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Human-Robot Interactions in the Workplace – Key Challenges and Concerns

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Abstract

Theoretical background: The use of robots/AI in the workplace has grown rapidly in the last years. There is observed enlargement not only of the numbers of robots but also the quality of their functions and applications. Therefore, many questions of practical, scientific and moral nature have arisen. The flowering use of robots has drawn scientists' attention to interactions between humans and robots. As a result, a new multidisciplinary research area – Human-Robot Interactions (HRI) – is growing. Representatives of HRI try to answer the questions like: How anthropomorphic features of robots may affect interactions between robots and employees? How are robots supposed to look and behave to make interactions more pleasant for employees? Can human cooperation with humanoid robots lead to the formation of socio-mechanical bonds?
Purpose of the article: The paper aims to identify determinants of human-robot interactions in the workplace and identify key research problems in this area.
Research methods: The method of a systematic review of the literature fulfilled the above-mentioned purpose. The Web of Science was chosen as the basic database. The list of publications from the Web of Science was supplemented with some other publications which were related to the topic.
Main findings: There are several factors that determine the perception and quality of HRI in the workplace. Especially trust, anthropomorphic features of the robot, and organizational assignment may decide

about the human acceptance of the use of a non-human agent and HRI. The concept of social interaction with robots is at an initial stage yet. An adopted research paradigm also plays an important role. It seems that the classical assumptions of organizational sociology will not stand the test of time. Researchers and practitioners are facing new challenges. Especially there are some ontological questions that are not easy to be answered unanimously. Can we treat a robot as a mechanical device or rather as a member of a newly created community?

Introduction

The dynamic development of robotics is irreversibly changing our workplaces and lifestyles. Cybernetic organisms, which have so far been associated with imaginary creations of science fiction literature, are entering our lives and workplaces. Robots' appearance and functionality are changing. Some robots, especially the group of humanoid robots have become more "close" to humans. This may influence collaboration between robots and humans. Humanoid robots are seen not only in science fiction movies but in many spheres of our lives. That is why interactions between humans and robots are at the center of a multidisciplinary research field called "Human-Robot Interaction" (HRI). Asimov (1950) can be considered as the founder of the HRI concept. He formulated three laws of robotics that preceded the creation of robotics (Asimov, 1950). Since the formulation of Asimov's law, the dynamic development of robotics took place. Robots have evolved from master-slave machines to a broad range of robots incorporating artificial intelligence having many applications.

Among many questions posed by HRI researchers the most popular are: Does the resemblance of the robot to humans (appearance, functionality, informatic "intelligence") may determinate HRI? What determinates these interactions in the workplace? Where is the fine line between a robot and a human?

The purpose of this publication is the identification of key determinants of HRI in the workplace and the identification of key concepts explaining these interactions. The research question is: are we observing the formation of new entity/resource/singularity of sociotechnical capital in organizations?

In order to fulfil the above-mentioned purpose, the method of a systematic review of the literature was used. The Web of Science was chosen as the basic database. The list of publications from the Web of Science was supplemented with some other publications which were related to the topic. The method of the systematic literature review was used (Web of Science database).

Key determinants influencing human-robot interactions at work were identified and future research directions were proposed. In a new workspace, there are challenges for management like how to build trust to change?; how do manage and evaluate human work in complicated networks of robots and humans?; how do shape the ethical competencies of programmers of AI systems? The development of robotics raises many questions which do not have simple straightforward answers. There is needed cooperation of scientists representing various fields of science. This is also a methodological challenge due to the diverse methodology used by distinctive disciplines.

A "figure" of a robot cooperating with humans

Generally, "robot" means a machine made by a man for performing his specific tasks. There is no commonly accepted definition of "robot" in the literature which brings some methodological problems (Sarowski, 2017). Probably, the first one who used the word "robot" was a Czech writer, Karel Čapek. He used the term "robot" in 1920 in his theatre play as a synonym of artificial "people" created for work (Moran, 2007). We can see here the similarity between robots and slaves.

The first industrial robot named the "Unimate" was created in 1959, and the first robotics company in the world was opened (Gasparetto & Scalera, 2019). Since that moment there has been a huge breakthrough in robotics and the use of robots in the workplace. Nowadays, Robot UR5e (a flexible collaborative robot arm) is gaining popularity in the industry.

Widespread use of robots and the dynamic development of technology has brought to the development of a specific ecosystem, a system in which robots have become its natural element. This element seems to be particularly interesting. This is due to the fact that its creators – humans – try to imitate his actions to resemble human actions. And if so, a question arises: what is role of robot definition/concept in studying HRI? Is perception of robots related to interactions in the ecosystem? Can we observe creation of new techno-social capital? Does the type of the robot and its functions may determine quality of HRI?

