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Social Acceptance of Robots in Different Occupational Fields: A Systematic Literature Review

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Abstract

Robots today are working in both industrial and service sectors. Robots have evolved from one-function automatons to intelligent systems of versatile features, and the new generation of service robots are sharing same space and tasks with humans. The aim of this systematic literature review was to examine how the social acceptance of robots in different occupational fields has been studied and what kinds of attitudes the studies have discovered regarding robots as workers. The data were collected in October 2016 from four major bibliographic databases. Preliminary search results included 336 research articles from which 42 were selected to the final research through inclusion criteria. Of the studies, 69% concerned robots working in health and social services. Positive attitudes occurred more frequently in studies exposing participants to robots. Robots were considered appropriate for different work tasks. Telepresence robots were highly approved by health care staff. The criticism was directed to decreasing human contact and unnecessary deployment of new technology. Our results imply that attitudes toward robots are positive in many fields of work. Yet there is a need for validated measures and nationally representative data that would help us to further our understanding of social acceptance of robots in work.

Keywords Robots · Work · Robot acceptance · Social acceptance · Attitudes · Social representations

1 Introduction

Automatization of work is facing a new era when robotic systems will assist in a variety of work tasks, including going beyond industrial work [11]. Robots have gradually evolved from one-function automatons to intelligent systems of versatile features, which has a wide effect on different kind of occupations. Current interest in deploying robots in service tasks that require more interaction with humans has directed the focus on a new generation of social robotics [57,92]. In order for service robots to integrate into peoples' daily lives as industrial robots have [11], they must be accepted and, above all, found safe [92]. In particular, the robots targeted at health and elderly care have generated much discussion on robot acceptance from ethical [80], legal [5], and employment [1,24] perspectives.

No consensual definition of robots exists, partly because of the rapidly evolving technology. The International Organization of Standardization defines a robot as a programmable device that can move and perform tasks in its environment [38]. This definition encompasses robotic devices from fully autonomous robots to remote-controlled robots such as telepresence robots. Despite the considerable work done in human-robot interaction and technology acceptance [15,16,45,68], advances in robotics requires supplemental research. Robots working closer to humans than before makes it essential to study the attitudes and social acceptance concerning robots as workers. In addition, the diverse robotic applications and varying definitions and conceptions of robots make it essential to consider how the actual experiences with robots influence the attitudes.

In this systematic literature review we report the findings based on our investigation of research done in human sciences on social acceptance of robots in different work tasks. We explored how social acceptance has been studied and what kinds of attitudes toward robots have been discovered. We focused especially on robots that could be considered

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as co-workers and assistance, and they hence are performing work tasks typical of humans or they are considered as colleagues to human workers in certain occupational fields.

1.1 Acceptance of Robots at Work

The deployment of new technology concerns social and human factors, and it has been studied under the concept of technology acceptance [16,88] based on the theory of reasoned action [25]. The technology acceptance model (TAM) consists of components such as attitude toward the technology in question, experience of usage of robots, facilitating factors, social norms, trust, perceived usefulness, ease of use, and enjoyment [e.g.,16,88]. An extended TAM-model by Malhotra and Galletta [54] places more focus on social influence in adaptation and usage of new technologies. This involves understanding how attitudes towards technology change and are internalized.

Examining technology acceptance is also closely related to research fields of social acceptance and attitudes in general. Attitudes refer to fairly constant positive, negative, and neutral evaluations of an object or concept [3,18,21]. Some have argued that attitudes could be defined as "a type of knowledge structure stored in memory" [21], and studies have also connected attitudes more closely to neurological processes [86]. One of attitude functions, the accessibility of the evaluation, is influenced by diagnostic information like sensory information about and direct and past experiences with an object [23]. In addition, attitudes based on direct experience have been found to be more extreme and less ambivalent [66]. For example, it is easier to form a clear view on robots if you have experience with them.

Social representation provides a more social aspect to the attitude discussion. Instead of viewing attitudes or acceptance as intrapersonal processes, attitudes toward a new technology can be viewed as social representations that form socially in the process of collective symbolic coping [4,40,89]. When referring to robots, we are also bound to the robot terms derived from science fiction [87] and the representation those concepts of robots produce.

