Guide Robots' Acceptance in Organizations: User's Self-Efficacy and Robots' Organizational Value

Submitted to: International Journal of Social Robotics

Authors:

1. Kristel Marmor – Tallinn University of Technology, IT College, Tallinn, Estonia; 0009-0004-0937-513X
2. Janika Leoste – Tallinn University of Technology, IT College, Tallinn, Estonia; Tallinn University, School of Educational Sciences, Tallinn, Estonia; 0000-0001-6919-0082
3. Mati Heidmets – Tallinn University, Tallinn, Estonia; 0000-0003-3193-7966

Corresponding author: Janika Leoste, leoste@tlu.ee

Abstract

The aim of this article is to explore the self-efficacy of guide robot (GR) users as well as assess the value of integrating guide robots in organizational workflows. The research covered in this article includes two studies, both conducted in Estonia. In the first study, the authors assessed user self-efficacy applying the *Guide Robot User Self-Efficacy Scale* (GRUSES) in controlled and uncontrolled environments, using variables such as age, gender, and prior experience. For the second study, semi-structured interviews were conducted with three stakeholder groups, including GR users, administrators, and retailers, to explore barriers to and propose solutions for a better adoption of GRs in organizations' everyday routine. The findings of the first study revealed higher self-efficacy among younger, male, and experienced users, with a significant drop of the test scores in uncontrolled situations as compared to the controlled ones. The second study revealed barriers to including GRs into organizational workflows as well as allowed identifying enabling factors. The research has allowed drawing recommendations for robot manufacturers, distributors, as well as organizational workflow managers to support a wider use of guide robots in an organizational context.

Keywords

guide robots; self-efficacy; emerging technologies; technology adoption; technology acceptance

1 Introduction

Recent advances in robotics and artificial intelligence (AI) have given rise to the development of social service robots (SSRs) that are designed to provide various socially structured services while allowing meaningful interaction with humans (Lee, 2021). According to Darling (2012), a social robot can be defined as "*a physically embodied, autonomous agent that communicates and interacts with humans*".

SSRs represent a particular type of social robots. Such robots are defined as *"system-based autonomous and adaptable interfaces that communicate and provide services to the organization's customers"* (Wirtz et al., 2018). SSRs have the potential to learn from previous interactions and adapt to new situations (Pagallo, 2013). They are seen as machines capable of carrying out complex series of actions (Singer, 2009). SSRs have many potential benefits, such as contributing to improving productivity, providing consistent service quality, and lowering staffing costs. Such robots can enable companies to quickly collect data from the environment, analyze it, and adjust their operations to changing customer needs (Lee, 2021).

The use of modern AI-supported and machine learning technologies has allowed increasing SSRs' capabilities in human-robot communication, enabling robots to engage in increasingly complex interactions (Dautenhahn, 2007; Leite et al., 2013). For example, robots such as Pepper and NAO can be used in educational settings to support learner engagement (Belpaeme et al., 2018), and the Care-O-bot robot has been used as a home assistant that enables elderly and disabled individuals to live independently (Asgharian et al., 2022; Bražinova et al., 2024; Graf et al., 2004). For these benefits, SSRs are increasingly used in sectors that traditionally suffer from workforce deficiency, such as healthcare, education, hospitality, and retail. In these sectors, SSRs provide various services, such as guidance, information delivery, companionship (Lee, 2021; Wada & Shibata, 2008; Fasola & Matarić, 2013), and virtual care (Turja, et al., 2019a). SSRs increase organizational efficiency, improve user/visitor experience in organizations, and help reduce labor shortage.

In spite of successful implementation of service robots in some controlled environments, for example, in manufacturing, implementing them in publicly accessible environments requires overcoming several obstacles (Zeller & Dwyer, 2022). Adopting robots in organizations with less predictable patterns of interaction is still challenging (Dautenhahn, 2007). Ensuring successful integration of robots into existing practices and minimizing possible disruptions requires assuming a structured approach. Accordingly, while guide robots (GRs) have significant potential for application, their actual areas of use remain narrow, and their further adoption poses several challenges, especially in organizational settings that aim to include SSRs in their everyday workflow.

Following the hypothesis that SSRs represent higher potential than their current level of use would suggest, we conducted a two-phase research project in 2023 and 2024. The first phase focused on the robots' nonverbal behavioral capacities, considering the limited attention paid to this particular aspect of human-robot interaction (HRI) (Leoste, et al., 2023; Leoste et al., 2024). One of the main conclusions from the first phase was that nonverbal behavior is an important factor for improving the self-efficacy of robot users in conjunction with other aspects of HRI, to allow integrating GRs in organizations' workflows.

Accordingly, a wider set of impact factors needs to be considered if robots are to be adopted outside of experimental or research settings, including in real-life organizational workflows. In the second phase of our research project, we adopted a more systematic approach to examine the roles of various factors in enhancing users' satisfaction as well as assess organizational acceptance of robots, focusing on one type of the SSR-s - GRs. The second phase of our research project, the results of which are presented in this article, was guided by the following aims:

a) Identifying factors that enhance GR users' self-efficacy.
b) Assessing the value for organizations of integrating robots in their workflows.

c) Drawing recommendations to organizations for practical steps integrating GRs in their everyday work routine.

2 Conceptual model and previous studies

The design of our second study was grounded in the traditions of HRI research, contextualized specifically within organizational environments. HRI as a field of study examines the dynamics of interactions between humans and robots, encompassing aspects such as communication, collaboration, and mutual adaptability. While much of the existing HRI research focuses on individual-level interactions or is carried out in controlled experimental settings, fewer studies explore these interactions within real-life organizational contexts. In the latter case, additional difficulties emerge from GR's integration in actual workflows and are caused by the complexities of multi-stakeholder dynamics as well as organizational goals. At the same time, further development and wider adoption of GRs represent a growing opportunity for organizations to innovate and optimize their workflows.

To meet the mentioned challenges and in agreement with the objectives of our research agenda to identify factors that enhance users' self-efficacy and increase the organizational value of GR, we proposed a three-actor model, including robots, users, and organizations. This approach contrasts with earlier studies, where organizations were often treated merely as the backdrop or context for HRI. Here, organizations are conceptualized as active agents that have made investments, possess distinct interests, and exert efforts that influence the successful adoption and integration of GRs.

To assess the acceptance of GRs, we used two evaluation criteria: self-efficacy from the user's perspective and organizational value representing the organization's viewpoint. Such dual perspective has allowed us to more comprehensively analyze the acceptance of GRs, addressing both individual and organizational factors. Three main dimensions of influence were outlined for each actor, expecting their role as facilitators or barriers in the process of RG acceptance in an organizational context.

The conceptual model we employed for this study is presented in Figure 1. The model represents a multidisciplinary approach that combines technological advancements, user-centered design, and organizational change management, paving the way for robots to become important contributors to modern work processes.

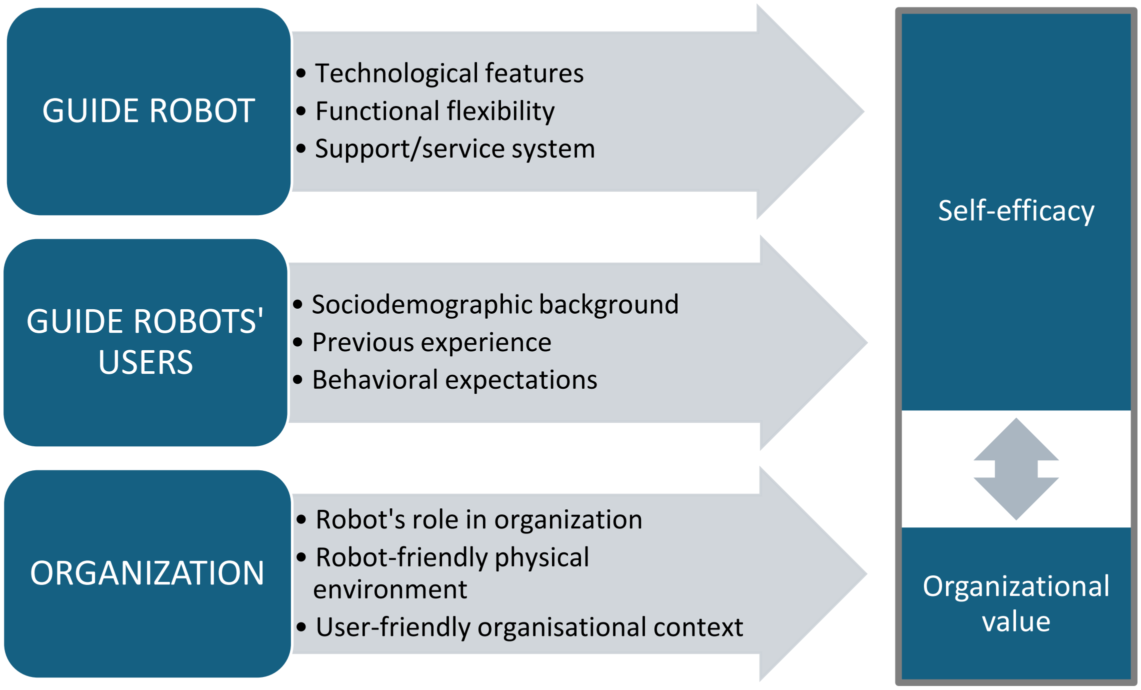

Figure 1. Conceptual model of guide robot acceptance in organizations.

The constructs outlined in the conceptual model are described in detail below, supported by references to prior studies.

2.1 Guide robots

GRs are SSRs that are specifically designed to assist users in navigating and finding their way in public places. The concept of the GR dates back to the 1970s, when projects such as MELDOG (1976) were developed to assist visually impaired individuals navigating their environments (Tachi & Komoriya, 1985). Over the decades, GRs have found use in various settings. They have been, for example, integrated into museums, where they provide interactive guided tours; or to healthcare facilities, where they alleviate shortage of guide dogs and human guidance personnel (Thrun et al., 2000; Degeurin, 2024).

Recently, the advancements in artificial intelligence (AI) and machine learning have significantly enhanced GR capabilities, making them viable in various fields. These include hospitals, universities, libraries, tourist attractions, theme parks, shopping malls, and museums (Adetaio et al., 2023; Lio et al., 2020; Ogle & Lamb, 2019; Shahzad et al., 2024; Gasteiger et al., 2021; Maniscalco et al., 2024). Contemporary GRs have sophisticated navigation systems, interactive interfaces, and context-aware functionalities that allow them to offer more seamless and personalized assistance to users. The future of GRs appears promising as these technologies continue to evolve, increasing the GRs usability in different tasks and environments (QViro, 2024). However, despite this growth of GRs capabilities and applications, there are still barriers that limit their broader adoption and use: technical limitations, lack of functional flexibility, and inadequate support and service systems.

