Unintended Impacts of Collaborative Robots on Social Relations at Work[1]

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ABSTRACT

In light of the growing use of collaborative robots in workplaces, this article investigates how they reshape workplace dynamics and have unintended impacts on the psychosocial work environment and social interactions—issues central to the Nordic model of 'good work'. This article builds on qualitative interviews from three workplaces in Sweden: a mechanical workshop, a university laboratory, and restaurants in an amusement park. To interpret the findings, we apply Collins's theory of interaction rituals. While robots were introduced to reduce physical strain, they initially also generated enthusiasm, learning, and ergonomic relief. Over time, however, they contributed to job intensification, additional tasks, and fewer opportunities for spontaneous interaction. The study contributes to debates on robot–human relations and interaction rituals by showing how robots can energize or disrupt social interactions, providing insights into the theoretical understanding and the practical implementation of social robots in the Nordic work context.

KEYWORDS

collaborative robots / social interaction rituals / work environment / workplace study

Introduction

The opportunities and challenges posed by the digital shift have been the subject of extensive research and debate both within and beyond this journal (Abeliansky et al. 2024; Alasoini 2022; Berkers et al., 2023; Haapakorpi & Alasoini 2018; Heinold et al. 2023; Johansson & Abrahamsson 2021; Murphy 2024; Pringle 1988; Solem et al. 2023). A part of the digital shift is the growing introduction of cooperative robots into workplaces (Weiss et al. 2021). As robots become colleagues, the future of work is

being reshaped in ways we are only beginning to understand (Brougham & Haar 2018; Frey & Osborne 2017).

The impact of new technology is complex and can have unintended consequences (Edwards & Ramirez 2016; Hughes 1996; Orlikowski 1992), as digital technology has been shown to be used in unforeseen ways when implemented (Dupret & Friborg 2018). By unintended consequences, we here mean effects that were not part of the explicit intentions behind the technology, but nevertheless emerged once implemented. Introducing new technology impacts the work environment already in the implementation process (Palm et al. 2024), and the effects of the same technology might differ even within the same organization (Regin 2022).

Research on the introduction of robots in the workplace has taken different approaches. Some studies have focused on risk elimination, such as preventing collisions in shared workspaces where humans and robots interact (Nikolakis et al. 2019; Oyekan et al. 2019). Others have examined how robots can reduce physical strain by eliminating ergonomically unfavorable tasks or making them more manageable (Armijo et al. 2019; Locks et al. 2018). At the same time, certain robotic applications may worsen the physical work environment. For example, in robotic surgery, surgeons have reported significant neck and torso strain, arm positioning issues, and posture challenges due to the design and use of robotic consoles (Craven et al. 2013). While robotic assistance has been shown to enhance efficiency, automated processes can also disrupt workflows and necessitate workarounds that ultimately counteract efficiency (Walsh et al. 2011), which can lead to job intensification and frustration (Cavuoto et al. 2017). A literature review on the work environment of healthcare personnel by Persson et al. (2022) found that the introduction of robots had both positive and negative effects. While robots improved the quality of work, they rarely led to better resource utilization or increased time efficiency, despite the common assumption that automation enhances effectiveness. Similarly, Wasen (2010) found mixed results in a study of robotic assistants. While the assistant contributed to a reduced workload and increased perceived independence, it also led to social isolation when robots replaced human colleagues over time.

The impact of technological changes differs between institutional settings, organizations, and jobs (Alasoini et al. 2022; Silverstein 2010), as issues of organization and technology are highly connected (Haapakorpi & Alasoini 2018). New technology might interrupt and reconfigure workplace roles and relations (Cascio & Montealegre 2016), which underscores the importance of recognizing the impact of the social mediation of technology in various settings (Joyce et al. 2023). Furthermore, the impacts of robots may also differ on an individual level. Some research suggests that those inexperienced in their roles benefit more from robotic assistance in terms of workload, stress, performance, and ergonomics (Chandra et al. 2010; Passerotti et al. 2015), whereas other studies indicate that older workers may face greater challenges when adapting to new technologies (Solem et al. 2023). However, Solem et al. (2023) argue that workplace conditions—such as access to training and the implementation process—play a more significant role than individual characteristics, underscoring the importance of organizational context when assessing the impact of robotization.

While robotic integration promises to enhance efficiency and ergonomics, it also presents challenges to workers' psychosocial wellbeing, particularly regarding the usage of skills, autonomy, and the sense of meaningful work (Craven et al. 2013;

Nikolova et al. 2024; Persson et al., 2022). The experience of meaningfulness and well-being at work is shaped by social factors such as interpersonal relationships (Adattil et al. 2024) and reciprocity (Olsson 2008), both of which may be affected by the introduction of robots (Nikolova et al. 2024). Social relationships and human interactions, arguably through social interaction rituals, play a crucial role in generating emotions such as excitement, anticipation, and identity (Collins 2005). Without these interactions, individuals risk experiencing isolation and a diminished sense of meaning. These interactions, however, have been seen as relying on direct human face-to-face engagement (Collins 2020).