People who lack real experiences with robots rely only on the social representations of robots' attributes and qualities. In research, this is of course a serious validity issue. In order to control the undesirable variance of imagination, robots should be carefully defined, if not introduced to the participants, when aiming to measure the attitudes towards the robots in question. A Japanese study in which care workers' opinions on hypothetical humanoid care robots were investigated supports this theory. The respondents, mostly nurses, struggled with not knowing exactly which abilities the said humanoid robots would have [29]. Consequently, before any ethical or practical consideration, this indeterminateness was the most common obstacle in viewing humanoid robots as suitable in clinical situations. The relationship between actual experiences and attitudes have been reported in other research as well [36,50,65].

In addition to a study design and the type and attributes of the robot used, attitudes could potentially be affected by the task or occupational field the robot is deployed in. Currently robots are starting to become part of work life in many sectors including journalism [42], education [62], agriculture [82], military [58], and medicine such as surgery [67]. Certain occupations are even at risk of being replaced by robots or other technology [28]. Another factor influencing the attitude toward robots may indeed be a concern over the risk of unemployment caused by robots [57]. Based on empirical evidence from US labor markets, Acemoglu and Restrepo [1] suggest that robots will have significant effects on employment and wages.

According to a Eurobarometer [20] survey, Europeans ($n = 26,751$) generally have a positive view of robots, but they do not feel comfortable about having robots in life domains such as caring for children, elderly, and the disabled. In fact, 60% of Europeans consider that robots should be banned from such care activities. They also reported high figures of disapproval in education (34%), health care (27%), or leisure (20%). On the contrary, very few people consider that robots should be banned in space exploration (1%), search and rescue (3%), manufacturing (4%), transport and logistics (6%), agriculture (6%), military and security (7%), and domestic use such as cleaning (8%) [20].

Applying more refined multivariable analysis to the Eurobarometer data, Taipale and his colleagues [83] specified further that people are reluctant to use robots in the fields of child and elderly care, education, and leisure. Interestingly, pensioners were more willing to accept robots [83]. Takayama and his colleagues [84] had partially different results in their research a few years earlier. In their online survey ($n = 250$) of adult respondents mainly from industrialized countries, robots were approved to work in collaboration with humans. However, people did not favor robots for "jobs that require artistry, evaluation, judgement and diplomacy" [84].

Although no general systematic review or meta-analyses has been conducted on attitudes towards robots performing different work tasks, some exclusive reviews exist, such as reviews about acceptance of health care robots for older population [9] and tele-ICU among intensive care unit (ICU) staff [94]. Also, reviews of efficacy and health effects of robots exist [49,70,72,73]. Kachouie and his colleagues [43] have published a mixed-method systematic literature review concerning socially assistive robots in elderly care. Based on 86 studies in 37 study groups, their findings suggest that socially assistive robots have positive effects on elderly people. In addition, they stated that the most acceptable robots are the ones affecting the well-being of elderly people positively in multiple aspects. This literature review focused, however, only on well-being outcomes and it did not analyze attitudes or opinions about robots. Hence, a need exists for a review of social acceptance of robots currently.

1.2 This Study

The aim of this systematic literature review was to investigate what has been studied about social acceptance of robots performing work tasks amidst disciplines in human sciences. All physical devices referred as robots in the research articles were included in the definition of robot. These vary from single-function automatons to humanoid robots and from remote controlled to autonomous robots. Consequently, this review focused on service robots and industrial robots and leaves virtual robots out of the examination.

The secondary aim was to examine whether the attitudes toward robots vary according to the experience with the robot and occupational field the robot is working in. Based on previous research concerning different job or life domains [83,84], robots could be harder to accept in more social contexts. The purpose of this literature review was to compile previous research knowledge, scrutinize the discovered research data, and bring forth a general view of the research field and subject matter. In addition, the aim was to identify the gaps in the research knowledge and notice prospective research subjects. According to these aims, the following research questions were set:

1. What has been studied about social acceptance of robots operating in different occupational fields?
2. Is the use of hypothetical research design associated with more negative views of robots?
3. What kind of attitudes do people have toward robots in different occupational tasks?

2 Method

2.1 Data Collection

A systematic literature review targeted at human sciences was conducted to answer the research questions. Four electronic databases were searched during October 2016: Scopus, Web of Science, PsycINFO (ProQuest), and Social Sciences Premium Collection (ProQuest). The search phrase "robot* AND (attitude* OR accept* OR experienc*) AND (occupation* OR work* OR profession*)" was used in all databases.