Technical challenges are one of the most perceivable barriers to GR adoption that influence HRI and user self-efficacy directly. Common technical issues include, for example, system malfunctions – for example, software problems or hardware failures that can be critical in dynamic and unpredictable public spaces. In addition, GRs can struggle with navigation, especially in complex environments that have obstacles such as narrow corridors, uneven flooring, or crowded areas. User interfaces that are sometimes non-intuitive, can amplify these challenges for people that lack experience with advanced technology, creating thus accessibility issues and hindering effective interaction (Ogle & Lamb, 2019). In order to address these limitations, ongoing improvements are needed in robot reliability, navigation systems, and the development of user-friendly interfaces to ensure that GRs meet the needs of diverse user groups.

Another barrier to the GR adoption is their *limited functional flexibility*. Many currently available GRs have been designed for specific tasks and cannot be implemented in different environments to conduct various tasks, all this because they lack the necessary adaptability. For example, a GR that was constructed for museum guidance, is not automatically suitable for hospital work, as it requires using different navigation manners and following different interaction protocols. For improved flexibility, GRs need to be customizable for specific tasks, and they need to be able to navigate complex uncontrolled environments seamlessly. These abilities would allow GRs to be used in different roles in different settings, widening the range of their usage possibilities (Frieske et al., 2024).

The *lack of robust support and service systems* is also a critical barrier to GR adoption. Many distributors and retailers are currently not able to offer comprehensive maintenance, repair, and customer support services, which are essential for any organization that seeks to integrate GRs into their work processes. Without effective support, organizations face increased operational risks that leads to diminishing confidence in the technology. Addressing this challenge requires that structured after-sales support infrastructures are established, including regular maintenance services, troubleshooting protocols, and training programs for both direct end-users and organizational staff. Improved collaboration between manufacturers, distributors, and end-users is needed to ensure that GRs are consistently functional and aligned with the specific needs of their usage environments (García et al., 2020).

2.2 Users of guide robots

GR users are typically individuals who collaborate with a robot to perform specific tasks, e.g., navigating to a destination, obtaining information about an exhibit, or scheduling activities in transport hubs (Lio et al., 2020; Shiomi et al., 2008). The interaction with GRs takes place in diverse settings, including museums, libraries, hospitals, and public spaces. Available data suggests that GR use is more prevalent among younger individuals, urban residents, and professionals in the service sector, underscoring demographic patterns in robot adoption (Carradore, 2022). Prior experience with robots is important in shaping user interactions, as familiarity with robotic systems enhances confidence and reduces apprehension (Savela et al., 2017).

User-related issues represent some of the most complex factors that affect GR adoption and self-efficacy. These challenges arise from individual perceptions, behavioral tendencies, and attitudes toward technology. Negative attitudes, often driven by technophobia or unfamiliarity with robots, can hinder acceptance and willingness to interact with robots (Nomura et al., 2006). Concerns regarding job displacement exacerbate resistance if employees perceive robots as potential threats to their roles (Turja et al., 2019a). Trust in robot reliability is another critical factor; users are less likely to engage with robots perceived as prone to errors or ineffective in fulfilling tasks. Behavioral expectations are central to user acceptance. Users expect robots to exhibit appropriate behaviors and communication capabilities, including maintaining personal privacy, observing proxemic norms, and using expressive nonverbal cues, such as touch, gaze, and gestures (Yi & Park, 2024). Privacy concerns are increasingly relevant as robots collect, store, and process user data. Transparent policies and robust ethical guidelines addressing data security and respecting user autonomy and dignity are essential for building trust (Vincent et al., 2015; Sharkey & Sharkey, 2012).

Nonverbal behavior is emerging as a critical component of HRI, with growing recognition of its importance in building user engagement, trust, and self-efficacy (Chaminade & Cheng, 2009; Saunderson & Nejat, 2019). Gestures, facial expressions, gaze, proxemics, and other nonverbal cues significantly enhance the perception of a robot's social presence and natural feel of interaction (Breazeal, 2003; Spatola et al., 2021) – for example, proxemic behaviors, such as maintaining an appropriate personal distance, help users feel more comfortable during interactions. Takayama and Pantofaru (2009) have pointed that people are more likely to engage with robots that exhibit patterns of proxemic behavior like their own. Robot's expressions are also important in interpreting their responses and improving coordination – for example, eye contact and gaze behaviors can make robots appear more attentive and responsive (Mutlu et al., 2009). Gestures and body movements can aid communication, making messages clearer and more engaging (Salem et al., 2012). Robot's expressiveness, including its facial expressions and body language, has been linked to increased empathy and social presence (Liu et al., 2008).

Previous works indicate that approrpiate nonverbal cues increase user satisfaction and their confidence in robots (Li et al., 2022). For example, animated facial expressions, smooth movements, and responsive behaviors help users feel more at ease, thereby increasing their willingness to engage with the robot. Also, nonverbal behaviors tailored to cultural norms and social expectations can further contribute to trust and comfort, making the interaction more intuitive and natural (Leoste et al., 2024; Baxter et al., 2016).

2.3 Organizational context

Organizations are increasingly seeking to integrate GRs into their workflows, driven by their potential to deliver strategic value through optimizing workflows, enhanced customer experiences, and the cultivation of an innovative and forward-thinking reputation (Dautenhahn, 2007).

Guide robots can be attributed different roles in organizations. GRs may perform routine, repetitive tasks with consistent efficiency, offering a compelling value proposition for organizations. Such tasks include visitor guidance, information provision, and logistical management, which allow streamlining operations and free staff to focus on more complex, higher-level responsibilities. For example, in libraries and hospitals, GRs have the potential to alleviate administrative burdens while enhancing user experiences through intuitive navigation and personalized interactions (Leoste et al., 2024; Jadad-Garcia & Jadad, 2024; Turja et al., 2019a).

Integrating GRs seamlessly in workflows, the use of robots does not only allow increasing operational efficiency but also contributes to creating an innovative organizational image. Despite these advantages, achieving the full potential of GRs necessitates addressing significant barriers.

Organizational readiness plays a critical role, encompassing infrastructural compatibility and the willingness of staff to embrace technological changes (Dautenhahn, 2007). Moreover, clearly defining the roles of GRs within the workflows and establishing robust support systems, such as training, maintenance, and troubleshooting mechanisms, are essential for ensuring their acceptance and long-term usability (Vincent et al., 2015).

Adapting to diverse tasks and cultural contexts. GRs can adapt to a variety of tasks and cultural contexts. Modular designs and AI-driven personalization enable GRs to cater to specific needs, from assisting elderly patients in hospitals to guiding multilingual international visitors in cultural institutions (Bražinova et al., 2024; Adetaio et al., 2023). User trust and satisfaction increase when robots demonstrate adaptive behavior and nonverbal communication skills tailored to their specific roles (Saunderson & Nejat, 2019). Effective use of nonverbal cues, such as proxemics and expressive displays, adds to the naturalness of human-robot interactions, fostering trust and improving user satisfaction (Takayama & Pantofaru, 2009). Ultimately, the value GRs potentially bring to organizations transcends their strictly functional contributions. By aligning their technical capabilities with organizational workflows and user expectations, GRs can contribute towards transforming traditional service models, making them more adaptive, efficient, and user centric.

Robot-friendly physical environment. The adoption of GRs demands significant adjustments to the physical environment, which can pose challenges for organizations. GRs frequently encounter difficulties with navigation and functionality caused by environmental obstacles and infrastructural incompatibilities. Features such as narrow corridors, door thresholds, stairs, uneven floors, and crowded areas can hinder their operational effectiveness and limit their usability in complex real-world environments (Gross et al., 2017; Moro et al., 2019). Organizations need to invest in creating robot-friendly environments by addressing these challenges. For instance, ensuring spacious layouts, installing ramps instead of stairs, and minimizing clutter can enhance the robot's navigation and interaction capabilities. In addition, signage and markers tailored to the robot's sensors and navigation systems can further improve their operational efficiency.

User-friendly organizational context. Adopting RGs also requires providing a user-friendly environment to facilitate the integration of robots (Tan et al., 2016). This would include visitor education, employee training, and establishing robust support systems. Informing visitors about the robot's functionalities and role within the organization can allow setting clear expectations and reduce user anxiety. Employee training programs can ensure that staff members are adequately prepared to interact with, manage, and maintain the robots effectively. These programs should address both technical aspects, such as troubleshooting and operation, and non-technical considerations, such as understanding the robot's behavioral patterns and communication methods.

Maintenance routines and protocols for resolving emergencies, such as system malfunctions or user safety concerns, should also be established to ensure the seamless operation of GRs. Organizations must adopt a proactive approach, soliciting user feedback and continuously refining their workflows to integrate GRs effectively (Turja et al., 2020). By fostering a supportive environment and emphasizing collaboration between human staff and robots, organizations can maximize the potential of GRs while mitigating resistance to technological adoption.

2.4 Self-efficacy

As robots become integrated in human environment, it is crucial to evaluate the interaction between robots and people to ensure that robots remain effective, acceptable, and useful to people

(Chaminade & Cheng, 2009).Various criteria have been proposed to be considered as a basis for assessment, for instance, anthropomorphism, behavioral realism, sociability, warmth, competence, emotional acceptance, agency, human-likeness, communication quality and nonverbal behavior (Mandl et al., 2022; Spatola et al., 2021; Leoste et al., 2024). Other aspects include attitudes towards technology (Savela et al., 2022) and trust in technology within specific contexts (Pinto et al., 2022) as well as the confidence of an individual in their ability to control robotic technologies (Rosenthal-Von Der Pütten & Bock, 2018), i.e., user self-efficacy (Bandura, 1977).

An increasing number of studies apply robot users' self-efficacy as a criterion for assessing the level of readiness to accept robots (e.g., Lin et al, 2024; Liao et al., 2023). Self-efficacy, defined as the belief of an individual in their ability to perform specific tasks in a specific environment (Bandura, 1986), is particularly important in the context of various SSRs, where the users must feel confident in their ability to interact effectively with robots (Robinson et al., 2020).

Self-efficacy, a term coined by Albert Bandura (1977, 1986, 1997), refers to an individual's belief in their abilities in a particular context or domain. It is a person's subjective assessment of their ability to perform tasks or achieve goals in specific situations. According to Bandura (1997), *"The stronger the perceived self-efficacy, the higher the goal challenges people set for themselves and the firmer is their commitment to them*." Bandura's social cognitive theory (2005) emphasizes that self-efficacy influences people's choices, their efforts, their resilience to challenges, and the outcomes they expect. Unless people believe they can produce desired effects by their actions they have little incentive to act or to persevere in the face of difficulties (Bandura, 2018). High self-efficacy can lead to greater engagement and persistence, resulting in better performance and satisfaction (Heslin & Klehe, 2006). For HRI, users with higher self-efficacy are more likely to have positive relationships with robots, adapt more quickly to new technologies, and use robots more effectively performing particular tasks.

