CAN YOU OUTSMART THE ROBOT? AN UNEXPECTED PATH TO WORK MEANINGFULNESS

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Abstract

Although many organizations are increasingly replacing human labor with robots, scholarly knowledge of how employees respond to robots is limited. In a qualitative study consisting of 117 interviews conducted over 20 months at two manufacturing companies, we explored how people respond to labor replacement by robots and how they handle working with unreliable technology to get the job done. We discovered a paradoxical scenario in which an apparently adverse situation—imperfect robots—had beneficial outcomes for the employees by enhancing their sense of the meaningfulness of their work. Our inductive analysis revealed a unique mechanism—outsmarting robots—as a key process responsible for the development of these positive effects. This research highlights important areas for further theorizing about the role of the worthiness of human work in automation efforts as well as the reliability and acceptance of robots in organizations.

Keywords: robot, technological unreliability, uncertainty, work meaningfulness, automation

“(The) robot will do twice more than we do. Maybe even three or four times more. Will anyone need us here after [robots are introduced]?”

“Robots would be lost without us [humans].”

(from our interviews with robot operators)

We began our research project with guiding research questions about how people respond to labor being replaced by robots and how they adapt to working with robots that are not reliable. In essence, we sought to understand how people handle multiple uncertainties within the context of automation technologies. The opening snippets from our interviews illustrate the empirical puzzle we encountered during this research project. First, we were intrigued by a distinct and recurring pattern we noticed during our interviews with workers in that the majority of them described the robots as annoying or “silly” because they break down, suddenly stop, malfunction, and break materials. Indeed, the pattern noted in our interviews with robot operators was one of increased uncertainty emerging from the unreliability of the technology used, which was most often described as a rather painful part of their daily work. Second, although the goal of robotization is to replace humans, or at least to significantly reduce their role in the production process, we were surprised to observe that, over time, despite experiencing multiple uncertainties, the employees working on the robotized production lines felt even more important to the manufacturing process after automation than they had before. They experienced a strong sense of work meaningfulness. How did this come to be? How did the workers go from the situation depicted in the first epigraph—fearing job loss and irrelevance–to the situation in the second quote, where there is a clear understanding that robots cannot perform effectively without humans?

A discovery of the meaningfulness of human work within this context was especially striking given that increasing automation efforts in the manufacturing industry are mainly associated with the replacement and devaluation of human labor (Frey & Osborne, 2017; Tschang & Almirall, 2021), dehumanization in organizations (Brison, Stinglhamber, & Caesens, 2022; Stinglhamber, Caesens, Chalmagne, Demoulin, & Maurage, 2021), and the potential for significant job loss (Acemoglu et al., 2022). At the same time, the automation and robotization of manual labor brings another type of uncertainty, namely, the robots' unreliability. Frequent breakdowns—according to one report the average time between incidents is only 87 minutes (Sickler, 2019)—require frequent operator intervention, as well as intense monitoring to maximize robot efficiency (Fleming, 2019; Parker & Grote, 2022). Given that automation using robots is becoming much more prevalent and new industrial robot installations are growing by double-digit rates every year in many countries around the world (International Federation of Robotics, 2021), inquiries into how people respond to automation are becoming more important than ever. Despite ongoing controversial discussions about the labor-substituting effects of automation (Ashley, 2022), recent studies confirm that the risk of unemployment is real, as applications of industrial robots replace human labor and impede employment growth (Jung & Lim, 2020), especially for low-skill workers, even though the hourly wages for the high-skilled jobs (i.e., robot operators) can show an increase (Damelang & Otto, 2023; Humlum, 2022). With the growing usage of sophisticated technologies in workplaces, the question of whether they "might diminish the value and worth of human beings, and hence impair task significance" are being asked (Wang, Liu, & Parker, 2020: 715).

Altogether, these emerging insights led us to realize that workers' responses to robots may be more complicated than previously suggested, and this motivated us to go back to the literature to better understand how workers respond to the uncertainty arising from both the unreliability of the robots in their workplaces and the threat of their jobs being replaced.

