On the Intention to Use the Pepper Robot as Communication Channel in a Business Context: Results of a User Acceptance Survey

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ABSTRACT

This paper presents the results of a user acceptance survey (based on the Technology Acceptance Model – TAM) of the humanoid social robot Pepper as a communication channel in different information retrieval scenarios in a business context. In total, 239 passers-by participated in the survey, which had a specific focus on the impact of perceived safety and security aspects. The results revealed a positive assessment of its perceived ease of use and perceived usefulness. It also showed how safety, data protection, and privacy concerns impact the intention to use the robot. The study findings are supported by the outcomes of eight expert interviews.

CCS CONCEPTS

• Human-centered computing • Human computer interaction (HCI) • HCI design and evaluation methods • Field studies

KEYWORDS

Acceptance, Humanoid Robot, Survey, Technology Acceptance Model, Privacy, Data Protection, Physical Safety.

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1 Introduction

Social robots are considered as a new generation of service and communication channel, which can potentially even replace, for specific use cases, existing in-person and electronic channels [1]. Perceived ease of use and perceived usefulness are considered key factors for user acceptance of self-service technologies [2]. However, the experience of social presence through the interaction with an embodied agent will continue to be important for a satisfactory consumer experience [3]. Intended application scenarios for social service robots are using the robot to instruct and communicate to people in public settings. The acceptance of so-called "kiosk" scenarios, in which the robot is providing information to passers-by in an interactive manner, has been studied substantially in Human-Robot Interaction (HRI) in the last decade. To our knowledge, the use of HRI in companies – which we define as business context – has not yet been sufficiently addressed [4].

1.1 Humanoid Robot Applications

The technology of social service robots has advanced to the point that commercial applications can be easily implemented. For instance, the humanoid robot Pepper from SoftBank Robotics is specifically designed to interact with people in a pleasant and intuitive way. The robot has a mobile base and can move its head, hands, and torso. The agent is 120 cm tall and has a 10.1" touchscreen display mounted on its chest. It is equipped with four microphones mounted on its head, two 2D cameras, one 3D sensor, and two ultrasonic sensors, which are used to record its environment. As the purpose of Pepper is communicating and navigating, developers fitted the robot only with cable pull arms, therefore it is not able to grasp or carry objects, except when they are very light in weight and easy to grasp, e.g., a soft toy.

The most extensively studied application for humanoid service robots in public space is the shopping context, where the results for user acceptance seemed promising [5], [6], [7], [8]. Not only communication scenarios were studied, but robots took over tasks, such as carrying shopping baskets in a grocery shop [7], guiding and advertising at a shopping mall [8], guiding and performing entertaining play behaviors at a mall [6] as well as guiding and helping with shopping in a home improvement store [5]. Conversational [7] and nonverbal communication features [5] have been proven to improve the interaction between the robot and the customer. Increased enjoyment [5], [7], especially for children [6], [8] was reported, as well as an encouragement of shopping activities has been noted [5], [7].

However, not only the shopping context offers applications for social service robots as communication channels. Various organizations, including public services, are looking for technology-enabled ways to streamline the customer service processes. Organizations and public service bodies have complemented and sometimes completely replaced traditional in-person service channels (face-to-face, phone, and mail) by electronic service and self-service channels such as website forms, email, and chat [9]. While the new channels can increase efficiency from customer and organizational perspective, many citizens still prefer human assistance and face-to-face interaction [10]. Social robots with a physical appearance and humanoid form could partially fulfill this purpose within contexts, where a physical service point exists, but the human staff need to focus their limited resources on more challenging duties [1].

Exemplary applications for deployment in public spaces are museum guidance [11], city center navigation [12], [13], care home support [14], airport guidance [15], and hosting or guiding visitors or guests [16]. We are not aware of any study, conducted in a business context comparable to our work. Moreover, most studies of social robot applications in public contexts so far have been exploratory in nature with rather small sample sizes. Claims on the overall acceptance for the application context can hardly be derived [17]. While many acknowledge the importance of user experience and acceptance of robots in these contexts and roles, it is often treated superficially, focusing on the agent's performance rather than interaction quality [18].

1.2 Acceptance of Robots

To implement innovations successfully, including humanoid robot applications, user acceptance is relevant for the actual use of products. The introduction of a system or product is cost and time intensive, and making changes is even more expensive after its launch. In the last decades, researchers developed several user acceptance models to find out whether and why individuals and companies accept or reject an innovation [19].