There are different classifications of robots and their types. According to Ben-Bari and Mondada, it may depend on mechanism of interaction and field of robots application (2018). Especially humanoid robots and social robots seem to be very interesting in the context of HRI. A humanoid robot can be described as a more complex robot, equipped with some kind of artificial intelligence and whose appearance resembles a human (Prucher, 2007). Wasielewska and Łupkowski (2021, p. 166) distinguish between humanoid robots and the class of social robots. According to these authors, a social robot is an autonomous machine that can recognize other robots and people and can engage in social interactions. While social robots are designed to serve humans and do not need to have anthropomorphic features resembling human body, social robot do not need to have a physical appearance at all, and can be totally virtual. The key feature of social robots is the ability to interact with other social agents (Wasielewska & Łupkowski 2021, p. 167). While humanoid robots due to their anthropomorphic features can have mechanical gender (Søraa, 2017) or mechanical race (Sparrow, 2019).

Identity of robots was raised in 1986 by Haraway in *A Cyborg Manifesto* (2006). She emphasizes that most American researchers assume the existence of a dualism of mind and body, animal and machine, idealism and materialism, social practices, symbolic formulas and physical artifacts related to advanced technology and its culture. According to Haraway's thesis, the boundary between the material and non-material world is difficult to define.

The social effects of robots' appearance, especially those having human appearance or endowed with some human features, are important for perception of robots and HRI (Phillips et al., 2018). Robots can learn and recognize the racial identities of other robots. Imparting traits such as race or skin colour can shape relationships both between robots and between robots and humans, analogous to human relationships in real life (Phillips et al., 2018). Even if the androids do not look exactly like humans, due to the colour of the robot, stereotypes are transferred from the real world to the world of robotics. It was noticed that in The Anthropomorphic Robot Database dominate robots with white and gray surfaces, while brown or black colours are rarely seen (Phillips et al., 2018). Nass et al. (1994) have found that people's interactions with computers may have social character. Reactions to computers are not the result of the conscious belief that computers are human or human-like, and social responses to computers are easy to generate.

The appearance of a robot can significantly affect how people perceive the "character" of the robot. In particular, this applies to intelligence (Haring et al., 2016), sociability (Powers & Kiesler, 2006), sympathy (Castro-González et al., 2016), credibility (Burgoon et al., 2000), and submissiveness (Von der Pütten & Krämer, 2012). However, trust plays a critical role in HRI. Trust decides about the acceptance of the robot by humans and the perception of the robot as a non-human agent at work (Mou et al., 2020).

Human agency in new workspace arrangements

In the new organizational environment robots are becoming our co-workers and intermediaries in complex processes of relations with other participants: humans and robots. Under these relations and interactions, a new organizational culture is being created. Dynamics networks and interactions are taking place between diverse agents. Therefore, a discussion on human agency in new settings is undertaken by researchers.

Networks of cooperation between humans and other "beings" have been discussed in the literature for some time. Especially the concept of networks called ANT (actor-network theory) created by Latour seems to be very interesting for explaining interactions between humans and robots (Latour in: Czarniawska, 2006, p. 1554). The ANT concept derives from the field of social sciences and is based on constructivist assumptions, achievements of science and technology studies, and the sociology of scientific knowledge. Latour proposed a new concept of community (2013). According to this author, the concept of community should be broadened. Latour's community consists of people, but also of other identifiable actors, which could be also robots. The basic ingredient of society in an *actant*, a factor that acts on other factors. It can be either a human or an object, a bacterium, or a concept. Actants interact with each other, creating a system of actors-networks. *Actants* can be understood as a more complex system of actors-networks. "The notion of actor-net-

work strongly suggests that (…) an »actor« may be a whole network" (Czarniawska, 2006, p. 1554).

According to the ANT, the concept of agency is assigned not only to humans, agency can be also assigned to non-human factors. Thus, the actions of non-human beings are analyzed equally with human actions. Additionally, material and semiotic networks are more important than the objects themselves. The name of the Latour theory – actor-network theory – correlates with actors and scenes. According to Latour, an actor is never alone on stage, he is never sure who or what works. The actor can be perceived as an element of the network, acting with other causative agents.