RESPONSES TO UNCERTAINTY WITHIN THE CONTEXT OF ROBOTIZATION

Uncertainty, defined as "any deviation from the unachievable ideal of completely deterministic knowledge" (Walker et al., 2003: 1), can be "inherently aversive" and lead to negative affect (Anderson, Carleton, Diefenbach, & Han, 2019: 6). Consistent with this idea, there is evidence that suggests that the uncertainties arising from job replacement and the resulting job insecurity are likely to result in negative consequences for employees. For instance, when workers are aware that they potentially face redundancy, this may lead to decreased organizational commitment, lower career satisfaction, higher rates of depression, and negative perceptions of the value of their own work (Brougham & Haar, 2018), as flawless automation technologies are supposed to replace human labor in order to "vastly surpass the limits of human intelligence, skills, and physical stamina" (Walsh & Strano, 2018: xix). Based on previous theorizing (Griffin & Grote, 2020), we view the uncertainty arising from the risks of job replacement as exogenous uncertainty because it is part of the external environment and, therefore, it is largely uncontrollable by individual workers. Overall, there is quite clear evidence of the adverse consequences caused by the uncertainty that arises from potential labor replacement and the fear of job loss.

The situation is more complex, however, when it comes to another type of uncertainty: that of the unreliability of the robots themselves. We consider this unreliability an example of endogenous uncertainty (Griffin & Grote, 2020). Robot unreliability is defined as the lack of dependability and consistency in the way this type of technology functions (Ayyagari, Grover, & Purvis, 2011; Stowers et al., 2017), or, as we define it simply in this paper, the degree to which a robot breaks down or fails to work in unpredictable ways and at unpredictable times. In the case of industrial robots, multiple factors can lead to breakdowns, including broken robot parts, conveyor problems, program faults, sensor faults, faulty electronic components, and variations in production input.

Generally, research assumes that perfect robot reliability is a “desirable good” for both organizations and individual users (Butler & Gray, 2006: 212), as it reduces workload (Cullen, Rogers, & Fisk, 2013), is linked to greater user satisfaction (Delone & McLean, 2003), eases the adoption of technology (King & He, 2006; Schepers & Wetzels, 2007), and improves overall performance (De Visser, Parasuraman, Freedy, Freedy, & Weltman, 2006). Theoretically, from the user perspective, the reliability of automation technology is seen as an important determinant of the trust in and acceptance of technology (Glikson & Woolley, 2020). For instance, research inspired by the influential Technology Acceptance model (Davis, 1989) suggests that new technology is more likely to be accepted if it is perceived as useful, easy to use, and trustworthy (Ghazizadeh, Lee, & Boyle, 2012; Hoff & Bashir, 2015). Because trust reduces uncertainty by minimizing both complexity and the need to calculate possible risks (Colquitt, LePine, Piccolo, Zapata, & Rich, 2012; Fulmer & Gelfand, 2012), it is seen as important for successful interactions with technology (Glikson & Woolley, 2020). Indeed, research suggests that robot reliability may be crucial in developing user trust because reliable robots will make users believe that they can achieve their goals with the help of technology (Wright, Chen, & Lakhmani, 2020), while meta-analyses link higher robot reliability with enhanced user trust (Hancock, Kessler, Kaplan, Brill, & Szalma, 2021; Hancock et al., 2011b).

However in contrast to this theorizing, a distinct research stream shows that people like robots more if they occasionally make mistakes rather than performing flawlessly (e.g., Mirnig et al., 2017; Ragni, Rudenko, Kuhnert, & Arras, 2016). This is because flawed robots evoke in their users a sense of similarity to human imperfection (i.e., anthropomorphism or human-likeness), thus supporting emotionally-laden trust (Glikson & Woolley, 2020). Both research streams therefore assume trust is important for human willingness to work with technology, but they differ in whether they assume unreliability is positive or negative for trust. Unfortunately, empirical research does not help to resolve this contradiction, relying on small-sample experimental research measuring short-term effects of reliability (Hancock et al., 2021; Ötting, Masjutin, Steil, & Maier, 2022). Moreover, the existing research mostly relies on experimental laboratory studies involving participants with little to no work experience with robots and the choices these participants make within the hypothetical (experimental) scenarios have no consequences on their own jobs or careers. However, it remains uncertain how relevant these insights, drawn from experimental research, are when applied to the real-life scenario of workers operating robots in high-stake situations (i.e., in the workplace as opposed to controlled laboratory settings). Furthermore, relying on laboratory research does not enable us to explore long-term consequences, such as the experience of meaningfulness of work in situations where employees face the replacement of human labor with automation.