Self-efficacy plays a crucial role not only in shaping users' initial willingness to engage with robots but also in influencing their long-term adoption, satisfaction, and overall experience with these technologies. As Li et al. (2022) aptly note, "*Self-efficacy helps determine how much effort individuals expend on an activity, how long they persevere when confronting obstacles, and how resilient they are in the face of unfavorable situations, which overall influence an individual's thought patterns.*" This underscores how self-efficacy impacts both the practical and emotional dimensions of HRI. In our research, we deliberately employed self-efficacy as an integral indicator to evaluate not only users' ability to effectively navigate tasks with GRs but also their subjective well-being during such interactions. By focusing on self-efficacy, we aimed to capture a holistic image of users' competence, resilience, and satisfaction while using GRs, offering valuable insights into both individual and organizational perspectives.

User self-efficacy is a pivotal factor influencing GR integration. Higher self-efficacy among users correlates with greater trust, engagement, and willingness to adopt robots, addressing the need for training programs that demystify robot functionality and mitigate technophobia (Bandura, 1986; Robinson et al., 2020).

Robinson et al. (2020) have developed a robot self-efficacy scale to assess people's confidence in interacting with robots. Their study found that robot-delivered instruction increased participants' self-efficacy, agreeableness, and willingness to interact with robots. Similarly, Leoste et al. (2024)

investigated how the nonverbal behavior of social robots affects user perceptions and self-efficacy, finding that appropriate nonverbal cues can increase user trust and satisfaction. The research by Kennedy et al. (2017) and Belpaeme et al. (2018) have highlighted the importance of social feedback and cultural context when interacting with robots, especially in educational settings.

Following the TELIP model, introduced by Leoste et al. (2021), the robot users' self-efficacy in organizational contexts is shaped by different factors that, in principle, can be grouped into three categories: technical factors (the robots' technical aspects); organizational factors (the readiness of an organization and its robot use scaffolding); and user-related factors (users' expectations for collaboration with robots). The adaption or robots in an organization is also influenced by several barriers, typically categorized into technical, ethical, and social dimensions, each presenting unique obstacles that hinder the integration of these robots into everyday workflows (Bražnikova et al., 2024; Vincent, et al., 2015; Turja et al., 2019a).

2.5 Organizational value of social robots

From an organizational perspective, the value of integrating GRs in organization's workflows transpires across three main dimensions: operational efficiency, enhanced user satisfaction, and strategic branding. Operationally, GRs improve workflow reliability and scalability, particularly in high-traffic environments, such as museums, universities, and healthcare facilities (Maniscalco et al., 2024; Van Wynsberghe, 2016). Their ability to consistently perform routine and repetitive tasks offers a clear value proposition by freeing human staff for higher-level responsibilities and reducing operational bottlenecks.

In addition to operational benefits, GRs contribute significantly to increasing user satisfaction through improved quality of interaction. (Ogle & Lamb 2019; Ruggiero et al. (2022), in their field study of service robots in fast-casual dining, demonstrated how these robots contribute to utilitarian value and positively influence customer loyalty. Similarly, Belanche et al. (2020) found that service robots enhance customer experiences by providing consistent and efficient service, thereby bolstering an organization's innovative image. This dual benefit of operational efficiency and improved customer interaction underscores the strategic importance of GRs in modern organizations. However, successful implementation of GRs depends on overcoming technological and organizational challenges. Technological limitations, such as navigation issues, communication barriers, and hardware malfunctions, can undermine user trust and satisfaction, directly affecting the robots' perceived reliability and users' self-efficacy. For example, user discomfort with technical glitches can diminish trust in the robot, reducing both the user's willingness to engage and their collaborative effectiveness. From an organizational standpoint, supportive work culture is vital to facilitate the integration of robots in workflows. This requires employees to embrace professional changes and for organizations to foster an environment that encourages technological adaptability (Turja et al., 2019).

Research on the adoption of GRs has been usually carried out in controlled experimental settings where participants voluntarily engage with robots, frequently in a playful manner or following low-stakes scenarios. While these studies provide valuable insights, they fail to capture the complexities of real-world organizational contexts where interaction with robots is often mandatory. In such environments, users are compelled to engage with GRs to complete specific tasks or achieve particular goals. Studies suggest that user self-efficacy and the effectiveness of collaborations decline significantly in uncontrolled, real-life settings. For instance, students and faculty members interacting with robots in higher education report high self-efficacy in experimental setups (Leoste et al., 2024), but this confidence diminishes in real-world settings, such as hospitals or offices (Hung et al., 2019; Lee, 2021).

Additional challenges in real-world settings include trust issues, communication breakdowns, and technical failures, which negatively impact users' perceptions of robots' reliability (Turja et al., 2019a; Vincent et al., 2015). Ethical considerations, such as concerns regarding dignity, privacy, and autonomy, are also critical. Addressing these issues requires transparent policies and guidelines being in place to ensure that the integration of robots aligns with ethical standards and user expectations (Sharkey & Sharkey, 2012; Sorell & Draper, 2014).

3 Empirical studies

To achieve the aims of our research project, two empirical studies were conducted in Estonia. In the first study, the self-efficacy of GR users was assessed both in real-life and experimental situations. The second study consisted of interviews with representatives of three stakeholder groups: GR distributors, end-users, and organizational administrators responsible for integrating GRs in organizational workflows, aiming at mapping practical steps of the process and identifying further actions that might facilitate better integration of GRs into organization's everyday work routines.

Taking into consideration that some of the most important criteria for assessing the suitability of GRs for performing their expected tasks are related to their perceived user-friendliness (i.e., how simple, pleasant, and useful their interaction with robots is perceived to be), the first study aimed to assess the users' subjective self-efficacy in using GRs. In addition, the study examined whether self-efficacy ratings depend on the users' gender, age, and prior experience with robots. We also sought to determine whether self-efficacy is influenced by the nature of the setting of using GRs, being either experimental (controlled) or real-life (uncontrolled).

The second study aimed to collect the GR users' assessments of the process of using GRs, as well as the views of GR distributors and those responsible for the adoption of robots. The goal was to map key barriers to GR adoption in public spaces from the perspectives of different stakeholders and to formulate recommendations for the stakeholders involved in GR adoption to address these challenges and improve the integration of GRs into their operational environments.

3.1 Study 1. Self-efficacy of guide robot users

3.1.1 Research questions

In this study, we sought to answer two research questions (RQs) related to the self-efficacy of GR users:

RQ1: How do GR users assess their self-efficacy, and does this assessment depend on their gender, age, and previous experience with robots?

RQ2: Does users' self-efficacy differ in situations where they are using GR controlled or uncontrolled life situations?

3.1.2 Instrument

Although there are other instruments for assessing robot users' self-efficacy (e.g., the RUSH-3 scale by Turja et al., 2019b), these are not taking into account the use of GRs in public spaces. Therefore, we had to construct a new scale, recording the GR user's assessments of their self-efficacy in the indoor public areas of an organization. While developing the scale, we followed Bandura's (2006) guidelines to ensure that the scale was context-specific ("*self-efficacy measures should be tailored to the selected domain rather than cast as a one-size-fits-all trait*"), reflected the construct ("*efficacy items should accurately reflect the construct... Perceived self-efficacy is a judgment of capability to execute given types of performance*"), and was empirically validated ("*Pretest the items. Discard those that are ambiguous or rewrite them...*") (Bandura, 2006, 312).

Accordingly, our *Guide Robot User Self-Efficacy Scale* (GRUSES) was developed in three steps: (1) *Expert panel*: the panel of three experts proposed an initial 17-item questionnaire that assessed self-efficacy while using GRs; (2) *Pilot testing and refinement*: a pilot survey was conducted (N = 28), ambiguous statements were reworded and one statement was added; (3) *Validation and administration*: the validation process included factor analysis and reliability testing, leading to the emergence of the 9-item GRUSES scale (see Appendix 1).

The questionnaire (Appendix 1) used in this study included GRUSES and information about the respondents' gender, age, and previous experience with robots. 7-point Likert scales were used to evaluate the efficacy statements.

3.1.3 Study design

GR users' self-efficacy was assessed in two situations to evaluate the participants' experiences and self-efficacy when using the TEMI v3 guide robot: controlled environments and uncontrolled real-life situations. These settings were designed to capture differences in user interactions and perceptions based on the context in which the robot was deployed. However, both controlled and uncontrolled settings were located in host organizations' premises, as opposed in a simulated lab environment.

Controlled environments. In the controlled environment, the participants performed tasks under the guidance of researchers. The interaction followed a predefined scenario where the participants were instructed step-by-step on how to use the robot. They were informed about the tasks, such as selecting the language of communication, choosing the robot's destination, and completing actions such as calling the secretary or accessing information through the robot's interface. This setup allowed the participants to explore the robot's functionalities in a structured and supportive setting, ensuring clear guidance was available throughout the process. Importantly, the controlled environment emphasized the voluntary use of robots, as the participants were aware that they could complete the tasks with the help of the robot but were not strictly required to rely on it.

Uncontrolled environments. In an uncontrolled environment, the GR was performing practical tasks without direct assistance from the researchers. The robot was stationed in a public area and waited for visitors with an animated face. When a person approached, the robot greeted them and activated the user menu. The participants independently selected the communication language and their desired destination from the menu. After the destination was chosen, the robot provided instructions and guided the participant to the selected location. Once the robot reached the destination, it announced the completion of the task, wished the participant goodbye, and returned autonomously to its starting position. Thus, in the uncontrolled environment, the participants were obliged to follow a predefined scenario of interaction, where the successful completion of the task depended entirely on their ability to use the robot effectively. After the participants had finished their activities with the robot, they were asked if they were willing to fill in the feedback questionnaire and if they had time to do it. Researchers observed the interactions and collected feedback through a questionnaire at the end of the session.

Key differences from the user perspective. From the participants' perspective, the key distinction between the two modes appears on the level of the provided guidance and the participants' autonomy. In the controlled environment, the presence of researchers and the voluntary nature of robot use allowed the participants to feel supported, thus potentially reducing stress. In contrast, the uncontrolled environment required the participants to rely solely on the robot while completing the assigned task, creating a more autonomous yet potentially challenging interaction experience. The latter appears as a situation that models the use of robots in an organization's everyday operations as opposed to conducting an experiment in a controlled setting. The dual-mode approach allowed the study to develop a comprehensive understanding of how the context influences user self-efficacy, trust in technology, and user experience while interacting with GRs.