Likewise, Latour (2013), also Ingold (2013), who is the anthropologist, believes that agency is not something that is typical for humans. Ingold thinks that agency is the result of human immersion in action (2013, pp. 96–97). Both authors represent a critical approach toward anthropocentrism, according to which human is the centre of the universe and the goal of the universe. Ingold and Latour present a new ontological and epistemological approach to agency, stating that there is the possible agency of non-human beings (and thus, of robots). This may raise some concerns about the social results of the robots agency. For example, Microsoft's experiment with a bot named Tay revealed the problem of AI testing in an isolated and controlled environment (Garcia, 2016). In real life, networks of human relationships are very complex and varied.

The consequences of technology is a central topic in the discussion concerning posthumanism and transhumanism. Posthuman reflection has contributed to the development of the relational ontology, environmental humanities, science and technology studies (STS), and the emergence of the actor-network theory (Domańska, 2007, p. 246). Representatives of posthumanism and transhumanism reject the traditional assumption of anthropocentrism. They propose new "beings" and perceive agency in their arrangements. This is the reference to Latour's concept in which it is crucial to observe various types of relationships and the formation of those relationships between elements that before the formation of these relationships had no social connections (sociology of association) (Domańska, 2007, p. 246).

Posthumanism started in the 1980s and is characterized by a radical decentralization of the human role in controlling the world. Posthumanism may be simply defined in opposition to humanism. Posthumanism created a set of techno-optimistic ideas, which can be understood as means designed to transform humans into "posthuman". The assumptions of transhumanism are somewhat similar to posthumanism. However, transhumanism is more oriented toward serving human well-being. This is an intellectual, cultural, and political movement, it postulates the possibilities and benefits derived from the use of technology and science in the process if overcoming human limitations and improving the human condition.

The development of transhumanism depends on the development of technology, and due to this, many ethical questions arise. Critics see transhumanists' goals as posing threats to human values. For example, one of the aims of transhumanism is the abolition of human death and aging. Thanks to AI, individuals will be able to

"upload their consciousness into a computer or AI robot to achieve immortality by discarding their biological bodies" (Belk, 2021, p. 867). Transhumanism is criticized for the low probability of meeting proposed goals and for the ethical and moral principles it postulates.

As we can see, the discussion on the perception of HRI and agency of humans/non-humans, depends on the cognitive paradigm of a given social/philosophical trend. At this stage of research, it is difficult to make a clear statement about the agency in workplaces. However, it can be concluded that the dynamic and tight cooperation between people and technology is starting to undermine traditional assumptions about the role of the human in the universe and human agency.

In new organizational systems, there can be observed the dispersion of ontological boundaries. There is a growing need for an interdisciplinary approach to human agency. For example, many representatives of social research studies, especially posthuman studies and performance studies, extend agency to non-human beings. This does not necessarily mean a complete departure from anthropocentrism where human is the centre of reality. However, it is necessary to look at humans' role from a broader perspective, from the perspective of the ecology of techno-social relations. One cannot completely escape from appreciating the impact of the so-called "technical rationality" guiding the co-evolution of interactions between humans and technology.

Placing employees in a wider, complex network of new relationships undermines simplified concepts of individual self-determination. There are growing ethical and social dilemmas related to human-robot interactions. Today some of the dilemmas may seem too futuristic and speculative. But while waiting for an answer – who is right who is wrong? – it is worth preparing some proposals for the legal, social and technical (programming) problems related to human robots interactions.

Systematic literature review findings

In this part, key findings from the systematic literature review will be presented. The purpose of the literature review was to identify determinants of human interactions with robots in the workplace and to identify the main research problems related to this area.

Based on the Web of Science Core Collection, "human-robot relations in organizations" password was used on 16 April 2022. And, as a result, 57 publications were found. These publications were published from 1993 to 2022 and represented 29 disciplines: Computer Science Artificial Intelligence (19); Robotics (13); Computer Science Theory Methods (7); Engineering Electrical Electronic (7); Neurosciences (7); Automation Control Systems (6); Engineering Manufacturing (4); Business (3); Engineering Mechanical (3); Management (3); Multidisciplinary Sciences (3); Psychology (3); Psychology Multidisciplinary (3), others (1), including economics.

Next publications representing management and quality sciences and related disciplines were selected. There were 10 publications. After further analysis, 9 publications were chosen (Table 1). One publication did not refer to the workplace. The most cited was the 2009 publication describing the problem of human agents in an organization.

