Enhancing Employee performance in Human-Robot collaboration: a review of literature

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***Abstract*—The emergence of robots has brought reforms in organizational operations and the workplace. The Advent of human-like designed robots and their alliance with humans has allowed organizations to boost their operational capabilities to improve employee performance. The transformed workplace needs human robots to collaborate fluently through greater team collaboration and interactions.**

These robots' resort to various industries for enhancing performance. However, it tends to develop errors while performing tasks if not created and managed scientifically. As collaboration and coordination with these robots by human workers has become a need to achieve organizational performance. There are crucial factors such as compatibility, anthropomorphism, trust, security, safety, and task fit for collaboration between human and robot workforce. Also, there are barriers such as perceived risk, usage barriers, and traditional barriers.

This paper focuses on understanding the Literature of collaboration with robots. It will also uniquely provide the measures managers need to take towards effective collaboration of robots and humans at the workplace. This paper brings a compelling framework for effectual coordination and teamwork of humans with robots towards organizational performance.

I. INTRODUCTION

For gaining competitive edge organizations are aiming towards hyper automation which is achieved through robotic process automation, artificial intelligence, machine learning, Internet of things (Haleem et al., 2021). Robots are defined as "Actuated mechanism programmable into two to more axes with a degree of autonomy moving within its environment to perform intended tasks" (ISO, 2012, p.1). The progressive organizations are exploring the great potential and benefit of Human- Robot collaboration (HRC) at workplace, which is very significant in various industries, factories, manufacturing units, service industries etc. (Arents et al., 2021; Kim et al., 2021; Li et al., 2021). Studies emphasize on the various opportunities under human and intelligent system collaboration for achieving shared goals while working and learning together (Terveen, 1995). Human-robot collaboration can be defined as a medium of direct interaction between humans and robots, aiming to achieve a common goal (Gervasi et al., 2020; Terveen, 1995). To reach to a new level of intelligence, workplace must combine human and machines in order to leverage their individual capabilities resulting in better problem solving and value creation named as super teams of human and machine working coherently (Deloitte, 2020). Also artificial intelligence and robots are to seize the significant jobs done by humans (Alex Howland, 2021) which creates a significant opportunity for human robot collaboration and coordination. The robots can be classified based on their application and need in various industries however, once included in workplace require humans to collaborate with them effectively to achieve the intended goal (Alex Howland, 2021). The inclusion of robots at workplace enhances productivity, performance and decision making (Pillai et al., 2021; Pupa et al., 2021).

Industry 4.0 have shifted the business landscape to include intelligent robots to team up with humans (Weiss et al., 2021). There are industrial evidences for the need of human robot collaboration to achieve business success. For example, in an industrial setting a collision free environment is evidently important for successful HRC (H. Liu & Wang, 2021). The hybrid system in manufacturing setup to match up the increased mass customized production which is successfully possible because of effective HRC (Dianatfar et al., 2020). As robots are employed in organizations as per the business requirement, this create different avenues for humans to collaborate and

interact with robots to complete business operation (Gervasi et al., 2020) Such as, robots are included in assembly line in industrial setting (Hjorth & Chrysostomou, 2022), service robots for providing effective service to the customers (Kahraman et al., 2020; Pillai & Sivathanu, 2020), Humanoid robots for customer engagement (Wheelock, 2016) etc. According to the report published by Deloitte in 2018, around 78% of organizations are already have functional robots and organizations are planning to increase the investment in coming financial year also, robots have already replaced full time employees with an average of 20% in a year, with future performance projection towards various business arears such as cost reduction, improving the production quality and required compliances (Wright et al., 2018).