The Theory of Reasoned Action (TRA) is one of the basic concepts in the field of acceptance evaluation, developed by Fishbein & Ajzen in 1975. The TRA forms the basis for the Technology Acceptance Model (TAM), which was introduced by Davis in 1989 to predict and explain, why a system might not be acceptable for the user [19]. Based on the results, researchers and practitioners can implement corrective steps. Especially, at an early stage, there is great flexibility in changing a product or application. Taking corrective steps during the development can save a lot of resources [20]. TAM focuses on perceived usefulness (PU) and perceived ease of use (PEOU); two main specific variables to measure user acceptance. PU is defined as "the prospective user's subjective probability, that using a specific application system will increase his or her job performance within an organizational context" [19]. PEOU refers to "the degree to which the prospective user expects the target system to be free of effort" [19]. TAM considers that the usefulness of a system is clearly more important than the ease of use considering that no amount of ease of use can compensate for a system that is not useful for a given task. TAM assumes that the actual system use depends on the behavioral intention to use it (IU). This in turn depends on the PU and the attitude towards system usage. External variables, e.g., demographic data such as age and gender, influence the PU and the PEOU [19], [20], see Figure 1.

Apart from robot evaluations [21], [22], TAM is widely used in different domains and for various applications. Hornbaek & Hertzum [23] e.g., give an insight into evaluations using the model. The Almere model [24], which focuses more on the attitude of the user, was developed as a specific acceptance evaluation model for social robots. However, it is less suitable for our study context than the TAM, as it was developed for use within a context of personal assistive robots.

In this paper we present a survey study on the user acceptance of Pepper as an information medium for a large corporation using TAM, due to its suitability for the business context and the validated survey questions. In the course of the study, Pepper was introduced into different kiosk scenarios, such as an information medium at career fairs, a receptionist at the company's entry hall, and for safety instructions and health information. Our study focuses on the user acceptance of the social agent technology after a direct interaction between the humanoid robot Pepper and a passer-by.

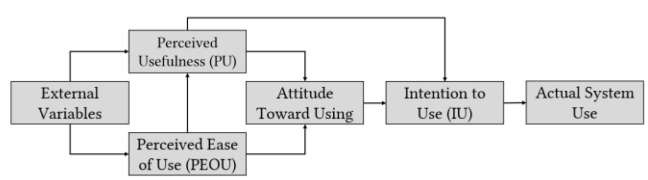

Figure 1: Technology Acceptance Model adapted after [19].

1.3 Research Aim and Hypotheses

Our aim was to explore the acceptance of the humanoid robot Pepper as communication channel in a business context through a large-scale survey study. We based this survey on the influencing elements PU, PEOU, and IU of the TAM. Apart from our interest on the correlations of socio-demographic factors, such as age, gender, and education, we were interested in the effect of privacy aspects on acceptance in a business context.

Previous studies on this topic had no preceding direct interaction to a social robot [25] or a relatively small sample size [26]. Therefore, our aim was to fill this research gap and to explore whether participants have concerns after an interaction and whether this could have an impact on further use.

As mentioned in section 1.1, Pepper is equipped with several sensors to perceive its environment and in the course of this, inevitably processes data, which might be misused. This can also be sensitive data including biometric data of the person's bodies and faces or typical behavioral data, which can disturb the privacy of persons. In this study, we wanted to especially focus on these privacy aspects and their relation to user acceptance. Pepper might also raise physical safety concerns due to its physical properties and capabilities. The three technical concerns should be tested by the following hypotheses:

H1. Concerns about physical safety issues negatively influence the intention to use the humanoid robot.
H2. Concerns about data protection issues negatively influence the intention to use the humanoid robot.
H3. Concerns about privacy issues negatively influence an intention to use the humanoid robot.

Our participants interacted voluntarily and unplanned with the robot in a real environment to enable a high ecological validity of the gained data [27].

2 Methods

For our study purposes we developed two basic scenarios to create a communication situation for passers-by with the robot: (1) a kiosk scenario where information can be retrieved from the robot by asking questions, and (2) a lecturer situation in which the robot gives information as a co-host. Both scenarios were developed only by using the robot's built-in software. For the survey we created an item-based questionnaire.

In addition to the survey we conducted eight semi-structured expert interviews with Human-Robot Interaction experts (lasting between 30 minutes and one hour each) to substantiate and complement our findings with qualitative insights from a non-layperson perspective.