Table 1. Publications from the Web of Science database

Author	Keywords	Findings
Barandiaran et al. (2009)	agency, individuality, interactional asymmetry, normativity, spatiality, temporality	A theoretical type. Discussion on the concept of an agency and its various definitions. Difficulties in understanding and modeling agency in spatial-temporal organization processes were identified. The shoreline conditions of the agency have been indicated. An organization able to meet them has been defined. Such an organization is not limited only to living organisms. The authors highlighted problems related to AI research in the context of rationality of system, real emotions, and awareness.
Peng et al. (2016)	AIML, customer service, intention graphs, intention recognizing, online robot	The authors are describing the future of e-commerce customer robot service, based on artificial intelligence markup language (AIML). The functioning of modern robots (reaction to different keywords) and the need to focus on studying the intentions of customers were critically assessed. A theoretical model of the functioning of a robot that can recognize the intentions of e-commerce customers was proposed.
Arslan et al. (2021)	artificial intelligence, HRM strategies, e-HRM challenges, human robot interaction, team work	Theoretical character. The authors identified management challenges related to the interaction between artificial intelligence (AI/robots) and team members. These interactions pose challenges for HRM. Employees are afraid of losing their jobs. Building trust between employees and team robots is needed. Maintaining the collaborative spirit is a challenge. The role of organizational support is important (friendly environment, training opportunities, and ensuring technological competencies). The most difficult task is the evaluation of efficiency results of team members, in teams where people and robots work side by side and perform complex tasks. The authors proposed to look for findings from computer game literature. There are performance evaluation models developed to analyze human interactions and artificial intelligence.
Schweitzer and Puig-Verges (2018)	artificial intelligence, cognitive psychology, epistemology, ethics, robotics, social environment, technology	The development of humanoid robots/AI has positive and negative consequences. The growth of interactions, along with robots' ability to learn, raises numerous questions. For example, will robots change our relationships with other people, what will be our relationships with objects? Living and working with robots is thought-provoking. The development of robotics and artificial intelligence generates new forms of social relations and requires preparing new regulations. The authors believe that robots are new kinds of beings, and state numerous questions: how the change will relate to our autonomy and independence? How to define robots' legal status?
Rodriguez-Lluesma et al. (2021)	(none)	The paper deals with the impact of AI/robotics on work transformation. Building on relational sociology, the authors explore changes that may occur in interpersonal relationships at work. They state that the development of technology may contribute to the creation of new work culture. The new culture is based rather on a relational than a transactional sphere. Work can be perceived as a social relationship having four dimensions: value of exchange, intrinsic and economic purpose, communication for reciprocal services, and correspondence with primary human needs. New culture requires understanding and integration of those dimensions. Thus, human work consists not only of instrumental transactions related to economic resources, but also of mediation and exchange between actors that constitute increasingly complex social networks.

Author	Keywords	Findings
Turja et al. (2021)	change management, meaningfulness, robotization, service robot, stress, technology, well-being, work	An empirical paper. The authors stress reactions of education professionals (2,434) to expected robotization. Are we ready for changes? The respondents indicate that robotization of work may affect the sense of the meaning of work and life optimism. Nevertheless, opinions are divided. Perceptions of further robotization are associated with burnout and lowered meaningfulness, and optimism about the future. There is a need for starting an honest consultation with employees to keep them motivated during technological change.
Vertesi (2019)	aerospace robotics, cognition, human-robot interaction, Mars, planetary rovers, team working	Ethnographic research in NASA mission teams. The author is studying the communication with robots used in NASA missions. Vertesi points out that decisions about robots' actions are the result of group processes. Underlines the meaning of emotional connections with robots, and team synergy in collaboration with robots (which are millions of miles away). NASA team members show a special and peculiar empathy with their robot/colleagues, which transcends anthropomorphism.
Robelski and Wischniewski (2016)	human-machine interaction, function allocation, interface design, safety and health at work	Literature review. The authors undertake the problem of the impact of human-machine interaction (HMI) on workers' health (physical and mental) and job satisfaction. Automation affects employee efficiency and workload. Characteristics of human-machine interaction affect well-being and performance. There is a challenge to designing proper human-machine interactions. Interactions should be understandable for employees, machines and systems must have an ergonomic design. Future research should focus on the detailed description of human-machine systems and their outcome variables. This will help to understand interactions. Identification of harmful and beneficial human-machine interactions are needed to ensure safety and health at work.
Belouaer et al. (2010)	spatial representation and reasoning, spatial relations, ontology, planning, human-robot interaction	There is undertaken the topic problem of programming of spatial objects. According to the authors, future work should concern the integration of PDDL (planning domain definition language) in the context of AI development and human-robot interactions. Especially fuzzy relations that are not understood by robots cannot be ignored. Conclusions referring to the ontology of objects have been proposed. Especially, the problem of managing spatial relations (topological, metric) and blurring in spatial representation. The proposed approach allows the functioning of an organization characterized by hierarchical space and naturally managed by humans, easily understood by robots.