The business operational efficiency can be achieved with the synergy of collaborative team of human and robot (Buerkle et al., 2021). This synergy towards organizational performance is evident from several examples from across the industries such as, robots partnering with the medical staff to take care the patient while saving the humans from highly infectious disease (Gbouna et al., 2021). In construction industry, robots collaborating with humans to work in dangerous environment helps in achieving the business goals (Y. Liu et al., 2021). Service robots in the frontline for better customer service and customer satisfaction (Garcia-Haro et al., 2021). Collaborating with robots in extremely manipulative and dangerous work provide complete operational efficiency under HRC (Brantner & Khatib, 2021). The effective human-robot collaboration benefits human and organization in many ways like for humans, it leads to reduction in stress, workload, fatigue, risk, error etc. and focus in more strategic work (Green et al., 2008; Haleem et al., 2021). And for organizations in elevating business performance through improved quality, saving cost, better financial results, elevated operational efficiency, satisfied customers etc. (Sivathanu & Pillai, 2020; Wright et al., 2018). With the aforementioned evidences it is confirmed that human-robot collaboration and coordination leads towards tremendous benefits for the organization. However, "Human robot interaction problem is to understand and shape the interactions between one or more humans and one or more robots" (M A. Goodrich, 2007, p.15). Teaming human and robot to work together to achieve its full efficiency is still at infant stage in its practical scenario (Parvez et al., 2022).The employees need to be assisted and imparted with sufficient knowledge and skills for effective HRC (Parvez et al., 2022). There is a dearth of research in understanding the various components leading towards effective human robot collaboration (Arents et al., 2021; D'Andrea, 2021; Hjorth & Chrysostomou, 2022; Li et al., 2021; Parvez et al., 2022).

II. LITERATURE REVIEW

Human-robot collaboration can be defined as a humans working with robots in coordination to accomplish tasks a common goal (Castro et al., 2021; Weiss et al., 2021). Robots are made human-like with the technology of artificial intelligence, neural network, cognitive architect, and adaptive motor control, conversational, natural language processing and collective intelligence to substitute human intelligence (Robotics, 2022). The technological innovation in industry 4.0 require human to create inclusive environment for robots. The extensive research across the industries highlights the primary interface of human and robot coordination and collaboration, it is confirmed human need to pilot the intelligent robots (Brantner & Khatib, 2021). Lot of opportunities embark in Industry 4.0 with enhanced production with the help of intelligent robots (Roveda et al., 2020). In manufacturing industry specifically assembling the goods require a good collaboration of humans wherein robots perform functions like humans (Roveda et al., 2021). Machine learning enables the human-robot collaboration in which human guided robots perform with perfect coordination (Al-Yacoub et al., 2021).

The human robot collaboration where robot's compliment with humans to perform certain tasks. Like in healthcare robots assists the medical staff and patients with various medical requirements for taking care of patients and helping nurses for their exposure to infectious diseases (Gbouna et al., 2021). Industry 4.0 has given a perfect technological solution to the industries by introducing technology like robots, and its implementation at the workplace requires seamless interaction between humans and robots without any risk of safety for humans (Kofer et al., 2020). Another example can be portrayed in construction industry, where HRC brings an effective synergy in dangerous

environment and enhancing work effectiveness (H. Liu & Wang, 2021). Service robots are incorporated at both personal and professional levels to provide better service satisfaction for employees and customers (Garcia-Haro et al., 2021). In the working scenario, humans deficient in motor skills can be complemented with robots to optimize work capacities (Ferracuti et al., 2021).

III. RESEARCH METHODOLOGY

In Industry 4.0, the widespread disruption of technology has pushed humans to collaborate with robots to achieve and maximize organizational performance. HRC is beneficial in many ways towards organizations and humans in improving quality, production capacities, mass production attainment, financial benefits, customer and employee satisfaction, and well-being, etc. As can be observed through the extant literature, the positives of HRC. However, there are multiple advantages and barriers to its application. So, exploring multiple advantages and obstacles for human-robot collaboration and coordination is detrimental.

For studying literature, the authors have studied 120 research studies from various research databases, such as Scopus, ProQuest, EBSCOhost, and Shodhganga were sourced. The selected studies were selected according to the criteria of fitting the domain of management and business. Employee behavior towards technology and automation, and human-robot collaboration. The keywords were decided by the authors based on the study field and domain. The keywords used were human-robot collaboration, employee behavior, employee performance, employee attitude, employee perception, adoption of robots at the workplace, etc. Then the papers were thoroughly analyzed and segregated in Excel by author, title, year of publication, summary, conclusions, findings, construct studied, model used, and research method adopted. Post this analysis, a detailed study was conducted to understand the significance and the literature behind it and draw findings and conclusions from it. The duration of the study is from 2019 to 2025. As seen in the picture there is an increase in

The distribution of research papers across significant years is showcased in Figure 1.