As organizations increasingly integrate collaborative robots, further research is essential—especially at the workplace level—to understand their impact on social interactions and the broader sociotechnical dynamics (Weiss et al. 2021). This issue is particularly relevant in a Nordic context, where the Nordic model—characterized by strong unions, collective bargaining, and worker participation—has historically promoted a cooperative approach to technological change (Ahlstrand 2013).

While Nordic unions have actively engaged in the digital transition, emphasizing job quality and worker influence, the introduction of collaborative robots introduces new challenges, particularly concerning social interaction and workplace dynamics (Berx et al. 2021; Weiss et al. 2021). Researchers have identified and classified various risk factors in this collaboration, emphasizing the importance of addressing psychosocial, ethical, and cyber risks (Berx et al. 2021). While studies on digitalization suggest that the introduction of new technologies can negatively impact the work environment (MYNAK 2020), there remains a lack of research on the effects of collaborative robots outside laboratory settings—particularly regarding psychosocial aspects of the workplace (Berx et al. 2021; MYNAK 2022; Weiss et al. 2021). The psychosocial work environment encompasses factors that influence stress, mental health, and wellbeing. It includes the demands placed on employees, the resources available to meet those demands, and the responsibilities associated with their roles (see Bakker & Demerouti 2017). Additionally, it involves social aspects of work, such as interpersonal relationships and workplace dynamics (Adattil et al. 2024). The introduction of collaborative robots into the workplace could potentially reshape all these dimensions, underscoring the need for further research—particularly studies that focus on social interactions in human–robot collaboration, as there is a gap in research in that area (Berx et al. 2022; MYNAK 2022; Weiss et al. 2021).

This article seeks to address this gap by examining the unexpected impacts collaborative robots have on workplace interactions and the overall work environment. Drawing inspiration from frameworks on social interaction rituals (Collins 2005), this article focuses on identifying unintended and unexpected impacts through the following research questions:

- How do unintended and unexpected impacts of collaborative robots manifest in the work environment?
- How can collaborative robots impact the psychosocial work environment?
- How can collaborative robots influence social interactions at work?

The article discusses these issues by exploring the impact of collaborative robots in three different workplaces. We distinguish between intended outcomes (those argued

by managers when introducing robots, such as improving the physical work environment), unintended outcomes or impact (effects that were not part of those intentions but nevertheless emerged), and unexpected outcomes which we treat here as a subset of unintended ones referring to effects that were not only outside the stated intentions but also beyond what managers or employees imagined possible in advance (see Tonn & Stiefels 2019). The analysis shows that collaborative robots can produce outcomes across all three categories, and that their character may shift over time as the technology is put to use.

First, a review of research on new technology at workplaces relevant to this article is presented, followed by the theoretical framing of social interaction rituals, which has inspired the focus of this article. Thereafter, the cases and means of data generation are presented, followed by the findings and main conclusions. In the findings, the intentions and processes behind the introduction of the collaborative robots are discussed, followed by the reports of the experiences during and after the introduction of the robots. The effects on the psychosocial work environment are thereafter discussed, with an emphasis on how the robots affect social interactions at the workplace level.

New technology and social interaction rituals

Social relationships and interactions—with or without new technology—are key aspects of the psychosocial work environment, as the psychosocial work environment 'includes an individual's interaction with all aspects of their work situation' (Abrahamsson & Johansson 2013, p. 6). Reciprocity in social relations in the workplace is important for an employee's sense of wellbeing, where a sense of closeness and similarities can buffer negative aspects of the job (Olsson 2008).

To analyze the impact of collaborative robots on the psychosocial work environment, this article draws inspiration from Collins's (2005) theory of Interaction Rituals. Collins develops his framework by synthesizing insights from Durkheim, who emphasized rituals and shared emotions as foundations for social cohesion and collective experiences, and Goffman, whose micro-sociological perspective highlighted how everyday encounters shape identities and social organization (Johannessen 2023). Collins combines these traditions to extend ritual theory to both religious and secular, large and small, planned and spontaneous interactions. This provides a framework for understanding how micro-level interactions accumulate into broader social structures at the meso- and macro-levels (King 2019). Collins also situates his work within the conflict tradition, drawing on Weber to analyze how interaction rituals reproduce hierarchies and stratification (Collins 1975, 2005; Loyal 2019).

According to Collins, an interaction ritual is 'a mechanism of mutually focused emotion and attention producing a momentarily shared reality, which generates solidarity and symbols of group membership' (Collins 2005, p. 7). These interactions are one of the most fundamental forms of social interactions and a cornerstone to understanding group dynamics and human interactions (Collins 2020). While the term rituals might give associations to highly formalized or ceremonial acts, Collins (2005) stresses that in this framework, rituals are instead to be understood as interactions at

all levels, from greeting one's neighbor and bantering at work to formalized ceremonies in the likes of funerals and weddings. The interaction rituals are constituted by a mutual focus and coordination, where the participants share a physical presence that enables them to see, hear, or sense what others are doing, have a mutual focus of attention, share similar emotions connected to the situation, and in some ways get into the same rhythm in terms of intensity of speaking, rhythm of talk, or physical movement (Collins 2005, 2020). When successful, these interactions strengthen group solidarity and provide emotional energy in terms of (for example) enthusiasm, confidence, and engagement. These ongoing rituals, Collins argues, are what 'gives people their identities; makes them enthusiastic or antipathetic to various things in their social environment' (Collins 2020, p. 481). At the same time, failed rituals or lack of interactions leave the participants with a sense of isolation, meaninglessness, and fatigue. Collins further argues that face-to-face interaction and shared physical co-presence have been a cornerstone in shaping solidarity and a sense of closeness throughout human history, being the normal condition for human interaction (Collins 2020).