3.1.4 Procedure

The experiments were conducted from December 2023 to May 2024 in six different public areas. Five experiments were carried out between December 2023 and February 2024 in various relevant environments: on the first floor of the Ülemiste City office building, on the administrative floor of the IT College at Tallinn University of Technology, at the sTARTUp Day fair in Tartu, at the TalTech conference at Mektory, and at the Industry 5.0 conference in Tartu. Two additional experiments took place between March and May 2024 in uncontrolled environment: on the first floor of the Ülemiste City office building and at the Academic Library of Tallinn University of Technology.

The experiments consisted of three distinct steps (1-3 for controlled and 2-3 for uncontrolled experiment), designed to assess the participants' self-efficacy in interacting with GRs and to capture user responses, enabling the researchers to compare user experiences across controlled and uncontrolled settings.

Step 1: Preparation. Before the controlled experiment commenced, the researcher provided detailed instructions to each participant. These instructions outlined the sequence of actions they would need to perform during the interaction with the robot. The tasks included approaching the robot, selecting the communication language and destination, navigating to the chosen destination, selecting the secretary's location from the house manager's menu, initiating a call to the secretary through the robot, accessing the institution's website on the robot's screen, navigating to the relaxation area, and concluding the interaction. Once the participant confirmed their readiness, they approached the robot, which was positioned along the corridor wall.

Step 2: Interaction. The interaction (Figure 2) began when the robot detected the participant within its field of view at an angle of 90 degrees at the distance of one meter or closer for at least two seconds. The robot displayed a curious expression on its screen, greeted the participant with an animated face, and activated its menu. The participant was informed about the available menu options and the possibility of changing the communication language.

Figure 2. Experimental setup.

After the participant made a menu selection, the robot provided step-by-step information regarding the subsequent actions. For instance, it instructed the participant to choose a destination from the menu, follow the robot to the destination, initiate a call, wait 30 seconds during the call, and then end the call. Participants could also perform other tasks, such as filling out a questionnaire or accessing the institution's website on the robot's interface. If the participant paused for more than 10 seconds or failed to interact, the robot politely said goodbye and returned to standby mode. This stage aimed to simulate real-world interactions and evaluate how the participants navigated tasks with the robot's assistance.

Step 3: Feedback collection. After completing the interaction with the robot, the participants were asked to provide feedback through a paper-based questionnaire. The questionnaire captured their experiences, perceptions, and self-efficacy ratings. The researcher observed the interaction throughout and ensured that all feedback was collected. Once the questionnaires were completed, the researcher digitized the responses using Microsoft Excel for further analysis.

3.1.5 Robots

For conducting the experiments, we used a semi-autonomous social service robot TEMI v3 (Figure 3). The TEMI robot is an AI-assisted robot that offers various functions, such as voice recognition, pre-set location recording, autonomous navigation, and human-robot communication capabilities. These includes nonverbal behaviors, such as expressive facial animations on the screen, responsive movements, and appropriate proxemics (Leoste et al., 2024). A crucial aspect of TEMI's functionality is the TEMI Center Pro service, which is necessary to unlock the robot's full capabilities. This includes features such as room mapping, mobile app integration, Alexa/Hey functionality, video calls, and much more. TEMI Center Pro is essential for various applications, thereby enhancing the overall user experience. TEMI robot also has the capability to act as a telepresence robot, enabling remote participation via the robot and functioning as a personal AI assistant, autonomously interacting with people and performing simple tasks (Leoste et al., 2024).

Figure 3. TEMI v3 robot (left) and its main components (right).

3.1.6 Sample

Participants were recruited from among university students and staff, healthcare professionals, and public event participants who interacted with the robot following a specific scenario where the robot acted as a GR. A total of 226 individuals participated in the study, out of which 110 were men and 106 were women. 10 participants did not indicate their gender. The participants were divided by age groups: up to 30 years old (N = 78), 31-50 years old (N = 108), and 51 and older (N = 30). The participants' previous experience with robots varied from no experience (N = 103) to frequent users (N = 9). The experiment was conducted with 144 participants in a simulated environment and 82 participants in a real-life environment.

3.1.7 Ethics

Written consent was obtained from all participants before the experiment. The participants signed a consent form, stating that no personalized data would be collected. The form also stated that all photos would be blurred for research purposes, and videos would be deleted after analyzing observation data. As no personalized data was collected and no vulnerable people were involved then, according to national legislation, the ethics committee permit was not required.

3.1.8 Results

Psychometrics of the GRUSES scale. The descriptive statistics of the 9-item GRUSES measure indicate some positive bias while assessing self-efficacy in using the GR, with means of the single items ranging between 4.68-5.77. Descriptive statistics for the GRUSES items are presented in Table 1.

Confirmatory factor analysis indicates three underlying factors (dimensions) of this scale (Table 1). We categorized them as follows: (1) *Comprehensibility* (items 1-3), evaluating how understandable and straightforward interacting with the robot is for the users; (2) *Effectiveness* (items 4-6), assessing the perceived efficiency and speed in accomplishing tasks with the robot;

and (3) *Subjective pleasantness* (items 7-9), measuring comfort, safety, and enjoyment during interactions.

Table 1. GRUSES measure items descriptive statistics.

Item	Mean	Min	Max	Std. Dev.
1. Complexity	5.75	2.00	7.00	1.07
2. Understandability	5.77	2.00	7.00	1.10
3. Confidence	5.26	2.00	7.00	1.38
4. Effectiveness	5.29	1.00	7.00	1.10
5. Comfort	5.44	2.00	7.00	1.14
6. Speed	4.68	1.00	7.00	1.26
7. Safety	5.56	2.00	7.00	1.04
8. Reliability	5.29	2.00	7.00	1.13
9. Pleasantness	5.60	2.00	7.00	1.17

The subscales demonstrated acceptable internal consistency, with Cronbach's alpha values ranging from 0.76 to 0.81. The overall GRUSES measure had a Cronbach's alpha of 0.89, indicating high reliability of the scale. At the same time, high inter-correlations among the three subscales (ranging from 0.60 to 0.69) suggest that it is appropriate to use the GRUSES measure rather than focusing on individual subscales.

Based on the results of the GRUSES survey, RQ1 and RQ2 were answered as follows.

RQ1. How do GR users evaluate their self-efficacy, and does their evaluation depend on their gender, age, and previous experience with robots?

As already mentioned, the overall evaluation of self-efficacy was comparatively high, users consider themselves able to manage the robot and enjoy their interaction with the GR. According to the t-test, male participants reported higher self-efficacy ($M = 5.56$) than female participants ($M = 5.22$), with the difference being statistically significant ($t(213) = 2.92$, $p < 0.01$).

Also, younger participants exhibited higher self-efficacy scores compared to older participants. Using the one-way ANOVA test, a significant difference in scores was detected between younger (up to the age of 30 years) and older (51 years and older) respondents, $F(2, 42) = 6.42$, $p < 0.05$.

As expected, participants with a prior experience of using robots reported higher self-efficacy ($M = 5.69$) than those without previous experience ($M = 5.09$). A comparison between experienced and inexperienced users also showed a significant difference ($t(219) = 3.47$, $p < 0.01$).

RQ2. Does users' self-efficacy differ in controlled situations compared to uncontrolled situations?

Participants reported higher self-efficacy when interacting with the robot in controlled environments ($M = 5.68$) compared to uncontrolled environments (Mean = 5.05), with the difference being statistically significant ($t(219) = 4.91$, $p < 0.01$). This pattern was consistent across the GRUSES measure as a whole and within each subscale, indicating that the situational context significantly influences users' self-efficacy.

3.2 Study 2. Adoption of guide robots in organizations: barriers and possible improvements

3.2.1 Research questions

This study had two aims. The first aim was to identify the barriers hindering the effective integration of GRs into the everyday workflows of an organization, identifying users' and administrators' expectations regarding their interactions with a GR, but also to determine what measures could be taken to improve user engagement and satisfaction, ultimately ensuring the wider adoption of GRs. Specifically, we sought answers to the following research questions (RQs):

RQ3: What are the expectations for GR features, and in what direction should GRs' capabilities, skills and qualities be developed to ensure their better integration into an organization's workflow?

RQ4: What are the main barriers that currently limit GR user effectiveness in a workplace context? What are the users' behavioral expectations for a GR?

RQ5: What are the potential application areas of GRs in organizations? What tasks could GRs potentially perform, and what roles or jobs could be entrusted to them? How should organizations adjust themselves to the new workforce of GRs?

3.2.2 Instrument

Semi-structured interviews with representatives of three groups of individuals was used as the method to answer our research questions : (a) end-users of GRs: library, hospital and care facility employees, and office workers who interacted directly with the robots; (b) administrators of organizations: heads of departments and decision-makers responsible for the implementation of robots into the workflows of their organization; and (c) retailers and suppliers: representatives of companies selling or renting GRs.

The interview designed for users and administrators aimed at understanding the role, user-friendliness, and developmental needs of GRs within organizations. Participants reflected on the tasks GRs are suited for, identifying activities unsuitable for robots and envisioning their future role within the organization. Discussions covered the user-friendliness of GRs, including the appropriateness of their use by different employees and visitors, user concerns about current models, and fears like technophobia and privacy issues. The importance of training and support services was highlighted to encourage acceptance. Regarding development, participants highlighted technical and organizational barriers, proposed solutions, and outlined desired additional skills and functionalities for GRs. Finally, participants were invited to describe their vision of an "ideal robot," detailing how it should differ from current models to enhance effectiveness and user satisfaction.

The second aim was to gather knowledge regarding the users' behavioral expectations, including robot's non-verbal behavior. Participants reflected on how certain aspects such as body language, movement speed, distance, facial expressions, and gestures influenced their confidence and trust in the robot. Discussions also centered on improving behavioral patterns to enhance user confidence and cooperation, identifying specific aspects that could be refined for better interaction. Looking toward future developments, participants considered ways to improve GRs' behavioral patterns to increase user satisfaction and expand the robot's role in organizational workflows. Topics included the prospects for robots to engage in physical touch, the importance of adhering to cultural norms, and the need for user training on key aspects of robots' non-verbal behavior.

The interview with distributors focused on post-sale communication, factors promoting wider adoption, and obstacles to the inclusion of guide robots (GRs) in organizational workflows. Participants described how communication occurs after the sales process, including the training offered, common customer questions, and the support provided for integrating GRs into specific tasks. Discussions covered ways to increase GR adoption by improving robot design to better meet customer expectations, enhancing functionality, and making robots more understandable. Suggestions included training programs to reduce technophobia, improved instructional materials, and strategies for seamless integration into daily workflows. Participants also analyzed obstacles to GR inclusion, such as technical issues, environmental or cultural barriers, reluctance stemming from mistrust, and user discomfort. They proposed solutions to address these challenges and encourage greater use of GRs in organizational settings.