In Scopus the search was focused on titles, abstracts, and keywords of the articles. The topic search of the Web of Science database searched compatible words also from its own KeyWords Plus index. Subject headings, which searches keywords and major subjects, was selected in PsycINFO and Social Sciences Premium Collection as substitutes for keywords and in addition to abstracts and document titles. The searches were limited to peer-reviewed research articles published in 2000–2016. In addition, record or document types and document sources included journal articles and scholarly journals, depending on the database.

Disciplines included in the search in Scopus were social sciences and psychology. The substitutive selections in Web of Science were psychology, psychiatry, behavioral sciences, geriatric, pediatric, education, educational research, health care sciences services, linguistics, public administration, social issues, social sciences other topics, and sociology. The social sciences category in Scopus included disciplines similar to the ones listed above. It was essential the searches were directed broadly to different disciplines to assure the relevant research articles would be included in the data.

The four databases found 499 research articles and after the duplicates were removed the data consisted of 336 journal articles. Because the searched articles were not defined by research method, the data include quantitative and qualitative research articles. However, theoretical articles and literature reviews were excluded since this review was interested only in original empirical research articles. These were excluded during the data processing.

After the initial screening of the 336 research articles, we formed inclusion criteria and limited the data to 39 articles that address the social acceptance of robots in work life. The reasons for exclusion were as follows: (a) the research did not examine attitudes towards robots, (b) the research studied attitudes but the robots concerned did not perform work tasks, (c) the research was only theoretical, (d) the research was a literature review. With the second criterion, the emphasis was given to robots that were subjects rather than means of labor. However, even though a robot might be considered as an instrument rather than a co-worker, its implication to labor is often more extensive. For example, a telepresence robot might substitute or act as an option for a locally stationed specialist. Robots can also assist in diverse work tasks. For example, a robot might be an object for human care like in the case of seal robot Paro, which reacts to touch with movement and sound and is used to improve the quality of life of people with dementia [10]. In this case, the robot would at least support the care function reserved to a caretaker.

The first author was responsible of initial data collection, but we ran additional interrater reliability checks. Interrater reliability of the data inclusion was tested with two additional external raters. The average interrater agreement was 90.68% (Cohen's $\kappa = .75$) for the data inclusion and 86.85% (Cohen's $\kappa = .82$) for data inclusion criteria categories. In the cases of disagreement with raters, the inclusion of articles was separately discussed among the research group. After the reliability test, three more research articles were included resulting in a total of 42 articles in the analysis (see Fig. 1).

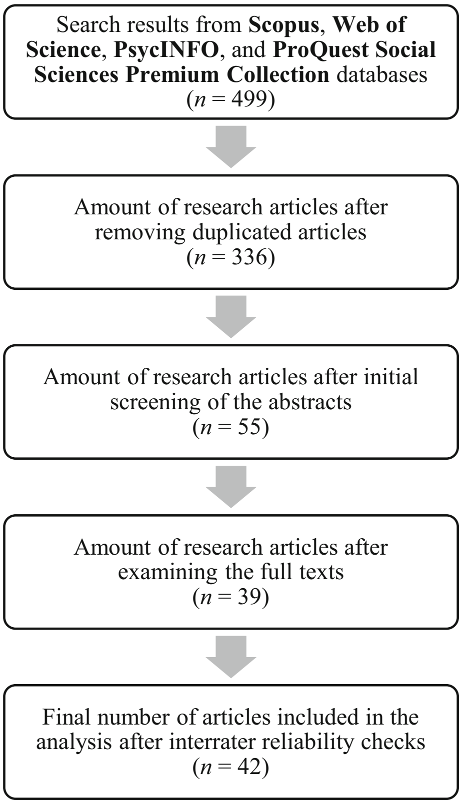

Fig. 1 Data collection process

2.2 Method of Analysis

The starting point for the analysis was to show what research has been done and where the research has been published so far. We gathered all the necessary bibliographic information on articles including year of publication, research method and design, quantity and country of participants, the occupational field the robot represented, and research results concerning the acceptance of robots. Content analysis was used to examine the attitudes toward robots in work tasks. We report descriptive information on the studies and the comparison of positive and negative attitudes that was carried out using cross-tabulations with Fisher's exact test (FET). Two-tailed FET was chosen over, for example, Chi-square test because of its ideal use in cross-sectional study designs with fixed but small frequencies [13,26,59, pp. 77–89].