2.1 Quantitative Survey

2.1.1 Participants. Participants were not explicitly recruited to be part of the user study. Instead, Pepper was implemented in existing processes and events in the company, and participants were asked after the interaction whether they wanted to fill in the questionnaire for the study. After obtaining their consent, the questionnaire was filled in.

2.1.2 Questionnaire. As the study took place in Austria, the questionnaire was offered in German and English and most of the participants (90.1 %) completed the questionnaire in German. As an introduction, the questionnaire explained the aim of our research, "to assess the acceptance of social robots, such as Pepper, within daily situations". The first part of the questions was based on the TAM. To evaluate the perceived usefulness, the questionnaire started with three questions about the content delivery and the further impression:

- "The content, presented by Pepper, was structured in a useful way."
- "I would consider the content, presented by Pepper, as useful."
- "When Pepper asked content relevant questions, I easily noticed highly relevant presentation topics."

To investigate the perceived ease of use, the participants were asked how they considered the interaction:

- "I consider the interaction with Pepper as easy going."

For the intention to use the robot, three questions were asked:

- "I consider it as beneficial to use Pepper as a presenter."
- "I can really imagine Pepper to be my personal assistant at work."
- "I can really imagine Pepper welcoming people in the reception area."

In addition, questions about the perceived physical safety ("I consider Pepper as a safe technology regarding the interaction with people."), data protection ("I consider Pepper to be a safe technology regarding the use of personal data."), and privacy ("Pepper disturbs me regarding my privacy.") were asked. The presented questions had to be answered following a 4-point-Likert scale from 1 (= completely disagree) to 4 (= completely agree). The questionnaire also offered the possibility to answer the following open question: "I consider Pepper to be very suitable for…". The survey ended with demographic questions on gender, age, current job position, and education level.

2.1.3 Procedure. The study participants were exposed to one of the seven variations of the two basic scenarios, shown in Table 1, before completing the questionnaire.

For the scenarios 1-4, where the emphasis was set on the dialogue between the study participant and Pepper, the following standard procedure was applied: A video introduces the technology and products of the company and the guidelines to visit the company site, to ensure a pleasant cooperation. After the video, participants were encouraged to ask the researcher or the robot questions, and to interact with the robot to get an impression of it, on a voluntary basis. To avoid a time bias and give every participant the same chance to experience Pepper, the participants were asked to fill in the questionnaire after ten minutes of interaction. After showing the video, the procedure did not follow a pre-elaborated plan, rather, participants should interact with Pepper in a natural, self-determined way by asking questions. Depending on the respective scenario, at least 20 possible questions, e.g., "What do you do here?", "What is your purpose?", "Can you provide me with useful information about the event?", "What do I do in case of an emergency situation?"

were preprogrammed for Pepper to provide an unforced, natural dialogue.

The kiosk scenarios 5-7 emphasized on providing lectures with Pepper as a co-host in a neutral, polite but determined portrayal of the respective content. Lectures always took place in front of a bigger audience (more than 30 people) inside the company. Topics ranged from instructions about the company summer school, to health and safety instructions. Pepper and a researcher presented alternately, while both tried to include the audience as well as possible during the lecture (e.g., by asking questions or providing remarks on the displayed content). The audience was encouraged to proactively think about the content and ask Pepper or the host questions. For instance, Pepper told the audience: "If you have any questions, want to make remarks, or need additional information, please feel free to interrupt anytime during the presentation. We appreciate that." The person controlling Pepper remained hidden, but was able to witness the scenario and to control Pepper's movements, if necessary. Every lecture was concluded with a Q&A session, where Pepper tried to answer the audience's questions with the help of preprogrammed answers. After the presentation, the questionnaire was filled in by attendees on a voluntarily basis.

Table 1: Kiosk scenarios and tasks of Pepper during the study.

	Tasks of humanoid robot Pepper
1	**Providing information about the company** at career fairs, schools, universities, exhibitions on science and innovation, and at the company
2	**Greeting visitors** at the company's reception desk
3	**Providing safety instructions** to employees and visitors
4	**Providing health information (ergonomics)** to employees
5	**Giving a speech** at a summer school at the company
6	**Providing safety instructions** to production workers
7	**Providing information** about summer internships

2.2 Expert Interviews

For the eight semi-structured expert interviews, the interviewer used a script consisting of 10 open-ended questions on:

The TAM and the questionnaire used in the quantitative survey, possible applications of Pepper in public and private settings,
the impact of the appearance of Pepper on the PEOU and of the expectations on the possible application areas, and
physical safety, privacy, data protection, trust, and ethical concerns.

