing orders, sending the robot, recording payments, and addressing any errors. Participant 22 explained: "*In this form, it [room service task] requires human personnel so that we can, to start with, place the right items inside the robot.*". The robot's dependence on employees includes handling special requests and intervening when the robot encounters problems. Interviewees suggested that reducing this interdependence could enhance efficiency, such as by enabling customers to place orders directly via in-room devices.

5.3. Robot characteristics

Robot characteristics include factors in robot appearance and embodiment, personality, intelligence, and autonomy level.

The appearance and embodiment of a robot refer to the form and structure of a robot, which has significance in establishing social expectations of the robot (regarding what is appropriate or inappropriate behavior from the robot) and affects how comfortable humans feel under the robot's presence (Fong et al., 2003). The interviewees likened the robot to various machines (e.g. a vacuum cleaner) and found it either cute or machine-like. Its non-human-like form was appreciated, yet some wished it had a smile or eyes. Due to its ambiguous appearance, stickers were added to clarify its function as a delivery robot. Interviewees suggested that the robot's design should match its environment and noted its compartment was too small for warm food delivery.

A robot's perceived personality results from humans' unconscious attribution (Joosse et al., 2013), and a robot may exhibit personality unintentionally or intentionally as part of its design (Fong et al., 2003). As You and Robert (2018) noted, the physical embodiment of a robot affects human emotions, which leads people to project personalities to them. As a

result, the robot's personality facilitates interaction with humans and influences task performance, either supporting or hindering it (Fong et al., 2003). Interviewees' opinions on the robot's perceived personality varied. Some saw it as an inanimate object without personality, while others found it had a persona, describing it as funny, stubborn, and polite. Its speaking ability and occasional errors contributed to this perception, making it seem more personable and engaging. For instance, Interviewee 5 explained, "*Kalle is quite funny because sometimes he says something like 'I did a good job'*".

The *intelligence and autonomy level* of robots is enabled by AI (Bartneck et al., 2008; Goodrich & Schultz, 2007). Even though Kalle navigated autonomously from the restaurant to hotel rooms, including using an elevator, external factors like obstacles could impede its progress. While some interviewees considered it smart, others found it limited and unable to adapt to changes. Suggestions for improvement included speech recognition and handling more complex tasks.

5.4. Employee characteristics

The scope of human characteristics involves age and gender, attitude towards robots, knowledge of robots, technical skills, and personality.

Age and gender were initially thought to influence how employees perceive and interact with the robot, but this assumption was not supported by interviews. Both older and younger employees, regardless of gender, had varied responses to using and testing the robot. Some were enthusiastic, while others were cautious.

The interviewees' *attitudes toward robots* were by and large quite neutral. Initial concerns about robots replacing human workforce were common but dissipated upon seeing the robot in action. While some interviewees worried about job displacement, most were excited and interested in the robot's capabilities. The consensus was that robots should not replace humans but serve as tools to improve efficiency without threatening employment. Interviewee 2 commented, "*Humans are also needed in restaurants. Perhaps in future most [workers] will be robots and then some humans manage them.*".

Employees' earlier *knowledge on robots* was reasonable, with them being aware of robots in various contexts, such as manufacturing, cleaning, and service industries, many also having encountered them before (e.g. grocery delivery and cleaning robots). They had also encountered robots in popular culture and movies, which sometimes influenced their perceptions, like Interviewee 4 mused: "*The word robot [...] commonly*

reminds people of movies where the robots are shown in a way where they turn against humanity [...] and there is less of those movies where robots have been used for some good purposes.”

Employees had varying levels of *technical skills*, impacting their confidence in using the robot. The training helped some, while others learned independently and found the robot easy to use. Generally, humans were seen as more capable than the robot currently in use.

Interviewees noted that resistance to change is common but varies by individual. Those in service roles, who typically enjoy customer interaction, had different reactions to the robot, depending on their *personalities* and openness to new technologies.

5.5. Task-Technology Fit

Task-technology fit denotes the level of assistance technology provides for an individual's tasks. It represents the connection between the technology's functionalities, the nature of the task and its requirements, and the characteristics of the individual (technology user) (Goodhue & Thompson, 1995). In the context of a service robot, we find that task-technology fit consist of the robot's compatibility, ease of use, and its reliability.