3 Results

3.1 General Details About Published Studies

General findings on studies published show that they were published between 2006–2016 and in increasing numbers in the 2010s (Fig. 2). Out of all the studies published 29% were conducted in North America and 52% in the European countries (Table 1). In 12% of the studies the data were collected from Asia-Pacific region. Rest of the studies (7%) used cross-country data in their research.

Studies conducted in the field of the health and social services comprised 69% of the published studies. In addition, the social acceptance of robot workers has been researched in the fields of surveillance and military, education, culture and communication, business, administration, agriculture, and industry. The majority of the reviewed studies used quantitative analysis (Table 1). Yet, so far most of the studies have been conducted with fairly small samples sizes. None of the studies were nationally representative. Smaller sample sizes are, however, understandable in experimental studies.

3.2 Attitudes by Research Design

Out of the studies, 60% had an experimental design where the participants were exposed to actual robots, and in 14% of the studies respondents were already familiar with the robot in question. These two study types were categorized as "participants exposed to robots" separating them from studies using hypothetical design where robots were considered only in theory. In the 26% of the studies where robots were not introduced to the respondents, usually some kind of illustration was presented.

The results presented in Table 2 shows that positive attitudes occurred more frequently in studies where participants were exposed to actual robots compared to hypothetical robots (Table 2). In addition, we found that all the different robot types received more positive than negative feedback, especially telepresence robots that received accepting attitudes in 78% of the studies concerning them.

3.3 Attitudes Toward Robots by Occupational Fields

The analysis of positivity and negativity of attitudes showed no statistically significant differences between occupational fields. In addition, we found no statistically significant differences between respondent groups. We then report descriptive qualitative information concerning the different attitudes in different occupational fields (Table 3).

Research in elderly care reveals that the attitudes of elderly towards robots are more often positive than negative [19,34,39,46,52,71]. Robots may also have entertainment value [31], with the risk of being regarded as toys rather than a reliable provider of care [19,71]. Professional care workers are generally not as convinced as the elderly. Compared to the elderly, care workers have more concerns about robots and they may find them unnecessary [78,93]. As an exception, a robot bathtub was considered easy to use by the staff, especially by the management staff, but the elderly did not find it necessary [6].

Fig. 2 Studies on attitudes toward occupational robots ($n = 42$), frequencies by year and participants' exposure to robots. Note: Data collection period extended only to October 2016

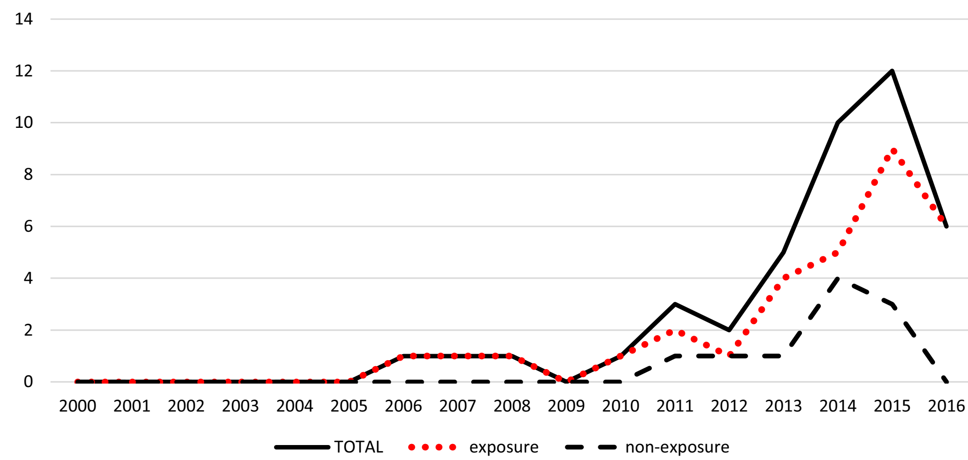

Table 1 Descriptive information about the included studies ($n = 42$)

Method	% n = 42
Quantitative	50% (21)
Qualitative	29% (12)
Both	21% (9)
Sample size	**Mean (SD)**
Quantitative research articles	182 (310)
Qualitative research articles	36 (37)
Study location	**% n = 42**
United States	19% (8)
Sweden	12% (5)
Canada	10% (4)
Germany	10% (4)
United Kingdom	7% (3)
Italy	5% (2)
Austria	5% (2)
Japan	5% (2)
Hungary	5% (2)
Australia, Spain, Macedonia, Norway, Singapore, Denmark, New Zealand	17% (7)
Multiple countries	7% (3)
Occupational field of the robot	**% n = 42**
Social and health services	69% (29)
Culture and communication	5% (2)
Education	2% (1)
Business	2% (1)
Agriculture	2% (1)
Industry	2% (1)
Other, general	2% (1)
Multiple professional fields	14% (6)