One critique of Collins' framework is how digital technology and mediated communication are perceived (Johannessen 2023): While Collins argues the importance of embodied interactions (Collins 2020, p. 496), other studies have challenged that statement (see Johannessen 2023 for a review). DiMaggio et al. (2018) found that even online communication can produce emotional energy, and von Scheve (2014) concludes that engagement with artificial companions can produce emotional energy in terms of enthusiasm and solidarity, creating emotional bonds and a sense of belonging, although not at the same levels as in human-to-human interaction. In exploring the impact of robots on interaction rituals, Kamino et al. (2024) found that while the socially designed robots in their study could not be perceived as social actors, the robots became a focus point and source of shared identity among robot owners. Analyzing the human-robot interaction as a chain of interaction rituals, Kamino et al. argue that 'Robots come to be focal objects in many different kinds of social interactions that people treasure' (Kamino et al. 2024, p. 350), initiating and strengthening interaction rituals among individuals. However, how collaborative robots impact workplace social interactions is still underexplored. This article, therefore, aims to contribute to the debates on the role of technology within Collins's framework (Johannessen 2023).

Another critique of Collins's framework of social interaction rituals is a lack of sensitivity to power relations and limited reasoning about how and why the interaction rituals emerge (King 2019), which is why the framework also needs to be sensitive to other socio-structural factors. Taking this into consideration, Collins's framework is not argued in this article to be the only possible aspect of the impact of robots in the line of work, but seen as one relevant perspective to explore, with a sensitivity to include other social-structural factors, such as division of labor, and the social mediation of technology related to the organization of work.

By exploring the introduction of collaborative robots in various work environments, this article contributes to addressing the research gap of unintended and unexpected impacts of robotization. Drawing on the theoretical framework of interaction rituals (Collins 2005), it provides additional perspectives on how collaborative robots influence social interactions and group dynamics within workplaces, contributing to

the understanding of how robots impact the psychosocial work environment, and the debates on the role of technology related to social interaction rituals.

Context and methods

Context

This article is based on data from three different workplaces: a mechanical workshop, a university lab, and restaurants and a café in an amusement park that introduced robots to reduce the physical workload, strain, and repetitive tasks. We searched broadly for workplaces that had robots introduced, where the robots were presented as colleagues or viewed as colleagues at the workplace. We advertised through social media and made direct contact with companies selling robots to find organizations with workplace robots.

These workplaces were not selected to represent particular differences, but because they had introduced collaborative robots. The workplace context shaped the interviews. In the lab and workshop, the focus was on co-worker interactions, while customer-facing interactions were also explored in the restaurants. Differences in organizational structure and work practices influenced who could participate and the experiences reported. This variation enabled the analysis to identify both common patterns and context-specific effects of robots on social interactions and the psychosocial work environment.

The mechanical workshop specialized in hydraulic systems. As part of their strategy to keep their production in Sweden and provide a sustainable work environment, the company decided to introduce a collaborative robot in the manufacturing process. The robot did tasks that would be highly repetitive, ergonomically straining, and degenerating for employees.

The university lab took samples, analyzed samples, and provided analysis consulting. The lab supported point-of-care testing performed by healthcare personnel. It was tech-heavy, meaning that a large part of the work was automated. As part of the lab's strategy to improve the physical work environment, they introduced two collaborative robots that eased the ergonomic work strain of the lab technicians. The lab was located at several sites.

The restaurants were located in an amusement park. Five robots assisted in the hospitality services with the intention of relieving the staff from heavy lifting and walking long distances. Robots brought food to the programmed position, and once in place, the waiting staff served the food to the customers from the robot to the table. The employees used the robots when they served food and removed dirty dishes. They also interacted with the customers, who were often families with children due to the location in or next to an amusement park, about the robots.

Data generation and analysis

The data in this article consists of qualitative interviews with employees and managers in the mechanical workshop, the university lab, and restaurants in the amusement park.

Altogether, the data consists of interviews with 21 individuals, where six individuals hold various managerial positions (See Table 1).