Compatibility means the scope of a technology aligning with individuals' values, needs, and past experiences (Rogers, 1995). In case of Kalle, the robot's compartment size was unsuitable for delivering warm food orders, limiting it to drinks and small snacks. This mismatch led interviewees to suggest that a larger, temperature-maintaining compartment would make the robot more useful. The robot was otherwise considered suitable for standardized delivery tasks, although some interviewees proposed design changes, such as removing compartment doors for easier access and to save time.

Ease of use of technology refers to individuals' beliefs on how easy and effortless the use of the system is. All else being equal, when the system is perceived as easy to use, users will likely accept it (Davis, 1989). Most of our interviewees found the robot easy and logical to use, comparing its interface to a smartphone. Interviewee 1 noted: “*Kalle has relatively good functionalities inside, and there are instructions on the interface, so with some reasoning power, you will learn how to use Kalle.*”. Some difficulties were mentioned, such as problems in using the emergency stop button and resetting the robot after errors. Interviewees recommended interface improvements, like local language options and manual button over timer for closing the compartment to avoid accidents.

Lastly, *reliability* has been identified as a related factor in trust between humans and automated systems (Jian et al., 2000). The robot's reliability was appreciated for its consistency and lack of human error, making it predictable and stable. Interviewees noted that the robot's movement was smooth and often skillful in navigating obstacles. However, its reliability was compromised by environmental changes and occasional errors. Development suggestions included making the robot's movements more predictable to bystanders by communicating its intended direction.

5.6. Utilization

Utilization is conceptualized as the extent to which a system is integrated into a work routine by choice or organizational mandate (Goodhue & Thompson, 1995). Except on Sundays, Kalle worked daily from 3 pm to 6 pm, which is the least busy period for restaurant employees. Its availability was adjusted based on the employees' estimated workload. Due to compartment size limitations, the robot only delivered items from a specialized menu featuring drinks and small snacks, rather than items from the standard room service menu.

The robot's initial introduction to the hotel had generated significant media attention, drawing customers who might not have otherwise visited. However, low demand for robotic room service persisted, prompting a shift from PR-driven to product marketing. Interviewee 18 noted the hotel's size and customer base were factors: “*There were not enough customers [for the robot] ... because we only have 66 rooms. The customer base should consist of more private customers or business customers who are tired after their workdays, want to order room service, and are not here for a conference.*” Additionally, customers' unfamiliarity with the service and the high price of robot menu items contributed to low usage. Interviewees suggested that more affordable and appealing menu options might have increased orders.

In addition to the frequency or diversity of use, the reasons for the decision to use the technology - beliefs, feelings, and social norms - are important precursors of utilization (Goodhue and Thompson, 1995). In our study, three types of precursors of utilization - cognitive, affective and behavioral - could be identified from the interviews.

5.6.1. Cognitive precursors. Cognitive mediators in our study include shared mental models between humans and robots, team identification, and expected utilization consequences.

The mental models influence the understanding of goals and involve understanding which tasks each team member needs to perform to achieve the goals (Kokar & Endsley, 2012). Therefore, the shared mental model also includes the understanding of the role each team member has (Andrews et al., 2023). Accurate mental models can enhance human-robot work performance while reducing the human cognitive load (You & Robert, 2017). At Hanaholmen, the interviewees often did not understand the robot's behaviors. For instance, they were puzzled by its deviations and frequent calls to the reception. Interviewee 20 exemplified this by stating, "I guess I don't know much of what goes on in his head." Interviewees emphasized the need to at least know the robot's capabilities, especially for critical tasks, even if full technical understanding is not necessary.

The **expected consequences of utilization** (i.e., the users' beliefs) and other precursors of utilization, including affect toward using, social norms, habit, and facilitating conditions, determine if the user utilizes the system. Initially, interviewees were excited about the robot, anticipating it would alleviate their workload by handling room-service deliveries. They were also prepared for challenges due to the novelty of such robots in Finnish hotels.