The conducted interviews were recorded, transcribed, and paraphrased. Thematic coding, a method for categorizing (segments) of qualitative data into meaningful themes was used for analysis. As the data was very homogenous and no comparative quantification was intended, the coding was performed by one coder, in order to reduce and summarize the data. The interviewees were experts in the fields of HRI, robot ethics, data security, electrical engineering, physical safety, psychology, architecture, and design. All of them had 10+ years of experience in research, development and/or application of robotics. The findings of the expert interviews are considered in the discussion and conclusion of this paper.

3 Results of Quantitative Survey

3.1 Data Correction and Demographic Analysis

The initial data set contained 244 filled-in surveys. Participant 117 was deleted because of the survey being incomplete. An analysis of standard residuals (Mahalanobis, Cook and Leverage) was carried out to identify outliers, which indicated that participants 148, 163, 183 and 219 needed to be removed, resulting in a final n of 239. Table 2 shows the demographic analysis of the data set. It shows that most of the participants were between 20 and 29 years old and mostly employees or interns of the company.

3.2 Data Reliability, Variable Computation, and Analysis

Based on the Cronbach Alpha of .70 and bivariate significant correlation results, three questions of the questionnaire were used for the variable PU. The PEOU was only queried by one question, and the dependent variable IU was queried by three questions with a Cronbach Alpha of .72 and bivariate significant correlation results. The questions were used to compute the three variables PU, PEOU, and IU, whose distribution of results is shown in Figure 2. The PU was rated relatively high with an average of 3.11 (SD = .57) and a median of 3.00. In comparison, the PEOU was rated a little lower with an average of 2.90 (SD = .88) and a median of 3.00. The IU was rated with an average of 2.56 (SD = .75) and a median of 2.67.

3.3 Model Analysis and Correlations

3.3.1 Model analysis. A Pearson correlation analysis revealed a significant correlation between PU and IU (coef. = .464, $p < .01$), and a Spearman analysis a significant correlation between PEOU and IU (coef. = .339, $p < .01$). Results of a multiple linear regression showed that 24 % of the variance of IU is explained by the model ($F(2, 236) = 38.599$, $p < .01$, $R^2 = .246$, $R^2_{adjusted} = .240$). Further results indicated that PU ($\beta = .407$, $p < .01$) and PEOU ($\beta = .187$, $p < .05$) were significant predictors of IU in the model.

3.3.2 Demographic correlations. A Spearman correlation analysis showed no significant correlation between gender and PU (coef. = .086, p = .184), PEOU (coef. = .072, p = .265) or IU (coef. = .042, p = .517). It also showed that the level of education did not correlate significantly with PU (coef. = .034, p = .605), PEOU (coef. = .113, p = .080) or IU (coef. = - .026, p = .690).

The age of the participants correlated significantly with PU (coef. = .187, p = .004), but not with PEOU (coef. = .105, p = .104) or IU (coef. = .070, p = .284). The job or relation to the corporate correlated significantly with PEOU (coef. = .228, p < .01), PU (coef. = .203, p = .002), and IU (coef. = .167, p < .01). Job candidates (∅IU = 2.87), others (∅IU = 2.82) and visitors (∅IU = 2.68) had a slightly higher intention to use the robot than employees (∅IU = 2.55) and interns/trainees (∅IU = 2.41).

3.3.3 Hypotheses Testing. Participants rated the physical safety of the robot on average relatively high with 2.99 (SD = .786) and a median of 3, shown in Figure 3. There was a significant positive correlation with PU (coef. = .319, p < .01), PEOU (coef. = .192, p = .003), and IU (coef. = .354, p < .01). The data showed that participants who perceived physical safety high, also rated the IU high. This supports hypothesis H1.

Participants rated the use of personal data average with 2.49 (SD = .902) and a median of 2, shown in Figure 3. There was a significant correlation with PU (coef. = .365, p < .01), PEOU (coef. = .189, p = .003), and IU (coef. = .250, p < .01). The data showed a positive correlation between how safe participants thought the robot is in terms of personal data usage and the IU. This supports hypothesis H2.

Concerns about privacy issues were rated lower than those about personal data usage with an average of 3.03 (SD = .872) and a median of 3, shown in Figure 3. There was a significant correlation with PU (coef. = .142, p = .029), PEOU (coef. = .140, p = .030), and IU (coef. = .262, p < .01). Detailed data showed a positive correlation between how participants rated the extent to which the robot disturbs their privacy and their IU. This supports H3, because if participants perceived that the robot disturbs their privacy, they also indicated a lower IU.