Table 1 List of participants

Workplace	Lable	Role
A - Workshop	Work_group_1	Two employees (group interview)
	Work_group_2	Two employees (group interview)
	Work_manager	Manager
	Work_CEO	CEO
B - Lab	Lab_1	Employee
	Lab_2	Employee
	Lab_3	Employee
	Lab_manager	Manager
	Lab_4	Employee
	Lab_5	Employee/ Health and safety representative
C - Restaurant	Res_manager	Manager
	Res_HR	HR manager
	Res_head waiter1	Head waiter
	Res_head waiter2	Head waiter
	Res_head waiter3	Head waiter
	Res_area_manager	Area manager
	Res_1	Employee
	Res_2	Employee

The interviews took place at the different workplaces, which also gave the interviewers an opportunity to see the robots in use. Although these were not systematic observations based on a predesigned observation protocol, these workplace visits and on-site interviews enabled a broader understanding of the role of the robots in the different workplaces. The interviews lasted between 15 and 60 minutes, and were guided by an interview guide focusing on themes such as social interactions at work, changes in work process, and experience from the introduction of the robots. These themes were informed by theoretical frameworks on the social work environment, social mediation of technology, and social interaction rituals. The interviews were guided by the same interview guide. Follow-up questions were adapted to each interviewee, for example, focusing more on customer interaction when interviewing restaurant staff. The data from the different workplaces were then combined to form the basis of the analysis. Although the workplaces were studied as individual cases, the interview questions and the following analysis were informed by the theoretical framework and overall focus: how robots impact the social work environment and workplace interactions.

All interview data was recorded and transcribed. The transcribed interviews were then coded and analyzed with inspiration from thematic analysis (Braun & Clarke 2006; Bryman 2016) using NVIVO. The coding and thematization were made in different stages, or cycles of coding and analysis (Bingham 2023), where thematization occurred

throughout the research process, with recoding and refinement at each step (Saldaña 2016). The coding of the data was not initiated before the transcription, and one initial reading of the interview was done, as recommended by Braun and Clarke (2006), to keep an open mind in the coding process. All project researchers were involved in the process at different stages to ensure an appropriate level of rigor in the coding (Maher et al. 2018).

After an initial close reading and familiarization with the data material, as encouraged by Braun and Clarke (2006), broader themes and patterns were discussed among the researchers involved in the project. This initial discussion resulted in the generation of general areas of interest, whereas one such area—the impact collaborative robots have on social interactions and the psychosocial work environment—is the topic of this article.

From these initial discussions, a first round of 'fracturing' of the data (Tracy 2024) was performed by the first author. This fracturing consisted of the creation of descriptive first-order codes (Bingham 2023) such as 'excitement', 'new tasks', 'frustration', 'relief', 'engagement', and, 'isolation'. This fractured data, the first order-codes, was then lumped together (Tracy 2024) in broader themes such as 'changes in the work process', 'job intensification', 'novelty effect', and 'patterns of social interaction'.

As a final step of the process of coding and analysis, the overarching themes of impact on social interaction at the workplace were developed through re-engagement with extant theory from the literature (Saldaña 2016). For example, the shared excitement among employees regarding the new robots was analyzed in relation to Collins's framework of interaction rituals, and experienced job intensifications were understood in the light of theories of social mediation of technology, which is why the research process has moved back and forth between theory and data in an abductive manner (Karlsson & Bergman 2016).

The generated themes were then brought together to shape the narrative that is presented in this article. Rather than structuring the findings based on the themes, such as work intensification, social isolation, or reduced social interaction rituals, the analysis aims to capture the processual impact of the robots. The findings are therefore structured as overarching narratives, abstracted from the dynamics and developments across the cases. We use illustrative quotes to provide nuances to the narrative presented.

The study was approved by the Swedish Ethical Review Authority (Dnr. 2023-04127-01).

Findings

Based on the themes generated in the analysis, the findings are structured in a narrative manner to reflect the whole process of robots entering the workplace, from the decision-making phase to their use, where analysis and engagement with previous research are interwoven in the narrative. Initially, the findings related to the intentions and processes behind the introduction of the robots are presented in relation to their impact on social interaction. This is followed by an examination of workers' and managers' experiences during the introduction phase. Thereafter, the subsequent experience of work when the robots were in place is discussed. In the final discussion, the findings are discussed in relation to Collins' theoretical framework before the conclusions are presented.

The decision process before the introduction of robots

The main aim or argument of introducing robots in all three organizations was to improve the work environment by removing strain and monotonous tasks. The Restaurant robots carried trays, the robot in the lab opened and sorted samples, and the robot in the workshop was designed to handle hoses and connectors. The robots were collaborative and intended to work independently but in shared work processes with employees, and in doing so, replacing certain work tasks previously performed by humans. They were intended to supplement and support the employees rather than replace workers. The rationale for introducing robots was similar in all workplaces: managers or other actors in contact with pre-existing technology decided that robots might be helpful in their respective organizations and started processes to find the proper use for the robots. There were, however, additional, perhaps unintended (Edwards & Ramirez 2016), effects.

While managers at the workplaces brought forth the aspect of work environment quality as an important factor behind investing in the robot, managers at the Workshop and the Restaurant also stressed the potential of the relief brought by the robot to improve productivity and thus cut manpower costs in terms of robots replacing workers. A mid-level manager at the restaurant said:

> The reason was probably that we could use the robot to serve the staff. And ergonomically, not having to exert ourselves so much when it comes to carrying and walking with carts, and so on. And that, in a way, we may not need to be as many in the serving if we can perhaps have more in the kitchen or if it is in the bar. Or maybe even reduce staffing if the robot helps and saves money. (Res_head waiter1)

There were also expectations from the Restaurant management that the robot could add something extra to the customer experience besides relieving the staff. While the idea was to reduce the workload, the robot could also 'be a bit of an amusement for our guests, for them to see and appreciate, as there are not that many restaurants that have these things today' (Res_manager). In that regard, there was, if not an intention, but an expectation that the robots in the restaurant might have an influence on social interactions at the workplace, although not between colleagues, but in the interaction between visitors, robots, and employees.