5.6.2. Affective precursors. Affective mediators are related to emotional attachment, trust, and robot attraction.

Emotional attachment to technology refers to the emotional bond or connection between an individual and technology and promotes greater engagement and better performance (You & Robert, 2018, 2022). Furthermore, it predicts an individual's intention to use technology, as when they feel emotionally attached to a system, they enjoy using it and want to use it more frequently (You & Robert, 2018). Some interviewees felt sorry for the robot when it was stored away, indicating emotional attachment. However, at least one interviewee looked forward to the end of the experiment due to frustration with the robot, indicating low emotional attachment.

Trust in an organizational context is understood as the willingness of one trustor to be subject to the actions of another party on the assumption that the other party will perform a task important to the trustor, regardless of whether the trustor can supervise or control the other party (Mayer et al., 1995). It is a self-reported metric by human team members who act as the trustor for robots (Ma et al., 2022). At Hanaholmen, trust in the robot varied. Most interviewees found Kalle trustworthy but relied more on humans. Trust was built through consistent, error-free performance. However, frequent errors eroded

trust, especially during busy times. Understanding and having plans to address errors also played a significant role in building trust.

Robot attraction relates to social attraction, which is the extent to which an individual creates positive perceptions from other individuals (You & Robert, 2022). It increased performance and viability through team identification (You & Robert, 2022). Interviewees were generally attracted to the robot, finding it humorous and adorable. Its quirky behaviors, like self-praise or calling for help, were endearing to many. However, the initial excitement waned for some as the robot proved less useful.

5.6.3. Behavioral precursors. Behavioral mediators in our study include communication, coordination, and social norms.

When task interdependence among human-robot team members is high, the requirements for *communication* and *coordination* increase (Jones & Hinds, 2002). Coordination involves the parties working together to achieve a common goal (Hsieh et al., 2007). Furthermore, it supports successful teamwork between team members by integrating activities and responsibilities among the members (Ma et al., 2018). Interviewees preferred minimal oversight of the robot but stressed the importance of knowing its activities. They suggested assigning one person per shift to manage the robot and ensuring human control over safety.

Social norms in the TPC model refer to organizational norms, where strong social norms can lead to individuals' mandatory use of an information system. Social norms such as speed and proximity (e.g., MacArthur et al., 2017) are also considered in the design of computer software and robots to ensure their behavior is socially acceptable, thereby facilitating their acceptance by humans (Reeves & Nass, 1996). The robot's inability to fully understand its surroundings, like standing idle during busy shifts, highlighted its limitations compared to humans. Interviewees found the robot's errors and need for help cute, a tolerance they wouldn't extend to human colleagues. Instances like closing compartment doors before warning were problematic, indicating a misalignment with expected social norms.

Team identification (TI) refers to how individuals experience team membership as part of their identity (You & Robert, 2022). Similarly to human teams (Pearsall & Venkataramani, 2014), You and Robert (2019) found that TI also leads to better performance in human-robot teams. Naming the robot ("Kalle") fostered team identification and personal attachment. Interviewees saw Kalle as part of the team, with some expressing a desire to

decorate it for Christmas, enhancing the sense of it being a team member.

5.8. Performance outcomes

The performance outcomes of Kalle's work with employees can be divided into more objective taskwork outcomes and subjective outcomes.

5.8.1. Taskwork outcomes. The taskwork outcomes relate to task time and speed of service, error rate, service output quality, task load for the employees and task shaping.

Task times were somewhat reduced, even though the robot could not pack goods, but required a human to prepare orders and program the destination on the robot's interface. This process, including human preparation, often took longer than direct human delivery. However, once in motion, the robot completed deliveries quickly, matching human walking speed. Adjustments to the robot's speed based on employee workload and improved obstacle navigation were suggested.

During the experiment, the robot frequently called reception for assistance, sometimes up to 10 times an hour, causing confusion and annoyance. The robot also deviated from its standby position, blocking walkways. These *errors* often stemmed from environmental changes, such as rearranged furniture. Interviewees emphasized the need for easy error fixes and proper preparations for robot malfunctions.