From an organizational perspective, scholars mostly draw on work design theory to conceptualize malfunctioning technology as one of the job demands that negatively impacts motivation, strain, and performance outcomes for workers (Parker & Grote, 2022). Breakdowns slow down the progress of work, and technology-related hassles mean that workers have to repeat actions (Ayyagari et al., 2011), causing worker overload and frustration (Cullen et al., 2013; Day, Paquet, Scott, & Hambley, 2012). From the theoretical perspective of motivation, frequent unexpected problems at work disrupt goal-directed behavior and require the increased application of both mental and physical resources, meaning little is left for the pursuit of the primary goals of a regular working day (Zohar, 1999).

Whilst the predominant perspective on the unreliability of technology highlights its negative consequences, early work design researchers suggested that high operational unreliability (including variations in technology) may, when combined with appropriate work designs, present a learning opportunity for individuals (Wall, Corbett, Clegg, Jackson, & Martin, 1990). In an expansion of this possibility, Griffin & Grote (2020) developed a new theory to suggest the possible benefits of uncertainty. Specifically, Griffin & Grote (2020) argued that the regulation of endogenous uncertainty could allow for exploration and discovery, even leading to the generation of further positive uncertainty, facilitating even more effective behavior in a complex environment. From this perspective, the emphasis is not on uncertainty as an entirely adverse situation to be avoided or reduced, but on how uncertainty can be optimally regulated to generate benefit.

Altogether, the nascent idea that there might be upsides to technological uncertainty has had limited empirical attention, especially in relation to broader and longer-term outcomes like work meaning. We currently know little about whether or not people achieve or restore a sense of meaningfulness in the context of automation efforts aimed at replacing human labor and, if they do, how they do it (Fleming, 2019; Parker & Grote, 2022). Indeed, in a recent cross-disciplinary literature review on the impact of sophisticated technologies on human work, Wang et al. (2020) called for research on how technologies influence the significance and meaningfulness of work. Given the initial empirical puzzle described above and the shortcomings of the existing literature, we refocused our research interest toward a new question: ***how do individuals achieve a sense of meaningfulness in the context of labor replacement by automation technologies, and what is the role of technological unreliability in this process?***

METHODOLOGY

Research site

Interviews were conducted at two large manufacturing firms: a furniture producer and a producer of electronic tracking and networking devices, employing around 800 and 600 employees respectively at the time of the fieldwork (see Table 1). Both companies had similar strategies aimed at gradually automating their work. They had both acquired their first robots more than a decade ago, and were still continuing to automate more work and reduce the number of manual tasks at the time of the fieldwork.

Both companies were implementing new robots on a regular basis, intending to use them to replace human labor (exogenous uncertainty) in order to increase the efficiency, stability and quality of production. The General Manager at Furnit stated, “we need to produce more per time unit” (#F1). However, alongside this robotization process, both companies were also experiencing a rapid growth in sales, with the corresponding need to expand the workforce, so none of the displaced workers needed to be laid off, instead being reassigned to new roles. Even though the long-term goal was labor replacement, the rapid growth meant that during the study period two options were available to any displaced workers: they could either be upskilled and continue to work on the production lines, now as robot operators instead of manual workers, or they found new jobs in other departments of their company that had not (yet) been robotized. While we are not able to provide detailed statistics about these displaced workers due to confidentiality agreements with the organizations we studied, the overall labor replacement situation in our case studies corroborates the international trends mentioned in the introduction (Damelang & Otto, 2023; Humlum, 2022; Jung & Lim, 2020). The General Manager at Electro succinctly described the situation in just a few words, asserting that “with robot adoption, fewer workers are needed to perform the same operations, but those who work [with robots] earn more.” (#E4).