While there were expectations from management regarding the usage of the robots in all cases, there was also a degree of voluntariness in usage in all the different cases and discretion regarding the usage of the robots, ranging from the mandatory usage of one of the robots in the workshop, the expressed expectations from the management in the restaurant to use the robot, to the voluntary (but encouraged) use of the robots in the lab. A manager at the Lab (Lab_manager) stressed that the employees could choose to use the robot or not, as long as they got their job done, but also made it clear that if someone were to complain about the workload, they would be told to use the robot. These findings highlight how managerial decisions and the organization of work are impactful beyond the technology itself (Haapakorpi & Alasoini 2018; Pringle 1988).

The initial phase of deciding to introduce and design the robots was mainly a matter for the management and the robot providers, with little apparent consideration of how the technology might affect social interaction at the workplace. There were, however,

also examples of the staff being involved in the process of deciding the usage and having influence over the design of tasks to be performed by the robots. Depending on the level of employee involvement, these early stages of decision and implementation of the project had different effects on the social work environment (Cf. Palm et al. 2024). In the lab, the news that they had been selected 'to get a robot' sparked enthusiasm among some of the employees, making it a talking point, and a joy over being 'involved in the whole journey' with the robot (Lab_1). A lab manager said, 'Initially, I would say it had a significant social impact because it became a sort of talking point among us… and people started talking to each other across different departments. Everyone was curious, and it led to a lot of social interaction in that way'. At the restaurant, on the other hand, there was a perceived lack of information and involvement, and the news of getting a robot was treated as a matter of fact, with little reflection on or impact on social interactions. The different levels of involvement demonstrate how organizational factors in the introduction of new technology influence their social impact (Joyce et al. 2023).

The actual introduction of robots and their impact on social interaction

The theme of increased interaction and excitement became even more prevalent in relation to the introduction of the robots. However, it was perhaps not so much the function of the robot or the interactions with the robot that had a significant impact, but the novelty of this new technology. One aspect of the increased shared interaction between employees at the various workplaces seemed to be the shared attention directed to the robots in terms of collective learning and cooperation in figuring out how to use the robots, how to reorganize adjacent work tasks, and establishing norms of usage, making the robot a shared focal object in a social interaction ritual (Collins 2005; Kamino et al. 2024). There was also a more general excitement about having this new machinery, with testimonies of the excitement when the robot was introduced and how they all gathered up, ready with cameras, for the formal unveiling of the machine. One employee (Lab_2) said that:

> Yes, it was exciting, people thought. Yes, they were unpacking it, and you were there watching. 'Well, what do they do with it now?' [laughter]

One aspect of this excitement was the joy in being part of the introduction of the robot, stressing the importance of the implementation process (cf. Solem et al. 2023). This excitement, however, did not directly seem to be connected to the specific technology but was a pleasure of learning something new in an area that is far from their original line of work. Lab_4 expressed this in terms of: 'I mean, I am a nurse, and I have never even thought about things like this, and I am not an inventor of anything like that, but when I got involved in this, it really became something that I see and think is great fun that you can really develop further'. Another source of anticipation and excitement was the mere fact that something new was happening that would bring variety to the workplace. Both the introduction of the new technology, the process of learning how to use it, and the recurring breaks in their work routine to support or feed new tasks to the robot were considered positive. It created opportunities to do something else for a while

or to learn something new, as a part of the reconfiguration of workplace roles (Cascio & Montealegre 2016).

One additional aspect of the excitement of robots was the interest they drew from people outside of the workplace. While there were some tendencies of this in the workshop, where the robots drew attention from customers (and researchers) visiting the location, it was more present in the lab and the restaurant. When asked what they thought of getting a 'robot as a colleague' in the lab, there was excitement about the attention it had attracted from others. For example, one participant explained how a relative had seen a clip about the robot on social media and reached out to tell them about it. Others recalled being asked to host visitors and talk to them about their experiences. In that regard, it might be an excitement over the fact that others saw their workplace as interesting, which in turn increased the enthusiasm they felt over their own work (cf. Collins 2020).

This excitement and increased social interaction were, however, more prevalent in the early phase of robot usage and diminished when interaction with the robot became part of the everyday routine. A mid-level manager at the restaurant (Res_head waiter1) summarized their initial engagement with the robots, saying that the staff was 'getting used to it now, but it is fun for the new employees'.

The robots, after the introduction, decreased physical strain and increased workload

While the robots were introduced to relieve the staff from physically strenuous work tasks, the robots were also, in some regards, used to increase the pace of work and the overall workload. For example, in the lab, the usage of robots was initially driven by a clear idea of what tasks the robots were to take over from the humans and how that would positively affect the work environment. However, after the robots were introduced, the discourse changed, and the potential to improve productivity became more prevalent.