The robot's performance was generally reliable and consistent. However, language barriers and Kalle's compartment door closing before the customer had taken their items out affected *service output quality*. Interviewees noted the importance of the robot speaking the local language and allowing sufficient time for customers to retrieve items.

The robot's presence altered *workloads*, reducing physical but increasing mental demands. While some saw potential in reducing physical strain, the robot's errors and integration challenges added stress. Frequent customer inquiries about the robot also contributed to the mental workload for a few. Introducing Kalle to the hotel *shaped the tasks* of some employees. The task of delivering room service orders was shifted from employees to the robot but this also created new tasks, such as preparing the robot and supervising it. Employees adapted to these new tasks, though they added to their workload.

5.8.2. Subjective outcomes. The perceptual subjective outcomes manifest in form of different attitudinal and emotional reactions (You & Robert, 2017).

Eventually, most interviewees accepted the robot conditionally, appreciating its uniqueness but fearing job displacement. Acceptance was linked to the robot performing different tasks from humans and its error rate. Some interviewees, however, were more resistant, preferring human reliability as well as human companion. Interviewees favored robots for repetitive tasks, freeing them to focus on more enjoyable aspects of their jobs. However, they concluded that working alone with a robot might become tedious over time.

Consequently, satisfaction with Kalle varied, with some finding the robot unnecessary and others appreciating its functionality. Interviewees agreed the robot could be more useful with additional features and praised its ability to work without breaks.

Concerns about the robot becoming a bottleneck due to errors, the need for quick repairs, and low utilization affected perceptions of its long-term viability. Interviewees emphasized the need for the robot to be helpful, efficient and not additional burden. Interviewees often attributed the robot's errors to its personality traits, such as seeking attention, due to their limited understanding of what caused the errors.

6. Discussion

In this study, we examined the performance outcomes of employee-service robot collaboration in a hotel setting for successful service co-delivery. Through in-depth interviews with 22 hotel employees and guided by the Technology-to-Performance Chain model, we explored various factors influencing performance.

Taskwork outcomes included task time, speed, error rate, output quality, workloads, and task shaping. Subjective outcomes encompassed, attribution, acceptance, satisfaction, viability, and work meaningfulness. The robot's task technology fit was a significant mediator for its utilization.

Concerns about job replacement were mitigated by the perception that the robot was not intelligent enough to replace humans. Employees accepted the robot for simple, repetitive tasks but noted that this interdependence could negatively affect work meaningfulness, creating new repetitive tasks for humans. Sequential interdependence caused stress by interrupting other tasks.

Social norms and robot errors influenced acceptance, with some interviewees finding mistakes humorous, though operational errors increased stress and decreased acceptance. Trust in the robot was primarily performance-based, with higher error rates decreasing trust and reliability boosting it. Some

employees even trusted the robot more than those human coworkers deemed unreliable.

Employees' curiosity to test the robot influenced their perception of ease of use, with high curiosity levels leading to better performance as in (You & Robert, 2016). Overall, performance outcomes related to trust, usability, and acceptance were crucial for successful human-robot collaboration. While the robot was expected to reduce physical workload and stress by managing tasks, it increased mental workload for some individuals.

7. Conclusions

This study contributes to the literature on service robots by linking task-technology fit with performance impacts in human-robot interaction, addressing calls for a deeper understanding of human-robot teams and service-robot employee interactions. It enriches service robot literature with detailed qualitative insights and enhances understanding of employee reactions to working with service robots.

Practically, the study provides valuable insights for integrating service robots, emphasizing feasibility requirements for optimal utilization. It offers design recommendations for robots to ensure multilingual communication, adherence to social norms, and safe interactions, especially when customers handle items. Additionally, it highlights the importance of informing employees about robot errors to maintain their satisfaction and acceptance.

This study's findings are based on the subjective experiences of employees at a Finnish hotel in fall 2023, interpreted by the researchers. While qualitative data collection may not cover all relevant aspects, the findings are presented as comprehensively as possible. Future research should focus on validating the identified performance outcomes and proposed factors to further advance the understanding of human-robot collaboration in service settings.

9. References

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