Both elderly and care workers were prone to accept the use of a monitoring robot [39,46]. In addition, elderly people find robots useful for communicational assistance [46]. Generally, robots are preferred to help with chores rather than giving company or care [44,93]. Robots were not considered a replacement for emotional companions such as assistance dogs [30], but in one study robots were seen suitable for talking about personal matters with [44], which is somewhat contradicting.

In the occupational field of surveillance, robots are accepted for dangerous tasks, but excessive robotic monitoring and military robots receive also critique [12,17,44,61]. In educational fields, robots are accepted for education and are best suited to teach science, technology, engineering, and mathematics [17,74]. Robots were also well received in cultural fields such as dancing [55,76] or as a tour guide [64], in business fields such as guidance in a shopping mall [77], in administration [17], and in agriculture [35]. A few research articles found the acceptance of robots to be dependent on the appearance [85,91] or movement [95] of the robot in question.

4 Discussion

This systematic literature review examined how social acceptance of robots in different work tasks has been studied in human sciences and what kinds of attitudes the previous research has discovered. We found that social acceptance of robots is still a relatively new but an incremental field of research as most of the 42 selected studies were published in the 2010s. This is also shown in the variety of methods and measures used in the articles. Out of the studies, 29% were qualitative and the rest were at least partially quantitative. The majority of the 42 studies focused on the fields of social and health care. The emphasis, more precisely, is on telemedicine and elderly care, which indicates

Table 2 Studies by positive and negative attitudes and robot exposure

Studies ($n = 42$)	Positive/approving attitudes	Negative/conflicting attitudes	
Participants exposed to robots	67.7% (21)	32.3% (10)	100% (31)
Hypothetical robots	18.2% (2)	81.8% (9)	100% (11)
FET (two-tailed) $p < .05$			

Table 3 Summary of the results related to robot acceptance in different occupational fields

Occupational field	Research results categorized by positive/approving and negative/conflicting attitudes of the respondents
Social & health care	By respondent group
	+ Robots are accepted in work tasks related to hospital by general public [17]. Patients accepted robots in reflexology [27] and brain injury rehabilitation [8], and professionals in surgery [41,90]
	– Professionals [8,51] and elderly respondents [6] questioned the necessity and feasibility of robots in social and health care fields
	– Robots were not well accepted by care professionals [78,93] or as a robot bathtub by the elderly respondents [6]
	As equipment or as a worker
	+ Robots were accepted as substitutes for tools or equipment [2,69,76] and co-workers [90], and even referred to as a social actor or a citizen [76]
	+ Robots were perceived more desirable than computer tablets for providing health care information [56]
	+ A social robot representing an extroverted female was well accepted in the health care field [85]
	– Robots were not desired to replace human workers [48,63] or assistance dogs [30]
	– Robots were perceived more as toys or entertainment than as sources of security by elderly respondents [19,71]
	Health outcomes
	+ Robots were perceived as having a positive effect on patients in physiotherapy and rehabilitation [22,31,32,34], and physiotherapists accepted their use in clinics and homes [53]
	By robot type
	+ Telepresence robots were perceived as having positive effects on patient care [60,75] and communication [63,79] and ranked at least as desirable as telephones [7,47]
	+ Assistive robots were well accepted by the elderly people [19,39,46,52,71], robot bathtubs by professionals [6], and monitoring robots by both respondent groups [39]
	By work task
	+ Elderly people preferred robots for communication and professionals for monitor or to remind patients about medication or schedule of the day [46]. Housework [44,93], rehabilitation [93], tasks of a butler, and discussing personal issues [44] were perceived as most desirable among multiple work tasks
	– Robots are not desired in work tasks that require social skills [2,39] and sensitivity [63]
	– Among different work tasks, the least desirable tasks were keeping company or providing care [44,93] and grocery shopping or programming help [44]
Surveillance & military	+ Robots are accepted in work tasks related to a police force [17]
	+ A social robot representing an introverted male was well accepted in the surveillance field [85]
	+ Robots were preferred for dangerous tasks or tasks related to search and rescue or the military in the field of surveillance [44]
	– Robots were least preferred to perform security or house guard tasks [44]
	– Military robots, especially autonomous military robots, were evaluated more negatively than a robot bathtub for elderly patients by general public [61]
	– Future scenarios of surveillance robots presented concerns related to privacy, excessive control, hacking of the systems, and unemployment [12]
Education	+ Robots are accepted in work tasks related to education [17]
	+ Attitudes toward educational robots were neutral and robots could be imagined in subjects such as science, technology, engineering, and mathematics [74]