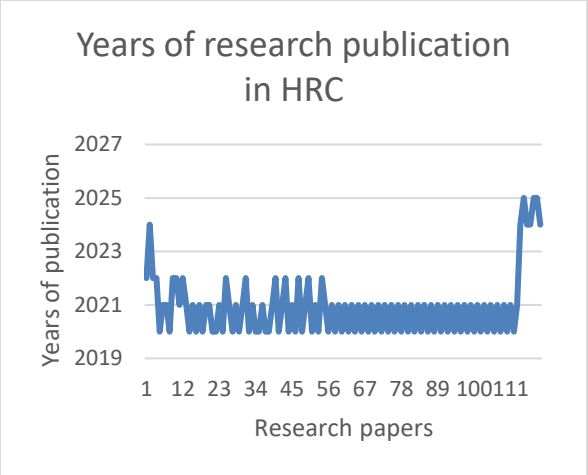

Figure 1: Research paper publications over the years

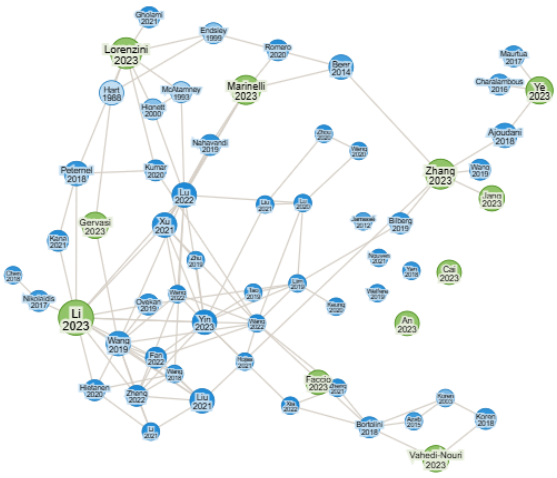

Figure 2: Network of authors for HRC studies

Figure 2 elaborates the network of authors who reportedly have contributed to human-robot collaboration studies. Also, the population considered in the reviewed literature is given in Figure 3.

Population	Headcount
Not specified	65
USA (recruited participants)	8
EU (Expert Panel)	2
Greece (manufacturing workers)	2

Not specified (HRC teams)	2
Not specified (manufacturing workers)	2
USA (educators)	2
USA (emergency workers)	2
USA (office workers)	2
Austria (office workers)	1
Belgium (manufacturing workers)	1
Denmark (agricultural workers)	1
Dutch and German (industry workers)	1
France (therapists)	1
Germany (assembly line workers)	1
Germany (assembly workers)	1
Germany (industrial workers)	1
Germany (public workers)	1
Germany (recruited participants)	1
Germany (Restaurant)	1
Global (Tourism sector)	1
Hungary (automotive workers)	1
India, Jordan	1
Indonesia (611 public sector employees)	1
Italy (automotive workers)	1
Italy (logistics workers)	1
Japan (office workers)	1
Mexico (manufacturing workers)	1
Not specified (assembly line workers)	1
Not specified (general HRC teams)	1
Poland (190 cobot operators)	1
Portugal (assembly workers)	1
Portugal (Industrial workers)	1
Recruited participants (not specified, recycling context)	1
Spain (industrial workers)	1
Thailand (hotel employees)	1
UK, NZ, USA	1
USA (329 respondents via Amazon Mechanical Turk)	1
USA (caregivers)	1
USA (household workers)	1
USA (manufacturing workers)	1
USA (service workers)	1
Total	120

IV. CONCLUSION

This research paper provides thoughtful and evidence-based insights on the direction and progress of HRC studies. Especially on highlighting the gaps in literature in terms of the populations, as only a few studies have been conducted on the Indian population. Also, the research area of HRC has increased substantially post-2021. The studies specifically related to employee behavior, perception, and attitude require studying to enhance employee acceptance of robot and automation at workplace leading to seamless human robot collaboration.

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