> When we got the first robot, it was 100% that it would help us with the work environment. That was the main objective when we went into that project. There were no other thoughts. Then, of course, we saw a side effect and a benefit/gain that we also freed up time to do other things (Lab_manager).

One effect of this increased efficiency in the lab was that the robot freed up time in the work process, thus enabling the employees aided by the robot to relieve employees at other workstations. The opportunity to add instrumental and social support in the line of work also had implications for the social relationships at work, as it provided time to 'breathe and talk' (Lab_1) a bit among colleagues, enabling increased social interaction.

At the same time, a process of job enlargement seemed to occupy the time freed up by the robot. One aspect of this was additional work tasks connected to work process adjustments needed for the usage and maintenance of the robot. This was found in all workplaces explored in this study, whether it was cleaning and redirecting the robot in the restaurant, checking in and filling up boxes for the robot in the workshop, or taking care of the Lab robot and making sure it had something to do. Another aspect of the

additional work tasks was the increased workload, which was not met with increased staffing; as a result, the supposed relief to be brought by robotization did not materialize. One of the employees at the lab suggested that:

> If we had remained in a world where nothing changes, where we had had the same number of samples coming in, then perhaps more time would have been freed up, but as the sample volume is constantly increasing, you do not notice that you have more time. There is always something additional that is added, so to speak (Lab_2)

In the restaurant, the robot seemingly led to increased efficiency, or work pace, among the employees. As the robot took over some of the time-consuming parts of the work processes, the employees could focus more on serving customers and preparing the tables in the dining area, leaving the robot to carry out dishes and bring food to the table. 'It makes me work faster', as an employee (Res_1) puts it when asked how the robot has affected her work. It is difficult to determine whether these effects should be regarded as unintended since stated intentions might be accompanied by unstated expectations (Edwards & Ramirez 2016). However, some of the impacts are arguably more the result of managerial decisions and the organization of work rather than the technology itself (Pringle 1988).

While the robots, in general, seemed to have had a positive impact on the physical work environment, there were also limitations, creating a need for adjusted work processes and ways to work around the limitations of the robots (cf. Cavuoto et al. 2017; Walsh et al. 2011). In the Lab and the Workshop, there was seemingly no need to use the robot for smaller tasks, such as small batches of samples that are to be sorted or small orders to be prepared in the workshop. In the restaurant, on the other hand, the use of the robot was not used during peak hours, as it ran into problems if there were too many customers in the restaurant; perhaps a bit ironically, the robot thus seemed to malfunction when it was most needed. An interviewee (Res_head waiter3) said that the robot got stuck if there were too many people in its way, meaning that the employees needed to roll it back to its starting position and restart the process, concluding that 'it can also get to a point where they are not so helpful, and you need to spend more time picking them up, going and charging them or helping them to the place they are going' (Res_head waiter3). Another limitation was the time that it took for the robot to navigate in a crowded room, leading to cases where the food got cold before it reached the guests. In these situations, the use of the robot seemed to be reduced, as the staff would instead go to the kitchen to pick up the food themselves. Reduced physical work strain because of the introduction of robots, which occurred in parallel with job intensification, increased the workload at different workplaces. While arguably not a direct effect of the robots, besides the limitations and occasional malfunctions of the technology, this intensification might be seen as an indirect effect (Hughes 1996) in terms of the reorganization of work enabled by the introduction of robots (Haapakorpi & Alasoini 2018; Pringle 1988).

Impact on social interactions

According to one manager in the restaurant, the robots led to increased social interaction because the robots brought the work process of different employees closer together,

which would indicate increased opportunities to engage in interaction rituals (Collins 2005). On the other hand, that narrative is contradicted or perhaps given another perspective by another restaurant employee who witnessed reduced social interaction with the kitchen employees, as it was now the robot rather than themselves that brought the food from the kitchen to the tables:

> I think you can communicate better with the kitchen if you always have a constant conversation about 'how is the food?' 'When should I come and pick it up?' So that it can come out of the kitchen as quickly as possible and be served to the guests. And then... Yes, it is just that tasks are taken from you in a way, even though, at the same time, it can sometimes make things easier. But also, if you enter the kitchen, you will also be talking to more colleagues, and that can also be nice. It is the daily human contact or what to say. I do not know how to express myself properly, but it is... (Res_2)

The reduced social interaction among employees because of the introduction of the robots was most visible in the restaurant. When the robot became the physical link between the kitchen, dining area, and dish station, there was no need for the staff to move between these different areas, removing an important precondition for social interaction rituals (Collins 2005). As a result, some employees experienced isolation and monotony, saying, 'I am alone, and I do not have the opportunity to go anywhere. Because I cannot leave the café, I am stuck here all day. Then I stand here for almost ten hours every day' (Res_2). The same employee also saw it as a risk that the guests might lose some of the service value if they are serviced by a robot rather than a human.