Source: Author's own study based on the literature review.

Findings

After the analysis of the above-mentioned publications, several conclusions can be drawn referring to determinants of HRI in the workplace.

1. An important role in the development of the concept of human-robot interactions and its future is played by the agency theory and concept of human and robot agency (Barandiaran et al., 2009). The concept of agency and the development of cognitive science are intercorrelated. From the literature review, we can see that more and more often scientists depart from anthropocentrism to another direction. As one of them states "agency is attributed to both human and non-human beings, and the changes caused by the subject are seen as the effect of cooperation between people and non-people" (Domańska, 2007, p. 53).

2. Future of human-robot relations depends on progress in cognitive sciences in the area of programming robot language. Especially this refers to the language which can start these interactions. Improvements in the development of communication language is observed. This changes the numbers and scope of use of robots in the workplace. That is why there is needed deeper research in robotics and programming the language of communication. New programming languages range from logic probabilistic programming to designing a language enabling understanding of whole systems. Robots need programming language that enables understanding of the language used in the real world. The human mind does not work like a Turing machine. Human minds remain in relation to the environment, and these relations fulfil their intelligent functions.

3. Future of HRI remains under the influence of people's perception of technology. Especially it relates to the fear of jobs losses and may remind the Luddite movement during the Industrial Revolution. Researchers are showing both potential threats of robotization of work and possible benefits. The impact of technology on society varies according to occupational groups, income levels, gender, and minority status (Petersen et al., 2021). Public policy at the governmental level must be developed. This is required to avoid future social problems. Dahlin (2019), on the basis of research results derived from the US economy, concludes that the increase in the number of robots in the workplace is related to an increase in the number of jobs requiring high skills. He also noted that the number of jobs requiring medium skills increases. He claims that we are witnessing the emergence of a new era in which robots are technologically advanced and can better cooperate with human workers (Dahlin, 2019).

4. Trust in robots and the performance of robots are two important factors that influence HRI. Trust can be understood as "the intention to accept vulnerability to a trustee based on positive expectations of his or her actions" (Colquitt et al., 2007). The credibility of autonomous systems is an important issue. A question arises: Are AI programmers able to create trustworthy and robot-controlled systems? Can humans trust in self-steering systems? Who is responsible for potential errors? What about access to data? The moral values of researchers and robot creators are becoming a very important issue. Can programmers code our values, morals, and ethical principles? Trust is a key factor in the effective functioning of interactions in teams composed of various agents (human, robot), performing complex tasks. The programmer's ethics and competencies are becoming a key issue.

5. HRI is also an important aspect of human resource management. The development of HRI influences work efficiency and new managerial, ethical and social challenges. For instance: how can managers evaluate the individual efficiency of employees who are in networks with robots? Arslan (2021) proposes solutions from computer games literature. Robots/AI are becoming part of the HRM strategy. Human-robot/AI cooperation is planned by many HR specialists. It refers not only to

everyday work but also to the development of learning intelligent systems, recruitment, training, or introduction to the workplace.

6. Design of robots, especially ergonomics, plays an important role in HRI. Good design should ensure the mental and physical comfort of employees. Especially in the case of industrial robots, which can carry heavy goods and use dangerous sharp tools. The future research into human-robot relationships should consider mental and psychical health problems. Both beneficial and harmful effects of these interactions on humans should be identified.

Conclusions

Technological development is fascinating but also brings some new challenges. If challenges are not undertaken early enough, they may become threats to organizations, employees, and societies.

Technological and social changes transform organizations. We cannot change the direction of these changes. However, we can observe it carefully and take necessary actions. Actions related to the economic, social, and ethical effects of this transformation.

A new organizational culture is being created. This raises concerns on moral, epistemological, and ontological grounds. Collaboration of scientists representing various disciplines is necessary, in particular representing computer science, robotics, psychology, sociology, ethics and management. Moral values of programmers, managers, scientists have become very important today.

James Bridle, the author of *The New Dark Age: Technology and the End of the Future* (2018) is warning us, stating that technology is exacerbating inequalities, and that we may become slaves to digital technology. Moreover, the research has also shown that robotization and machine learning have not fully eliminated the prejudices observed in society and workplaces (e.g. AI recruitment). Therefore, an issue of human agency in the new workplace needs to be discussed carefully. The nearest future will show which paradigm of human relations with nonhuman beings will be adopted.

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