3.2.3 Sample

The interviews, aimed at understanding the role, user-friendliness and development needs of GRs in organizations, and to gather knowledge about how the robot's non-verbal behavior affects the users' self-efficacy or the acceptance of the guide robots, were attended by representatives of robot retailers and organizations where a social service robot had acted as a guide robot. A total of 26 participants were interviewed from various organizations such as hospitals, nursing homes (Tartu University Clinic, East-Tallinn Central Hospital Nursing Clinic, East-Tallinn Central Hospital, Pihlakodu nursing home), university (Tallinn University of Technology IT College), library (Tallinn University of Technology library) and corporate public spaces (Ülemiste City).

3.2.4 Procedure

Interviews were conducted from June to December 2024. Participants were invited by e-mail, explaining the purpose of the interview and the use of collected data. The interview started with not recorded part where the interviewee was asked for consent to participate and to publish. The interviews lasted 35-45 minutes, either in person or via e-channels. Interviews were audio recorded with the consent of the participants and transcribed using a paraphrased transcription. Two interviews were conducted in writing. An open-ended interview protocol was used to explore participants' experiences, perceptions, and propositions related to GR.

3.2.5 Data analysis

We used thematic analysis (Braun & Clarke, 2006) to systematically identify, analyze, and present patterns within the data. This method offered a rich, detailed, and nuanced understanding of participants' experiences, allowing us to explore both explicit and underlying themes in depth. The process began with familiarization, where two independent coders thoroughly read and re-read the recorded texts to immerse themselves in the data. The next step involved generating initial codes. Coders systematically highlighted relevant segments of text, assigning descriptive labels that captured the essence of each data fragment. These codes were then reviewed and refined through discussions between the researchers to ensure clarity and consistency. Regular meetings and consensus-building sessions between the coders enhanced reliability and helped resolve discrepancies in interpretation.

Table 2. Identified codes and themes.

Category	Sub-Theme	Description
Technical Capabilities	Technical Reliability	Ensuring reliable, malfunction-free operation of GRs.
	Smooth Navigation	Facilitating effective movement through various physical environments.
	Language/Communication Interface	Providing user-friendly interaction in the preferred language and intuitive interface.
	Customization to Tasks	Adapting GR functionalities to specific tasks and user needs.
User's Expectations	Privacy	Ensuring that GR interactions respect personal data and intimacy.
	Proxemics	Maintaining appropriate spatial distance and positioning in user interactions.
	Gaze	Orienting visual sensors respectfully, making appropriate eye contact.
Organizational Arrangements	GR Role in Organizational Workflow	Defining clear roles and responsibilities for GRs within workplace processes.
	Customized Infrastructure	Adjusting the physical setting to accommodate GR operations (e.g., space, signage).
	Training and Support	Offering adequate preparation, instruction, and ongoing assistance to users and staff.

Once coding was completed, the researchers moved on to theme development. Codes were grouped into broader categories based on patterns and relationships within the data (Table 2). Themes were iteratively refined to ensure they were both distinct and representative of the data set as a whole. This involved reviewing themes against the coded data and the original transcripts to ensure alignment and accuracy. Next, the three broader categories of codes are described:

Technical Capabilities. This category focuses on the challenges posed by the current design and functionality of GRs. Participants repeatedly cited reliability issues, such as frequent malfunctions and instability, which led to frustration and reduced trust in the technology. Navigation challenges were also significant, with GRs struggling to operate in environments with narrow foyers, uneven floors, and obstacles like carpets and thresholds. A lack of language support and intuitive user interfaces further alienated users, particularly those unfamiliar with advanced technology. To address these limitations, participants suggested developing more natural nonverbal communication capabilities and ensuring GRs are customizable to fit specific organizational needs.

Users' expectations. The final category captures the barriers stemming from user perceptions and readiness. Many participants described technophobia as a significant obstacle, with some users avoiding GRs altogether out of fear of making mistakes or damaging the equipment. Privacy concerns also emerged prominently, with users hesitant to engage with GRs due to fears of surveillance and data misuse. Proxemics, or the robot's ability to maintain an appropriate physical distance, was highlighted as crucial for user comfort. Participants noted that distances of around one meter were generally well-received, while closer proximity could feel intrusive, and further distances diminished the sense of engagement. Dynamic adjustments to maintain this ideal distance were especially valued in crowded environments. Similarly, the robot's gaze played a significant role in building trust and fostering connection. Eye contact, or the appearance of the robot "looking at" the user, was perceived positively, as it reduced uncertainty and made interactions feel more natural. Participants emphasized the importance of training and support mechanisms to improve user confidence and self-efficacy, suggesting tailored programs and ongoing assistance to address these issues.

Organizational Arrangements. Barriers in this category arise from the interplay between GRs and workplace dynamics. Participants highlighted the limited integration of GRs into workflows, leading to underutilization and unclear responsibilities. Organizational resistance was another key theme, driven by staff fears of job displacement and discomfort with adapting to new technologies. Environmental compatibility issues, such as buildings not designed for robot navigation, compounded these challenges. Operational challenges, including insufficient support for maintenance and troubleshooting, further hindered the long-term adoption of GRs.

3.2.6 Results

RQ3: What are the expectations for GR features; in what direction should GRs' capabilities, skills and qualities be developed to ensure their better integration in an organization's workflow?

Participants identified several areas for improvement to enhance GR functionality and integration. Enhanced language support was a recurring theme, with one participant noting, "*Better language support, improved SDK to control the robot functions, more standards*" [P6].

Advancements in facial expressions and gestures (Figure 4) were also seen as critical for creating more engaging interactions: "*Develop robots with a friendlier and more human-like appearance and behavior, making them more pleasant and less intimidating to users*" [P8] or *"A smiley face or a questioning look on the screen helps build trust"* [P20]. For the interviewees, it was important that the robot could make animated expressions such as smiling or raising eyebrows, or that the robot could establish eye contact: *"I liked it when the robot moves the screen, so it looks like it's looking at you"* [P21].

Figure 4. TEMI emotions.

Customization and modularity were also highlighted as priorities. Participants emphasized the need for robots tailored to perform specific tasks, operate in different environments, and allow adjusting user preferences: "*Users should be able to easily customize the robot's appearance and behavior. Modular design allows for easy addition or replacement of components*" [P8]. The distributors highlighted that language models are important and that the robot should be able to communicate with users in their native language: "*... quite often a customer's wish is that I want a robot attendant that speaks Estonian*" [P2].

There are several categories of barriers that must be addressed in order to improve GR users' self-efficacy. Technological barriers included frequent malfunctions, limited navigation capabilities in complex environments, and insufficient (nonverbal) language support. For example, one participant remarked, "*These products are so raw; they are not ready*" [P2]. The user interface design was also criticized for being unintuitive, which reduced accessibility for less tech-savvy users.

RQ4: What are the main barriers that currently prevent users to be effective in using GRs in a workplace context? What are the users' behavioral expectations for a GR?

Among user-related issues, technophobia, fear of making mistakes, and privacy concerns were mentioned. Some users hesitated to interact with robots due to a lack of confidence: "*Some people have a fear of technology. They are afraid of touching things they do not know*" [P12]. Privacy concerns further discouraged users, with participants expressing unease about surveillance and data security: "*People said, 'No, I do not want to interact with it because I don't know who's watching from inside or who's monitoring'*" [P9].

Context dependent proxemics issues were raised. Tasks requiring contact demanded closer proximity: *"The robot could come closer to allow pressing the screen but kept a greater distance between customers"* [P24]. Users emphasized the importance of proactive adjustment of distance when people approach quickly, particularly in crowded environments: *"The robot should be able to quickly assess how to pass a person in space"* [P24]. The interviewees mentioned considering cultural norms as an important aspect in improving the adoption of GRs. Inability to adapt to cultural norms, such as maintaining personal space or respecting social customs, could hinder the acceptance of a GR. "*It must be taken into account. It causes discomfort when you have to change your habits, and it limits the use"* [P23].

The interviews revealed the users limited prior expectations for GRs' non-verbal behavior. To better understand the GR's behavior, some respondents recommended offering a short training session on robots' non-verbal behavior and felt that, in addition to the technical manual, there should also be a manual for better understanding the robot's behavioral patterns. To accelerate establishing effective HRI, the participants expressed a need for training before using a robot: *"I would even expect prior training or instructions"* [Katrin A], or *"The robot could say: I'll tell you about myself. How I behave, move, why I do something, etc. What should you consider when communicating with me? What I can do better, but where I still need to practice"* [P23].

The participants were asked for their views on a robot possibly touching them at some future point. The respondents expressed the opinion that a robot should not touch a person: "*I don't dare shake the robot's hand, because I know that there is no human brain but a machine.*" [P20]. Instead, the situation where the robot offers a person the opportunity to touch itself was found more acceptable: *"It's not that it holds on, but the robot could have a place to lean on, if you wish. It offers the possibility to lean on, rather than holding on"* [P26].

RQ5: What are the potential application areas of GRs in organizations? What tasks could GRs perform, and what roles or jobs could be entrusted to them? How should organizations adjust themselves to a new workforce like a GR?

Our findings revealed that GRs are comparatively well-suited for performing routine and repetitive tasks that require minimal emotional intelligence or decision-making capacity (Figure 3). Commonly suggested roles include guiding visitors, providing information, managing logistics, and assisting with inventory tasks. For instance, one participant noted, "*Robots are well-suited for performing repetitive and routine tasks, such as serving food/snacks in restaurants/events*" [P8]. Another participant suggested, "*If TEMI could guide the reader to the exact spot, say, 'Look here, and there's your book,' that would be great*" [P12]. A third participant's suggestion was *"While the human is waiting, the robot might say: 'Take out these documents that need to be submitted'"* [3]. However, GRs were seen as unsuitable for tasks requiring empathy or complex problem-solving, emphasizing the importance of clearly defining their roles within organizations.

Organizational factors such as resistance from the part of staff members and unclear procedures were highlighted. Some staff members expressed fears of increasing workloads or even a job loss, with one person stating, "*The receptionists did not want to show their faces during calls... The employee should understand that TEMI helps them*" [P9]. Privacy and security improvements were considered essential for building user trust. Transparent data collection practices and robust security measures were also recommended: "*Transparency about data collection is necessary to alleviate fears*" [P9].

There were different opinions regarding the speed of movement of the robot. However, the interviewees agreed that the speed of movement depends on the task being performed*: "There are different opinions in the hospital. There are those who thought it moved too slowly. Since it was necessary to reach a different ward quickly, the robot was too slow. But if it moves in such a way that it doesn't have to follow orders but just patrols, then it can move at a leisure pace"* [P26].

As a new suggestion for a potential further development, the robot's ability to notice anomalies in human behavior and offer assistance was added. For example, in large buildings (hospitals, universities) where a person does not necessarily know where to go or is confused when entering, a robot could approach them and offer assistance : "*A person does not understand, they can go to* *the robot by themselves, but a robot perceives that they are standing there and looking at some board for 3 minutes and then goes and asks itself if it can help"* [P20].