These companies use articulated industrial robots (see example in Figure 1), which are robots that have automated arms, are reprogrammable and multipurpose, interact with the production line using sensors, are capable of moving on three or more axes, and are equipped with safety mechanisms to protect any humans who endanger themselves by entering the robot cell

(International Federation of Robotics, 2020; Siciliano, Khatib, & Kröger, 2008). The robots we observed had different levels of sophistication: some of the older generation robots that were introduced years ago are still used alongside the newer, more technologically advanced robots. Both companies developed complex multi-robot systems (Siciliano et al., 2008) and used a number of fully automated manufacturing lines—a production line that is broken down into a series of small steps, in which the product is manufactured by being sequentially moved from one step to the next (see example in Figure 2).

INSERT Figures 1+2 ABOUT HERE

Each production line comprises a series of operations performed by robots (e.g., cutting, soldering, assembling, packaging, etc.) and various types of machines (e.g., material transporter, which moves the product from one step to the next, spray painter, etc.). Humans are needed to ensure the delivery of production materials and components for the robots, to monitor the robots' work, and to carry out maintenance. The sequential interdependence of the production line means that the work of robot operators is highly dependent on robot reliability: if one robot starts malfunctioning, the whole production line is likely to be affected. At both companies, the control panels and monitors are in the same room as the production line, so the robot operators and the manufacturing workers mostly worked in close proximity to the machines.

Both organizations use a just-in-time production approach and pay-for-performance principle. Employee pay is related to production volume and quality, both of which are highly impacted by incidents involving technology because they result in increased downtime (lower production) and damaged materials. Worker performance in the manufacturing department is contingent on the operation of robots on the production lines. An important feature of the work cultures of both companies is high performance pressure, which is evident in many of the interviews with both the employees and the top managers, who repeatedly emphasized operators' responsibility to keep the robots running all the time.

INSERT TABLE 1 ABOUT HERE

Data collection

Over a 20-month period, between March 2018 and October 2019, we conducted 117 semi-structured qualitative interviews with robot operators (N=44), their line managers (N=15), other workers (N=38), HR and training managers (N=10), and directors and department managers (N=10). We conducted the interviews in two waves with a gap of approximately one year between the waves (1^{st} wave N=65; 2^{nd} wave N=52). The second wave included 26 of the people interviewed in the first wave in order to pick up on any individual-level changes due to these employees having more experience with the robots. We analyzed the data between the waves and used the results of the analysis to revise the questionnaire and probe specific topics that we had identified as important themes, including the unreliability of robots and the associated practices. As is typical in qualitative research, we covered diverse functions, job positions, and production lines in order to understand the different perspectives and experiences of the employees and use this as a source for within-method triangulation in order to ensure the internal consistency of our data (Jick, 1979; Jonsen & Jehn, 2009). At both companies, we interviewed workers with varying robot experience: from junior operators (those with little to no experience with robots) to senior operators (those with up to 16 years of experience with robots). We interviewed participants in their native language and audio-recorded with their consent. The interviews ranged in duration from 30 to 95 minutes. After completion, they were fully transcribed and coded in the original language. During analysis, the authors translated the concepts and quotes into English (see Appendix A for more information on the interview design and the translation process).

INSERT TABLE 2 & 3 ABOUT HERE

Data analysis

Given the exploratory character of our inquiry, we followed an inductive and interpretative approach in our data analysis (Gioia, Corley, & Hamilton, 2013; Schwartz-Shea & Yanow, 2013). We collected data at two sites; however, because we analyzed the data at the individual level, we did not engage in any cross-organizational comparison, instead treating the two sites as manifestations of the same phenomenon (Stake, 2013).

We carried out the analysis in three main stages (depicted in Figure 3), and during each, the full dataset was re-analyzed multiple times. The research question for this study actually emerged from the data gathered while working on a larger project about how people respond to robotization-related uncertainties at work. We were therefore already very familiar with the data before engaging into the analysis.