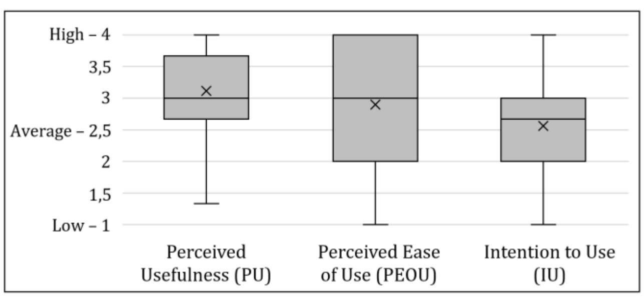

Figure 2: Distribution of the answers to the questions, merged into the variables PU, PEOU, and IU including median (line) and average (cross).

Table 2: Demographic Analysis (n = 239).

Category	*Characteristic*	*Frequency*	*Percent (%)*
Gender	Male	116	48.5
	Female	122	51.0
	Divers	1	.4
Age	< 20	43	18.0
	20-29	98	41.0
	30-39	39	16.3
	40-49	33	13.8
	50-59	25	10.5
	> 59	1	.4
Job	Intern/Trainee	71	29.7
	Employee	103	43.1
	Visitor	40	16.7
	Job candidate	5	2.1
	Other	20	8.4
Education	Compulsory School	66	27.6
	A-levels	82	34.3
	BSc, BA and similar	35	14.6
	MSc, MA, DI and similar	38	15.9
	PhD / Dr.	7	2.9
	Other	11	4.6

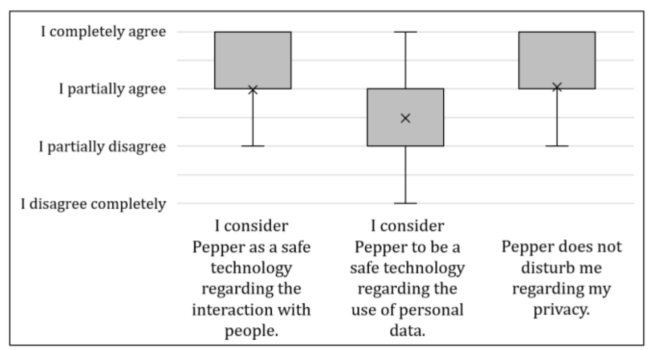

Figure 3: Distribution of the answers to the questions about physical safety, data protection, and privacy including average (cross).

4 Discussion

In the present study, the user acceptance toward a social robot in a kiosk scenario was investigated. The results and correlations displayed that the TAM described IU respectively, the user acceptance towards the embodied agent suitably, whereby PU has a higher impact on IU than PEOU, which supports the premises underlying the model [19]: Utility is primarily more important for IU than usability. This also corresponds to the results of other acceptance surveys concerning robots [28].

Not all external variables e.g., age, gender, job, and education level displayed a significant impact on the intention to use the robot. Neither gender nor the level of education correlated significantly with IU and are thus no longer discussed. All tested variables in the hypotheses showed significant correlations with IU.

4.1 Impact of Age

Interestingly, the PU correlated significantly positive with the age of the participants. Chien et al. [21] found a similar correlation between the age and the perceived ease of use, and explained this inter alia through the assumption that younger adults are more experienced with new technologies and therefore their standard of perceived ease of use might be higher. For example, if the robot could not respond to voice commands immediately, younger adults might become annoyed more easily [21] and their intention to use the technology decreases. It could be the case that due to the high standard of available technologies, including computers, tablets and smart devices, the perceived usefulness of a robot has not much to contribute and therefore younger adults perceive the PU rather low.

4.2 Impact of Job or Relation to the Corporation

Although the PU of our survey participants was rated relatively high, the experts cast a rather negative picture on the usefulness of Pepper. It was mentioned that the robot is not mature enough and does not meet the expectations it raises e.g., in terms of conducting a natural dialogue or being able to joint attention. This may also explain why the results showed a trend, the further away someone was from the actual application, the more likely they were to use Pepper: For job candidates, others, and visitors the IU was higher than for company employees or interns. This reflects a problem of robotics that there are many fields of application and possibilities, but the actual implementation is often not possible or reasonable.