Figure 5. TEMI V3 robot working in TalTech library.

4 Discussion and recommendations

Growing shortage of skilled workforce is a significant challenge for the European labor market (Thrun et al., 2000; Degeurin, 2024). One potential remedy to this might be a wider adoption of robots. Yet, current practice shows that simply selecting and purchasing robots would not be sufficient; integrating robots in organizational workflows is a long and complex process hindered by various obstacles and challenges. The aim of our research project was to explore the nature of this process and identify interventions with the potential to support the adoption of guide robots in organizations. In addition, we sought to determine factors that might improve the self-efficacy of robot users and increase organizations' readiness to use robots as a substitute for human labor in certain tasks.

Our first study suggests that demographic factors such as gender and age, as well as prior exposure to technology, shape users' self-efficacy. This aligns with some previous studies (Czaja & Lee, 2007; Lattikka et al., 2021; Rakic et al., 2020) and suggests that while adopting GRs, it is important to consider the characteristics of the involved user groups and their previous experience in interacting with robots.

Most significantly, we found that users' self-efficacy significantly decreased when transitioning from a controlled/experimental scenario to a real-life situation where the use of GRs was unavoidable or mandatory. The optimistic conclusion drawn in many previous empirical studies regarding "high interest and acceptance of robots" is likely to lose its validity in real-life situations.

Analogous differences between user experience in experimental and real-life situations have been described by other researchers, noting that users demonstrate higher self-efficacy in controlled settings due to the predictable nature of the environment and the availability of support (Hung et al., 2019; Lee, 2021). The realization that trying GRs "for fun" and using them in the context of routine workflows lead to significantly different user experiences was also one of the starting points of our second study.

The aim of the second study was to identify barriers to effective integration of GRs in organizational workflows with the aim to determine whether adjusting the robot's behavioral patterns might contribute towards increasing user confidence and a more efficient use of robots. The results of the study allow drawing important recommendations for a more successful adoption of GRs in organizational settings.

A key finding from the study was that user self-efficacy plays a critical role in the successful integration of GRs, most likely because users with higher self-efficacy are more inclined to trust robots and operate them with a greater skill. Similarly, low self-efficacy is likely to strengthen existing barriers, such as resistance to adopting new technologies. Fear of making mistakes also appears as a likely cause of a reluctant attitude towards adopting robots, particularly in situations where no alternative is available. Another important conclusion was that improving some of the key features of robots, such as gestures, facial expressions, emotional expressions, the tone and speed of speech, patterns of movements, and social gestures, supports user's self-efficacy and increases their trust in robots. This helps the user feel more comfortable while operating the robot, having a positive effect on integrating GRs in organizational workflows. Our respondents emphasized that tailored training and availability of support mechanisms are essential to building confidence and ensuring a positive user experience. These findings underscore the importance of designing GR-systems that not only address technical and organizational challenges but also actively support users in developing their self-efficacy. Similar suggestions have been made also by Turja et al. (2020).

Some of the recommendations derived from the two studies and suggestions to various stakeholders in adoption of GRs are as follows.

Recommendations to GR manufacturers and distributors. Manufacturers should focus on simplifying user interfaces, providing intuitive and user-friendly designs, and incorporating full language support for better accessibility in diverse settings (see also Leite et al., 2013). Enhancing nonverbal communication capabilities, including culture-specific gestures and facial expressions, is essential to creating robots that align with human social norms and expectations. Proxemics algorithms should also be improved to ensure robots maintain appropriate distances, thereby increasing user comfort (suggested also by Takayama & Pantofaru, 2009).

Proxemics and gaze have a profound impact on human-robot interaction, shaping user comfort and engagement. Maintaining an optimal distance of approximately one meter was perceived as neither intrusive nor disengaging, while effective gaze behaviors (maintaining eye contact or orienting visual sensors toward the user) help foster a sense of connection and trust. Our findings regarding such preferable behavioral features align with the findings by Takayama and Pantofaru (2009), which emphasize the importance of robots mirroring human spatial norms to enhance social interaction and user confidence.

Distributors and retailers should introduce after-sale support programs, including updates on software improvements related to robots' nonverbal behaviors. Collecting clients' feedback on their specific needs and challenges is also essential. By communicating user feedback to developers of robotic technologies, distributors can contribute towards further product development.

Manufacturers should make available services such as user training, robot behavior customization, and technical support to improve the adoption of robots. Emphasis should be placed on modular designs of robots and improved nonverbal communication capabilities to enhance their usability and improve human interaction with robotic equipment.

Addressing the specific aspects of desired technological improvements, training, privacy considerations, and advanced nonverbal communication can help robot manufacturers, distributors, and organizational stakeholders working together to improve GR integration in workflows of a wider variety organizations. It appears that the initial adoption of guide robots might be more feasible in larger organizations with high-volume workflows, as smaller organizations may find the related investment less cost-effective in the absence of further external incentives, such as for example government supported pilot projects.

Recommendations to guide robot users. Users should be encouraged to adopt robots and be provided with additional information. Launching information campaigns in the media discussing the use of robots would be highly beneficial for the wider adoption of robotic technologies in society. Many potential users are still unaware of the possibilities that social robots offer, particularly in public spaces. Examples shared in social media and television, displaying how GRs assist in transport hubs, medical institutions, museums, and other settings, would undoubtedly increase the number of people who, without fear or uncertainty, are ready to turn to robots for assistance.

Users wish to receive initial assistance as well as further training, but also to see ongoing support available before being ready to rely on GRs on a regular basis. Tailored training programs should address the needs of various user groups, including those with limited prior experience. Our research demonstrates the significance of user trust. This requires transparency in data collection and robust privacy safeguards being put in place. Issues such as technophobia, interpersonal communication preferences, and privacy concerns all require attention, with ethical considerations such as autonomy and dignity playing a vital role in fostering user acceptance. Similar observations have been previously made by Sharkey and Sharkey (2012) and Vincent et al. (2015).

As already mentioned, user self-efficacy may be also improved by means of offering more effective nonverbal cues, such as proxemics and movement patterns (Lio et al., 2020; Li et al., 2022). Considering cultural norms makes interaction with robots feel more natural and engaging. Gazes, eye contact, facial expressions, and expressions of positive emotions increase the user's self-confidence and trust in the robot. On the negative side, factors such as the robot's sudden movements or its lack of facial expressions can lead to discomfort and reduced trust. To address this, robot designs should prioritize human-like expressiveness and social norms, consistent with research on the importance of nonverbal cues in HRI (suggested also by Saunderson & Nejat, 2019; Baxter et al., 2016).

Recommendations to organizations considering adopting GRs or testing such equipment. From the organization's perspective, the first step should be to define as precisely as possible the tasks or the role that a GR is expected fulfill within the organization. Currently, GRs are better suited for routine, repetitive tasks that require minimal emotional intelligence or decision-making capacity, such as guiding visitors, providing information, managing logistics, and assisting with inventory.

The tasks assigned to robots and challenges experienced doing so are heavily influenced by organizational environments. In transport hubs, such as railway stations and shopping centers, robots are adjusted to the conditions of noisy surroundings while performing complex speech recognition tasks, yet they can still effectively disseminate information or provide guidance (Shiomi et al., 2008; Kanda et al., 2010). In museums, robots serve as tour guides, offering interactive experiences and information regarding the exhibits (Lio et al., 2020). In libraries, robots must function in quiet settings, requiring further measures to be taken, such as a noise-reducing carpet, to ensure that their operations do not disturb visitors. In hospitals, ethical and privacy considerations are paramount, particularly when addressing the needs of elderly individuals. At the same time, it is crucial to avoid creating an illusion that robots can replace human care and emotional connections (Turja et al., 2020; Sparrow & Sparrow, 2006).

Adoption of robots and assuring effective HRI requires the involvement of entire organizations. Turja et al. (2020) have reached the same conclusion. Comprehensive, multi-level training programs tailored to specific organizational contexts are essential. Establishing transparent support protocols, such as maintenance and troubleshooting procedures, is also critical to ensuring that robots remain functional and accessible. Environments should be created that encourage user feedback and can lead to continuous improvements in robot design and integration. Successful integration of robots also requires paying attention to creating a robot-friendly physical environment. For example, problem-free navigation requires smooth and even flooring, easily opening doors and sufficiently wide doorways, and removal of obstacles or clutter from frequently traversed areas. In addition, installing ramps instead of stairs and maintaining proper lighting can significantly improve both robots' mobility and user experience.

4.1 Limitations and future research

The limitations of the current research project include a relatively small interviewee sample size and a potential self-selection bias. The context-specific findings may not be universally generalizable across cultures and situations. More accurate information can be gathered through larger-scale studies with diverse populations of respondents in a wider variety of settings. This would allow to validate the findings of the current research as well as broaden the scope of the research. Longitudinal studies have the potential to provide further insights into the evolving user perceptions and self-efficacy, as well as assessing the impact of certain patterns of nonverbal behaviors on HRI during the continuous use of robots.

Future research should distinguish between real-world and laboratory settings, while also focusing on the specifics of various environments, involving museums, transportation hubs, such as airports or rail stations, and hospitals. Regardless of the environment, it is critical to develop robots that are functionally designed to support human activities and whose HRI features are adjusted according to human needs and preferences in specific environments. Nonverbal behavior is one of the key factors of a robot in establishing contact with people in HRI. Exploring adaptive AI that personalizes the variety of robot behaviors, based on user preferences and contexts, may further improve user acceptance and satisfaction (Kanda et al., 2004; Van Assche et al., 2024). Further research in the area of ethical considerations related to privacy, data security, and user autonomy is essential for the responsible deployment of robots (Turja et al., 2019; Dignum, 2019).

Declarations

Competing interests

The authors have no competing interests to declare that are relevant to the content of this article.

Funding

This research received no external funding.

Financial or non-financial interests

The authors have no relevant financial or non-financial interests to disclose.

Ethics approval and Consent to publish

This study involved the use of anonymized human data that cannot be traced back to individual participants. As such, it did not require ethics committee approval, in accordance with national guidelines in Estonia, as (a) no identifiable personal information was collected or used; (b) the principle of informed consent was followed; and (c) no risk factors were present during the study, including risks to security, wellbeing, or the use of sensitive personal data.

Written consent was obtained from all Study 1 participants before the experiment. The participants signed a consent form, stating that no personalized data would be collected. The form also stated that all photos would be blurred for research purposes, and videos would be deleted after analyzing observation data. Oral consent was obtained from all Study 2 participants in the beginning of the interview, after that, if allowed, the rest of the interview was recorded.

Data availability

The data are available from the corresponding author upon request.