   In contrast to this sense of increased isolation, some employees in the lab described how the robot constituted something similar to social company in certain situations, demonstrating how new technology could be used in unforeseen ways when implemented (Dupret & Friborg 2018). The room at the lab in which one of the robots was located was called the 'dispatch room' and was where samples were sorted and sent off to different labs for testing. Except for the robot, there was often just one employee manning that station. In the following passage, a participant (Lab_2) describes how the robot provided company:

> It keeps working over there, well, at its own pace [laughs]. In a way, it's company when you are in this room because you can be quite lonely in the dispatch room. It keeps chugging on over there.

Besides this description of a robot as a social company, in some regards comparable to human interaction, leading to decreased loneliness (an issue that is discussed further at the end of this article), robots in the Restaurant and the Workshop seemed to have the most impact on social interaction. The robots, in these cases, came across as objects shared by the employees to direct their attention to (either shared between co-workers or between employees and guests) and to build interaction around them (see Kamino et al., 2024). In the workshop, the robot—despite its non-humanlike appearance—was treated in an almost human fashion and interacted beyond the instrumental assignment of tasks and restarts of the work process. A participant from the Workshop (Work_group_1) said, 'You talk to it a bit sometimes if it is rowdy or... If it has behaved, you can even praise and pat it a bit, "good job." Not that I think he is really listening, but it feels

better somehow'. The robot was not only appreciated for bringing variation and attention from outsiders but also treated as a participant in the ongoing social interaction at the workplace, potentially challenging the notion of social interaction rituals demanding human face-to-face interaction (cf. Collins, 2020).

In sum, the implementation of robots in various work environments had mixed effects on social interaction. Consequently, some employees experienced increased isolation and monotony, particularly in settings like restaurants where robots replaced human interaction. Other employees found the novelty and learning opportunities exciting. In the initial phases, the robots fostered increased interaction among colleagues as they collaborated to integrate the new technology. Over time, however, the novelty wore off, and the impact on social interaction varied. In some cases, the robots seemingly served as a source of company and even a topic of conversation, enhancing social cohesion. Conversely, in environments like the restaurant, the robots reduce the direct interaction between staff, impacting the quality of work and employee satisfaction. Overall, the robots' influence on social dynamics was complex, with direct consequences on the psychosocial work environment, exemplified by job intensification and social isolation. This is now further discussed in relation to the theoretical framework of social interaction rituals.

Discussion and conclusion

Discussion

In this section, the findings and analyses presented in the Findings section are discussed in relation to Collins's framework of social interaction rituals.

Broadly, two aspects of robots' role in social interaction rituals can be identified. The robots affected rituals either by altering the preconditions for interaction rituals or by being perceived as actors within them. The latter is arguably due to some participants' tendency to add human attributes to the robot that create what can be likened to social interaction. This potential replacement of humans in rituals is the main focus of this discussion.

However, first, the robots seemingly influence the preconditions for interaction rituals in different ways, at different stages of the implementation process. The novelty of the robots and the collaborative efforts to integrate them create a shared sense of purpose and enthusiasm, enhancing social cohesion and job satisfaction. The robots served as a focal point for social interactions, acting as totems that employees and customers rallied around (Cf. Kamino et al. 2024). However, as the novelty wore off, some employees felt isolated, particularly in restaurants where robots replaced human interaction. In that regard, rather than fueling interaction rituals, replacing humans with robots reduced the potential for these rituals. This dual role of robots—both as a source of isolation and a social catalyst—illustrates the complex dynamics of workplace rituals. One insight from this is that, besides recognizing socio-structural aspects and organizational context as influencing the emergence of interaction rituals (King 2019), timing or temporal aspects also need to be added to the analysis of interaction rituals.

When looking beyond the novelty effect of the introduction phase, the restaurant and the Workshop cases are particularly interesting. In both cases, the robots were

treated as somewhat 'living', but in different ways. The 'life-giving' of the robot in the restaurant could be seen as an act for the customers, part of the performance provided by the employee to make the robot come to life in the eyes of the customers. In that regard, the robot was not a participant in the ritual but rather the object, similar to the robots in the Kamino et al. (2024) study, where they became the focal objects for interaction rather than being considered actors. However, in the case of the workshop, the object of the ritual is (arguably) the labor process. The interaction with the robot at the workshop is an interaction in a shared work between the employee and the robot—the emotional responses and ascribing (if jokingly) of emotions to the robot suggest a shared interaction ritual, not performed for an outsider with the robot as an object, but with the robot treated as a made-up actor. The fact that the least human-like robot was perceived as the most 'human' raises important questions about what triggers perceptions of robots as colleagues and how they come to be seen as part of interaction rituals.