4.3 Impact of Perceived Safety

It was shown that physical safety correlates significantly with the IU of the robot. As participants considered Pepper, with its humanoid, interactive design, and sensor technology, as a safe technology regarding the interaction with people, there was a positive impact of physical safety on the intention to use the robot. This fact should be considered when designing other robots. Inherently safe robots indicating with their design that they are not dangerous for humans will gain higher user acceptance.

4.4 Impact of Perceived Data Protection

Although, PU and PEOU were relatively high, IU was only slightly above average (∅ = 3.11) and one could have expected a higher rating. As H2 was supported by the results and the concerns about data protection were distributed on an average level, see Figure 3, uncertainties regarding personal data protection could be the reason why IU is not as high as PU and PEOU predict. This interpretation is also supported by the statements from the expert interviews. Experts mentioned inter alia that Pepper lacks data security and one could easily access the system in terms of camera view and microphone recordings.

4.5 Impact of Perceived Privacy

In response to the question, whether the participants feel their privacy is disturbed by Pepper, they indicated low considerations. It must be noted that the interaction was short, and participants were not forced to interact or communicate with the robot. A prolonged interaction, for example in a daily scenario at the workplace, might have a negative impact on the IU.

Based on the survey results it can be assumed that Pepper can replace existing in-person channels in a business context in a satisfying manner for employees in the seven scenarios, see Table 1. This is also confirmed when asking participants about suitable application scenarios for Pepper. From the 239 participants, 135 mentioned one or more scenarios. Most of them suggested to use the robot as an assistant in a business environment (40), for receptions and greetings (37) or for presentations, moderations and providing information (34). Some mentioned they see the robot in entertainment, for motivating employees or as a toy (17). 14 participants explicitly mentioned they could imagine using the robot as an assistant in everyday life, e.g., in the household.

5 Conclusions and Outlook

In this paper the results of a user acceptance survey (based on the Technology Acceptance Model – TAM) of the humanoid robotic agent Pepper as a communication channel in different information retrieval scenarios in a business context were presented. The results, which consist of 239 completed questionnaires and eight expert interviews, displayed that physical safety, data protection, and privacy concerns have an impact on the user acceptance towards a social robotic agent.

The design and development of social robotic agents for public settings focused for a long time predominantly on appearance and interaction design to achieve a high user acceptance [29]. The overall experience of a social robot is created by the interaction of expectations, interactions with the robot, and contextual factors [30]. Therefore, the results of the present study should influence the design of social robots and the HRI design, as indicated in section 4. This means that designing a suitable personality and behavior for the robot and its application context, is crucial for developing social robots that will provide practical benefits in real-world settings [31]; functionality and usability must not be neglected to achieve a high user acceptance in a broad range of users, see section 4.1 and 4.2.

Aspects such as safety, data protection and privacy concerns of interaction partners have not been studied extensively and the results of the present study point toward the relevance of further research in this direction, as these concerns correlate with the intention to use the robot as communication channel. The use of person-related data in assistive systems, including social robots, increases the need to explore the implications of acceptance within business settings. Apart from short voluntary human-robot interactions as in this study, looking at an interaction at the workplace, where the interaction is no longer voluntary, but necessary for the execution of the work, strict regulations must be followed. Agreements between employers and employees frame the use of robots or other assistive systems. Further research is therefore envisaged to discover the user acceptance of industrial applications that are based on assistive systems that use personal data of the employees.

Within the ongoing project "SensiTrack", use cases in manufacturing are investigated to understand the most crucial settings and features of the use of personal data for industrial optimization. That covers productivity-based applications such as tracking, quality control and interaction with lightweight collaborative robots but also worker-centered solutions such as the automatic adjustment of workplaces towards the users' anthropometric characteristics. Based on the results of the project "SensiTrack", guidelines of privacy by design for work-related purposes will be elaborated. The defined guidelines serve to improve acceptance and benefits of the use of technology for companies and their employees. To provide one example, previous research showed a significant positive effect of transparent information representation via the user interface on the user experience [32]. A concept for transparent data recording would be advantageous. This could include informing people on first contact with Pepper that the robot has various sensors and is collecting and processing data in a transparent way to maintain its functionality.

Further, to compare social robotic agents with other assistive systems to establish this technology in the long term, a more comprehensive evaluation of it is necessary. Therefore, a multi-criterial evaluation method including further factors, such as usability, user experience, mental effort from a user's perspective, and the consideration of costs and the economic impact from the company's point of view, has to be elaborated and applied on social robots in different scenarios [33].

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