Table 3 continued

Occupational field	Research results categorized by positive/approving and negative/conflicting attitudes of the respondents
	− Respondents were reluctant to participate in teaching provided by a robot and could not imagine a robot in subjects such as social sciences or art [74]
Culture & communication	+ Professional dancers perceived robot dance as realistic and aesthetically acceptable [55]
	+ Robot developers perceived a robot dancing a traditional folk dance as uniting social and technological needs [76]
	+ A tour guide robot was perceived as friendly, polite, and competent in interactive communication [64]
Business	+ A shopping mall robot was well accepted, even though most perceived it mainly as a mascot or entertainment for children [77]
Administrative	+ Robots are accepted in work tasks related to office work [17]
Agriculture	+ Transition to milking robots was rationally justified and accepted [35]
Industry	− Nonhuman-like movements of a robotic manipulator increased the stress reactions of humans compared to human-like movements [95]
Other, general	+ Robots are more accepted when replacing people in cognitive rather than emotional work tasks, but a robot perceived as more emotional is also accepted for emotional work tasks [91]

current needs and trends towards using robots in these fields of work [4,9]. The research has focused on technology that already exists, like automated robotic devices and telepresence robots, instead of emerging technology like autonomous service robots. Hence, there is still considerable work to be done on the field, especially because of the implementation of new generation of service robots.

We found out that when the participants did not have actual experiences with the robot in question, negative attitudes were more likely reported in the studies. This finding is consistent with previous research [29,36,50,65]. The lack of first-hand experiences forces people to rely on their social representations or mental images of robots, which seems to affect the attitudes toward them and is in accordance with attitude theories [23,66].

The results of social acceptance of robots in different occupational fields were partly in conflict with some previous studies that had found robots were not well accepted in the fields related to social interaction [9,83,84]. The results of our review showed, however, that in health and social services people have as positive attitudes towards robots as in other occupational fields. Although social acceptance was not the focus of most of the research, the respondents answered questions such as the suitability of a robot for different work tasks.

Consistent with the results of Taipale and his colleagues [83], monitoring robots were more valued by elderly residents than care workers in two research articles [39,46]. The result suggests that, at the end of the day, the elderly may sacrifice some of their privacy at home for better security facilitated by monitoring technology whereas care professionals are more hesitant to do so [81]. The motivation of the care professionals to answer more negatively, however, cannot be evaluated due to the lack of statistically significant differences between different respondent groups.

Telepresence robots were highly approved by health care staff. This can be understood from both the patients' and workers' standpoint, especially regarding home care. Monitoring telepresence robots have been proven highly beneficial in home care, where rehabilitating patients feel exhausted by the amount of travelling to therapy sessions and other appointments [14]. Similarly, home care workers feel frustrated allocating so much time travelling from customer to customer [33,37].

The lack of research concerning occupational fields other than social and health care fields limited the possibility to compare acceptance of robots in different work fields. The studies so far have been conducted with fairly small samples and most of the studies did not use the same theoretical framework and measures. Hence, meta-analysis of quantitative data proved to be infeasible. In addition, the sociodemographic information of the study subjects was not provided in every study and consequently they were not considered in this review. In addition, search words used in the databases have their limitations. For example, studies that did not refer to therapeutic robots with work-related terms could not be included in the data. Future research should additionally include virtual robots by adding terms such as "bot" and "virtual agents" to the search words.

This research has generated a state-of-the-art review of the current research field related to acceptance of robots in different work fields. In addition, it has verified the previous literature on the influence of a hypothetical study design on respondents' attitudes. The results of this systematic review suggest that if we are to continue to research social acceptance of robots at work with more defined statistical analyses, then we ought to wait for the future research that uses more systematic instruments and statistical tests. This would make it feasible in future to systematically compare the social acceptance of robots in different occupational fields.

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Compliance with ethical standards

Conflict of Interest The authors declare that they have no conflict of interest.

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