The apparent replacement of humans in social interaction rituals raises questions about where such ritual occurs—within or between humans. In other words, is it sufficient that a human experiences a sense of interaction and recognition, or is a 'real human' counterpart needed to generate emotional energy? While Collins (2020) argues that it must be humans, preferably interacting face-to-face, to generate a successful interaction ritual, and others (DiMaggion et al. 2018; Johannessen 2023) have claimed that mediated communication between humans might also create successful interaction rituals, the outcome in this study could add aspects to this debate—depending on how the question is framed. Returning to the lab, and the statement that a robot in the room made an employee feel less alone, and to the workshop, where an operator seemingly had an energizing interaction with a robot arm, we could read the situations in two ways:

One interpretation is that humans have a constant need for social interaction, which leads them to act as if they were interacting even with 'dead' objects. One reading of this situation is that the interaction rituals are bottom-line internal individual experiences, and that it does not really matter if it is a human agent or a robotic agent (or, for that matter, any other kind of agent) that the human shares interaction with. The tendency to anthropomorphize 'non-human' or 'non-living' actors is then a process that takes place within the person, providing emotional energy regardless of the counterpart's actual consciousness or agency.

This challenges some of the underpinnings of Collins's framework, suggesting that social actions may be rooted in the individual rather than requiring human co-actors. Put differently, the need for interaction is constant; when humans are absent, we ascribe human attributes to whatever is available in order to create a sense of interaction.

In contrast, experiences from the restaurant highlight a loss of human interaction, as the robot entered the chain and replaced direct contact between the kitchen and the serving staff. While the robot became a part of the interaction play between customers and serving staff, it also lived its own life. The robot became a new link between the kitchen and customers, reducing the role and agency of the serving staff, thereby reducing their role and partly excluding them from the ritual.

To further pursue whether a robot could replace a human in the social interaction ritual, the role of the context is perhaps important to consider, then how we perceive the other 'actors' or what they really 'are'. The interaction ritual is not just about the direct interaction between two actors (humans or not, see Nyholm 2020, for a discussion on

the level of agency for non-human entities), but also the setting and framing of the interaction (Collins 2005). In some cases, where the robot is 'new' to the interaction, such as in the lab and the workshop, the robot is seemingly considered a social company, reducing the sense of isolation. On the other hand, in settings where human-based rituals are disrupted by 'robot actors', there is a sense of loss and increased isolation—possibly due to reduced potential of social interaction rituals. This indicates the role of anticipation (and perhaps past experiences) as an important aspect of the experiences and effects of social interaction rituals, again pointing toward the relevance of a temporal or timing aspect of the preconditions for interaction rituals.

Given the fluid and individual aspect of social interaction rituals, it may be difficult for management to have 'intended consequences' about the social impact of robots, as it comes down to the individual's interpretation, needs, and actions. However, while the intentional focus might need to be on ergonomics and technical aspects, it is important to have a sensitivity to the various impacts new technology might have on social relationships and the work environment.

Conclusion

This article aims to contribute to the understanding of the impact of robots on social interaction in the workplace and on the work environment. The following research questions were discussed:

In these cases, what are the consequences to the work environment of the collaborative robots? How can collaborative robots impact the psychosocial work environment? How can collaborative robots influence social interactions at work?

The analysis shows that while robots were introduced with the intention of improving ergonomics and reducing repetitive tasks, their consequences for the work environment were more complex. On the one hand, employees reported relief from physical strain, experiences of novelty, and moments of pride and excitement when working with new technology. On the other hand, job intensification, additional tasks, and reduced opportunities for spontaneous interaction also emerged, demonstrating how robots both alleviate and create new forms of strain.

In relation to the psychosocial work environment, the findings highlight a dual role of collaborative robots. Drawing on Collins's theory of interaction rituals, the study shows how robots can become focal points that spark collective attention, curiosity, and emotional energy, reinforcing solidarity and enthusiasm at work. Yet in other contexts, robots disrupted existing rituals by replacing face-to-face encounters and thereby contributed to feelings of monotony and isolation. This indicates that robots are not merely neutral tools but enter into the ritual fabric of workplaces, sometimes as energizing totems and sometimes as barriers to human interaction. Whether robots are experienced as 'colleagues' or as isolating devices is thus shaped less by their design than by the organizational context and the way they are integrated into social practices by the individuals involved in the interactions.

These insights are particularly relevant in the Nordic context. The Nordic model has long emphasized worker participation, collective regulation, and the pursuit of 'good work'. While collaborative robots may contribute to physical sustainability at work, they also raise new challenges for social sustainability. The cases demonstrate

that unexpected and unintended consequences arise not only from the technology itself but also from the ways in which robots alter interaction rituals and reorganize relationships. A cooperative approach to robotization, therefore, requires attention to the social dimension of technological change, ensuring that new tools support both efficiency and cohesion.

For practitioners, the study underscores the importance of viewing robot implementation as a sociotechnical process rather than a purely technical upgrade. Involving employees in decision-making, recognizing the value of interaction rituals, and monitoring both physical and psychosocial effects are crucial steps to avoid undermining the intended benefits. Managers and unions alike may draw from these findings to design introduction processes that safeguard recognition, belonging, and meaning at work.

Finally, the article also contributes to theoretical debates by exploring the role of non-human actors in interaction rituals. The findings suggest that while robots cannot fully replace human co-presence, they can function as focal objects that generate or disrupt social energy, depending on context. This adds nuance to Collins's framework and points to the need for greater sensitivity to how technological artifacts shape rituals, solidarity, and meaning in everyday work. Thus, collaborative robots raise new questions not only for Nordic work life but also for sociological theory on interaction and social order.

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