References

Adetayo A, Abwage K, Oduola T (2023) Robots and human librarians for delivering library services to patrons. Ref Libr 64:69–84. https://doi.org/10.1080/02763877.2023.2183303

Asgharian P, Panchea AM, Ferland F (2022) A review on the use of mobile service robots in elderly care. Robotics 11:127. https://doi.org/10.3390/robotics11060127

Bandura A (1977) Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev 84:191–215

Bandura A (1986) Social foundations of thought and action: a social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Bandura A (1997) Self-efficacy. In: Ramachandran VS (ed) Encyclopedia of human behavior, vol 4. Academic Press, New York, pp 71–81. (Reprinted in Friedman H [Ed] Encyclopedia of mental health. Academic Press, San Diego, 1998).

Bandura A (2005) The evolution of social cognitive theory. In: Smith KG, Hitt MA (eds) Great minds in management. Oxford University Press, pp 9–35

Bandura A (2006) Guide for constructing self-efficacy scales. In: F. Pajares F, Urdan T (eds) Self-efficacy beliefs of adolescents, vol 5. Information Age Publishing, Greenwich, CT, pp 307–337

Bandura A (2018) Toward a psychology of human agency: pathways and reflections. Perspect Psychol Sci 13(2):130–136. https://doi.org/10.1177/1745691617699280

Baxter P, Kennedy J, Senft E, Lemaignan S, Belpaeme T (2016) From characterising three years of HRI to methodology and reporting recommendations. In: 2016 11th ACM/IEEE international conference on human-robot interaction (HRI). IEEE, pp 391–398

Belanche D, Casaló L V, Flavián C, Schepers J (2020) Service robot implementation: A theoretical framework and research agenda. *Service Industries Journal, 40*(3–4), 203–225. https://doi.org/10.1080/02642069.2019.1672666

Belpaeme T, Vogt P, van den Berghe R et al (2018) Guidelines for designing social robots as second language tutors. Int J Soc Robot 10(3):325–341

Bražinová I, Kalenda Vávrová S, Mali J (2024) The introduction of social robots into the social work practice with older adults: a challenge for the education of university students in the field of gerontechnology. Tech Know Learn. https://doi.org/10.1007/s10758-024-09795-6

Breazeal C. (2003) Toward sociable robots. Robot Auton Syst 42(3–4):167–175

Chaminade T, Cheng G (2009) Social cognitive neuroscience and humanoid robotics. J Physiol Paris 103(3–5):286–295

Carradore, M. (2022). People's attitudes towards the use of robots in the social services: A multilevel analysis using Eurobarometer data. *International Journal of Social Robotics, 14*(4), 845–858. https://doi.org/10.1007/s12369-021-00831-4

Darling K (2012) Extending legal protection to social robots: the effects of anthropomorphism, empathy, and violent behavior towards robotic objects. In: We robot conference 2012, University of Miami, https://dx.doi.org/10.2139/ssrn.2044797

Dautenhahn K (2007) Socially intelligent robots: dimensions of human-robot interaction. Phil. Trans R Soc. B 362(1480):679–704. https://doi.org/10.1098/rstb.2006.2004

Degeurin M (2024) Can this robot help solve a guide dog shortage? Popular Science. https://www.popsci.com/technology/can-this-robot-help-solve-a-guide-dog-shortage/ Accessed 11.05.2024

Dignum V (2019) Responsible artificial intelligence: how to develop and use AI in a responsible way. Springer, Cham, https://doi.org/10.1007/978-3-030-30371-6

Fasola J, Matarić MJ (2012) Socially assistive robot exercise coach: motivating older adults to engage in physical exercise. In: Desai J, Dudek G, Khatib o, Kumar V (eds) Experimental robotics, vol 88. Springer, Heidelberg, pp 463–479

Frieske R, Mo X, Fang,Y, Nieles J & Shi B E (2024) Survey of Design Paradigms for Social Robots. arXiv:2407.20556v1 [cs.RO] License: CC BY-SA 4.0

García S, Strüber D, Brugali D, Berger, T, Pelliccione P (2020) Robotics Software Engineering: A Perspective from the Service Robotics Domain. Association for Computing Machinery. ACM https://doi.org/10.1145/3368089.3409743

Gasteiger N, Hellou M, Ahn HS (2021) Deploying social robots in museum settings: a quasi-systematic review exploring purpose and acceptability. Int J Adv Robot Syst 18(6). https://doi.org/10.1177/17298814211066740

Graf B, Hans M, Schraft RD (2004) Care-O-bot II – Development of a next generation robotic home assistant. Auton Robot 16(2):193–205

Gross H, Meyer S, Scheidig A, Eisenbach M, Müller S, Trinh TQ, Wengefeld T, Bley A, Martin C, Fricke C (2017) Mobile robot companion for walking training of stroke patients in clinical post-stroke rehabilitation. In: 2017 IEEE international conference on robotics and automation (ICRA). IEEE, pp 1028–1035, https://doi.org/10.1109/ICRA.2017.7989124

Heslin PA, Klehe UC (2006) Self-efficacy. In: Rogelberg SG (ed) Encyclopedia of industrial/organizational psychology, vol 2. Sage, pp 705–708

Hung L, Liu C, Woldum E, Au-Yeung A, Berndt A, Wallsworth C, Horne N, Gregorio M, Mann J, Chaudhury H (2019) The benefits of and barriers to using a social robot PARO in care settings: a scoping review. BMC Geriatr 19:232

Kanda T, Hirano T, Eaton D, Ishiguro H (2004) Interactive robots as social partners and peer tutors for children: a field trial. Hum Comput Interact 19(1–2):61–84

Kanda T, Shiomi M, Miyashita Z, Ishiguro H, Hagita N (2010) A communication robot in a shopping mall. IEEE Trans Robot 26(5):897–913

Kennedy J, Baxter P, Belpaeme T (2017) The impact of robot tutor nonverbal social behavior on child learning. Frontiers in ICT Human-Media Interaction, vol 4. https://doi.org/10.3389/fict.2017.00006

Latikka R, Savela N, Koivula A, Oksanen A (2021) Perceived robot attitudes of other people and perceived robot use self-efficacy as determinants of attitudes toward robots. In: Kurosu M (ed) International conference on human–computer interaction, vol 12763. Springer, pp 262–274, https://doi.org/10.1007/978-3-030-78465-2_20

Lee I (2021) Service robots: a systematic literature review. Electronics 10(21):2658. https://doi.org/10.3390/electronics10212658

Leite I, Martinho C, Paiva A (2013) Social robots for long-term interaction: a survey. Int J Soc Robot 5(2):291–308. https://doi.org/10.1007/s12369-013-0178-y

Leoste J, Õun T, Loogma K, San Martín López J (2021) Designing training programs to introduce emerging technologies to future workers – a pilot study based on the example of artificial intelligence enhanced robotics. Mathematics 9(22):2876, https://doi.org/10.3390/math9222876

Leoste J, Marmor K, Heidmets M (2023) Nonverbal behavior of service robots in social interactions: a survey on recent studies. Interaction Design & Architecture(s) 61:164–192. https://doi.org/10.55612/s-5002-061-006

Leoste J, Marmor K, Hollstein T, Hinkelmann H, Leoste LB (2024) Enhancing university visitor satisfaction: a human-robot interaction study on the design and perception of a guide robot assistant. In: Balogh R, Obdržálek D, Fislake M (eds) Robotics in education. RiE 2024. Lecture notes in networks and systems, vol 1084. Springer, Cham, pp 185–193, https://doi.org/10.1007/978-3-031-67059-6_20

Leoste J, Lubi K, Marmor K, Kangur K (submitted). Evaluating the suitability of social assistive robots as complementary tools in clinical nursing care. Comput Struct Biotechnol J.

Li Y, Sekino H, Sato-Shimokawara E, Yamaguchi T (2022) The influence of robot's expressions on self-efficacy in erroneous situations. J Adv Comput Intell Intell Inform 26(4):521–530. https://doi.org/10.20965/jaciii.2022.p0521

Liao S, Lin L, Chen Q (2023) Research on the acceptance of collaborative robots for the industry 5.0 era -- the mediating effect of perceived competence and the moderating effect of robot use self-efficacy. Int J Ind Ergon 95:103455. https://doi.org/10.1016/j.ergon.2023.103455

Lin CS, Kuo Y, Wang T (2025) Trust and acceptance of AI caregiving robots: the role of ethics and self-efficacy. Comput Hum Behav 3:100115. https://doi.org/10.1016/j.chbah.2024.100115

Lio T, Satake S, Kanda T, Hayashi K, Ferreri F, Hagita N (2020) Human-like guide robot that proactively explains exhibits. Int J Soc Robot 12:549–566. https://doi.org/10.1007/s12369-019-00587-y

Liu C, Conn K, Sarkar N, Stone W (2008) Online affect detection and robot behavior adaptation for intervention of children with autism. IEEE Trans Robot 24(4):883–896

Mandl S, Bretschneider M, Asbrock F, Meyer B, Strobel A (2022) The social perception of robots scale (SPRS): developing and testing a scale for successful interaction between humans and robots. In: Camarinha-Matos LM, Ortiz A, Boucher X, Osório AL (eds) Collaborative networks in digitalization and society 5.0. PRO-VE 2022. IFIP Advances in information and communication technology, vol 662. Springer, Cham, pp 321–334, https://doi.org/10.1007/978-3-031-14844-6_26

Maniscalco U, Minutolo A, Storniolo P, Esposito M (2024) Towards a more anthropomorphic interaction with robots in museum settings: an experimental study. Robot Auton Syst 171:104561. https://doi.org/10.1016/j.robot.2023.104561

Moro C, Lin S, Nejat G, Mihailidis A (2019) Social robots and seniors: a comparative study on the influence of dynamic social features on human–robot interaction. Int J Soc Robot 11:5–24. https://doi.org/10.1007/s12369-018-0488-1

Mutlu B, Shiwa T, Kanda T, Ishiguro H, Hagita N (2009) Footing in human-robot conversations: how robots might shape participant roles using gaze cues. In: Proceedings of the 4th ACM/IEEE international conference on human-robot interaction, pp 61–68, https://doi.org/10.1145/1514095.1514109

Nomura T, Kanda T, Suzuki T (2006) Experimental investigation into influence of negative attitudes toward robots on human–robot interaction. AI SOC 20:138–150. https://doi.org/10.1007/s00146-005-0012-7

Ruggiero A, Mahr D, Odekerken-Schröder, G, Russo-Spena T, Mele C (2022) Companion robots for well-being: A review and relational framework. In M. M. Davis (Ed.), *Research Handbook on Services Management* (pp. 309–330). Edward Elgar Publishing. https://doi.org/10.4337/9781800375659.00033

Ogle A, Lamb D (2019) The role of robots, artificial intelligence, and service automation in events. In: Ivanov S, Webster C (eds) Robots, artificial intelligence, and service automation in travel, tourism and hospitality (pp. 255–269). Emerald Publishing Limited, pp 255–269, https://doi.org/10.1108/978-1-78756-687-320191012

Pagallo U (2013) Robots in the cloud with privacy: a new threat to data protection. Comput Law Secur Rev 29(5):501-508. https://doi.org/10.1016/j.clsr.2013.07.012

Pinto A, Sousa S, Simões A, Santos J (2022) A trust scale for human-robot interaction: translation, adaptation, and validation of a human computer trust scale. Hum Behav Emerg Technol 2022(1):6437441. https://doi.org/10.1155/2022/6437441

QViro (2024) Humanoid robots in China 2024. https://qviro.com/blog/humanoid-robots-in-china-2024/. Accessed 27.08.2024

Rakic S, Tasic N, Marjanovic U, Softic S, Lüftenegger E, Turcin I (2020) Student performance on an e-learning platform: mixed method approach. Int J Emerg Technol Learn 15(2):187–203. https://doi.org/10.3991/ijet.v15i02.11646

Robinson NL, Hicks T-N, Suddrey G, Kavanagh DJ (2020) The robot self-efficacy scale: robot self-efficacy, likability and willingness to interact increases after a robot-delivered tutorial. In: 2020 29th IEEE international conference on robot and human interactive communication (RO-MAN). IEEE, pp 272–277, https://doi.org/10.1109/RO-MAN47096.2020.9223535

Rosenthal-von der Pütten A, Bock N (2018) Development and validation of the self-efficacy in human-robot-interaction scale (SE-HRI). ACM Trans Hum-Robot Interact 7(3):1–3. https://doi.org/10.1145/3139352

Salem M, Kopp S, Wachsmuth I, Rohlfing K, Joublin F (2012) Generation and evaluation of communicative robot gesture. Int J Soc Robot 4(2):201–217. https://doi.org/10.1007/s12369-011-0124-9

Saunderson S, Nejat G (2019) How robots influence humans: a survey of nonverbal communication in social human–robot interaction. Int J Soc Robot 11(4):575–608. https://doi.org/10.1007/s12369-019-00523-0

Savela N, Latikka R, Oksa R, Kortelainen S, Oksanen A (2022) Affective Attitudes Toward Robots at Work: A Population-Wide Four-Wave Survey Study. International Journal of Social Robotics 14:1379–1395 379–1395 https://doi.org/10.1007/s12369-022-00877-y

Shahzad K, Khan SA, Iqbal A (2024) Factors influencing the adoption of robotic technologies in academic libraries: a systematic literature review (SLR). J Librariansh Inf Sci 0(0). https://doi.org/10.1177/09610006241231012

Sharkey A, Sharkey N (2012) Granny and the robots: ethical issues in robot care for the elderly. Ethics Inf Technol 14(1): 27–40. https://doi.org/10.1007/s10676-010-9234-6

Singer PW (2009) Wired for war: the robotics revolution and conflict in the 21st century. Penguin, London

Shiomi M, Sakamoto D, Kanda T, Ishi CT, Ishiguro H, Hagita N (2008) A semi-autonomous communication robot – a field trial at a train station. In: 2008 3rd ACM/IEEE international conference on human-robot interaction (HRI). IEEE, pp 303–310

Sorell T, Draper H (2014) Robot carers, ethics, and older people. Ethics Inf Technol 16(3):183–195. https://doi.org/10.1007/s10676-014-9344-7

Sparrow R, Sparrow L (2006) In the hands of machines? The future of aged care. Minds Mach 16:141–161. https://doi.org/10.1007/s11023-006-9030-6

Spatola N, Kühnlenz B, Cheng G (2021) Perception and evaluation in human–robot interaction: the human–robot interaction evaluation scale (HRIES) – a multicomponent approach of anthropomorphism. Int J Soc Robot 13:1517–1539. https://doi.org/10.1007/s12369-020-00667-4

Tachi S, Komoriya K (1985) Guide dog robot. In: Brady M et al (eds) The robotics research 2: proceedings of the second international symposium on robotics research. MIT Press, pp 333–349, https://tachilab.org/content/files/publication/tp/tachi1985MIT.pdf

Takayama L, Pantofaru C (2009) Influences on proxemic behaviors in human-robot interaction. In: 2009 IEEE/RSJ international conference on intelligent robots and systems. IEEE, pp 5495–5502, https://doi.org/10.1109/IROS.2009.5354145

Tan N, Mohan R E, Watanabe A (2016) Toward a framework for robot-inclusive environments. Elsevier pp 68-78

Thrun S, Bennewitz M, Burgard W, Cremers AB, Dellaert F, Fox D, Hahnel D, Rosenberg C, Roy N, Schulte J, Schulz D (2000) Minerva: a second-generation museum tour-guide robot. In: Proceedings 1999 IEEE international conference on robotics and automation (Cat No 99CH36288C). IEEE, pp 1999–2005, https://doi.org/10.1109/ROBOT.1999.770401

Turja T, Rantanen T, Oksanen A (2019) Robot use self-efficacy in healthcare work (RUSH): development and validation of a new measure. AI Soc 34:137–143. https://doi.org/10.1007/s00146-017-0751-2

Turja T, Aaltonen I, Taipale S, Oksanen A (2020) Robot acceptance model for care (RAM-care): a principled approach to the intention to use care robots. Inf Manag 57:103220. https://doi.org/10.1016/j.im.2019.103220

Van Assche M, Petrovic M, Cambier D, Calders P, Van Gelder P, Werner F, Van de Velde D (2024) Socially assistive robots in aged care: expectations of older adults with MCI in assisted living facilities and their caregivers. Int J Soc Robot 16:687–698. https://doi.org/10.1007/s12369-024-01115-3

Van Wynsberghe A (2013) Designing robots for care: care-centered value-sensitive design. Sci Eng Ethics 19:407–433. https://doi.org/10.1007/s11948-011-9343-6

Vincent J, Taipale S, Sapio B, Lugano G, Fortunati L (eds) (2015) Social robots from a human perspective. Springer, Cham

Wada K, Shibata T (2008) Social and physiological influences of living with seal robots in an elderly care house for two months. Gerontechnology 7(2):235

Wirtz J, Patterson PG, Kunz WH, Gruber T, Lu VN, Paluch S, Martins A (2018) Brave new world: service robots in the frontline. J Serv Manag 29(5):907–931. https://doi.org/10.1108/JOSM-04-2018-0119

Yi E, Park, D-H (2024) Potential User Segmentation Based on Expectations of Social Robots Using Q-Methodology. IEEE*Access* Vol 12. 10.1109/ACCESS.2024.3430864

Zeller F, Dwyer LD (2022) Systems of collaboration: challenges and solutions for interdisciplinary research in AI and social robotics. Discov Artif Intell 2(12). https://doi.org/10.1007/s44163-022-00027-3

Appendix 1

Hello!

Please rate your experience of interacting with the robot today! Answer the following questions by clicking on the appropriate answer option. If you don't want to or can't answer a question or statement, just skip it. Your answers will remain anonymous, it will take 6-7 minutes to answer. Please confirm with your signature and date that you agree to the use of the data collected from you through this questionnaire for the preparation of research articles and that you are participating voluntarily.

Date: .... Name: .... Signature: ....

Thank you, IT Didactics Research Group, TalTech IT College.

Thinking about your experience today, how do you rate your interaction/communication with the robot?

	1	2	3	4	5	6	7
Difficulty. Communicating with the robot seem to you...	Very difficult	Difficult	Rather Difficult	So-so	Rather Easy	Easy	Very Easy
Understandability. How did you understand the robot's messages/conversations?	Very Badly	Badly	Rather Badly	So-so	Rather Well	Well	Very Well
Location. Was the location of the robot during communication...?	Very Unsuitable	Unsuitable	Rather Unsuitable	So-so	Rather Suitable	Suitable	Very Suitable
Security. Do you consider interacting with the robot...	Very Unsecure	Unsecure	Rather Unsecure	So-so	Rather Secure	Secure	Very Secure
Reliability. Do you consider the robot as a communication partner for you...	Very Unreliable	Unreliable	Rather Unreliable	So-so	Rather Reliable	Reliable	Very Reliable
Pleasantness. Do you consider the robot as a communication partner for you...	Very Unpleasant	Unpleasant	Rather Unpleasant	So-so	Rather Pleasant	Pleasant	Very Pleasant
Self-confidence. How confident or uncertain did you feel during your interaction with a robot?	Very uncertain	Uncertain	Rather uncertain	So-so	Rather confident	Confident	Very confident

Think about the tasks you solved in cooperation with the robot today. How would you evaluate the completion of these tasks (such as moving from one room to another, etc.) together with the robot?

Effectiveness. Do you consider that collaborating with the robot helped to complete the tasks better or worse?	Significantly worse	Worse	Rather worse	So-so	Rather better	Better	Significantly better
Comfort. How convenient was it for you to solve today's tasks in cooperation with the robot?	Very uncomfortable	Uncomfortable	Rather uncomfortable	So-so	Rather comfortable	Comfortable	Very comfortable
Speed. Do you consider working with the robot make solving tasks faster or slower for you?	Significantly slower	Slower	Rather slower	So-so	Rather faster	Faster	Significantly faster

Suitability. Was the cooperation with a robot just for solving such tasks (like today's)...	Very inappropriate	Inappropriate	Rather inappropriate	So-so	Rather suitable	Suitable	Very suitable
Naturality. How natural was solving tasks with a robot for you?	Very unnatural	Unnatural	Rather unnatural	So-so	Rather natural	Natural	Very natural

While you were working with the robot, other people were also present in the room. What was their attitude towards the interaction between you and the robot and acting together?

Attention. To what extent was attention paid to your and the robot's activities?	No attention was paid at all	In general, no attention was paid	There was little attention	So-so	Some attention was paid	attention was paid	There was a lot of attention
Intervention. To what extent did bystanders interfere in your and the robot's activities?	Didn't interfere at all	Didn't intervene	Rather did not intervene	So-so	Rather intervened	Intervened	There was a lot of interference
Acting in front of others. Was working with a robot under the eyes of other people for you...	Very unpleasant	Unpleasant	Rather unpleasant	So-so	Rather pleasant	Pleasant	Very pleasant

And finally!

To what extent has your previous work or study included communication or cooperation with a robot? 1) not at all, 2) rarely, 3) so-so, 4) often, 5) constantly

If in the future a robot could touch you (while acting together or solving tasks), would it be for you: 1) very unpleasant, 2) unpleasant, 3) so-so, 4) pleasant, 5) very pleasant

Did you perceive today's robot more as a machine or as a person? 1) definitely as a machine, 2) rather as a machine, 3) so-so, 4) rather as a human, 5) definitely as a human

You are: female male   Your age is between: up to 30 years, 31-50 years, 51 and more years

THANK YOU!