We began the first stage of analysis by discussing our reflexive notes and the in vivo codes that we had set aside during the initial analysis, which we found were mostly related to the endogenous uncertainty that workers in the study experienced (their experiences of the unreliability of robots). Guided by our initial research question, that is, how workers handle the uncertainties at work that arise due to automation and unreliable robots in order to get their work done, we wanted to focus on the specific instances in which the workers dealt with the unreliability of robots and identify practices related to those incidents. We read through the interviews and highlighted large units of data (e.g., one or more paragraphs) in which the research participants had recounted stories about these kinds of incidents (robots malfunctioning, breaking down, unexpectedly stopping, etc.). The first two authors then used holistic coding to code around 20% of the interviews. This coding method involves applying a code to previously selected large units of data—the stories of how the workers dealt with robot unreliability—and capturing the basic themes that could form the basis for more detailed coding later (Dey, 2003; Saldaña, 2009). As a result, we developed a list of emerging themes, for example, *the unreliability of technology as a strain, the proactive search for solutions*, and *unreliability as a symbol of mastery*. Due to the large scope of the interview material, we employed a research assistant to help us with the initial selection of the data units, as well as the classification of the remaining 80% of the data based on the template and definitions provided by the first two authors, who further reviewed the coded data units and refined the classification.

In the second stage of analysis, we reviewed the selected data units again and this time, we used in vivo coding in order to capture more granular data on the workers' practices, emotions and sense-making when handling incidents involving robots. Next, we used focused coding in order to group our in vivo codes into broader categories and bring the data back to a coherent whole (Charmaz, 2014). This was an iterative–recursive coding process in which we discussed the findings, reviewed them based on the existing literature, tried to find possible explanations, and returned to the data analysis multiple times (Schwartz-Shea & Yanow, 2013). We observed that although the workers had explained their painful experiences at work due to the uncertainty around unreliable robots, they had also reported a number of ways in which they try to "outsmart" the robots (we labeled the concept as "outsmarting" based on the jargon used by multiple research participants), which also helped them to achieve multiple outcomes–a sense of mastery, the perception of power, extended roles, increased significance and meaningfulness of work.

In the third stage, based on the results of the previous two stages of data analysis, as well as on our review of additional literature sources and on discussions within the research team, we narrowed our inquiry to focus on the so-called "outsmarting" practices associated with this sense of meaningfulness at work. Guided by the refined research question—how do individuals achieve a sense of meaningfulness in the context of labor replacement by automation technologies, and what is the role of technological unreliability in this process—the first two authors began reading the full transcripts of interviews over again and coding the incidents that were not highlighted in the previous rounds of coding. They also revisited the coding of the triggers of these outsmarting practices; revised the categorization of the sources of the unreliability of technology (endogenous uncertainty); and added another group of triggers: the threat of labor replacement (exogenous uncertainty), which remained implicit in the previous analyses. During the process, we discussed and considered multiple theoretical interpretations, iteratively refining our categories to yield a response to our initial puzzle (Grodal, Anteby, & Holm, 2021; Schwartz-Shea & Yanow, 2013). Our final analysis resulted in a three-level structure (Gioia et al., 2013) with three dimensions corresponding to the triggers of outsmarting, the actions of demeaning and outsmarting robots, and the consequences for employee perception of the meaningfulness of work (see Figure 4 for coding structure, and Appendix B for illustrative quotes).

FINDINGS

In this section, we bring together the discoveries that emerged from our data and explain how the parts of our findings relate to each other. Our inductive analysis revealed that uncertainty triggered two parallel mechanisms—demeaning and outsmarting—which explain how employees were able to construct the idea of their work as being meaningful and worthy. In what follows, we first elaborate on the multiple layers of uncertainty arising from the threat of job automation and employees' experiences of robot unreliability (exogenous and endogenous uncertainty, respectively) because this aids in the understanding of why employees were triggered to engage in demeaning and outsmarting the robots with which they work. We then explain the phenomenon of demeaning and outsmarting robots. Finally, we discuss how these mechanisms reinforced each other in a way that fostered an increased sense of the meaningfulness of their work.

Triggers of Outsmarting Robots

The threat of being replaced by robots. We learned from our interviews that, at least initially, there was a great deal of uncertainty and insecurity among workers who were afraid that the robots would take over their jobs. Prior to the advent of this robotization, manufacturing workers manually carried out the tasks that were to be reassigned to the robots. As the robots were gradually introduced, the workers witnessed their colleagues being displaced, waiting for their time to come. The managers at both companies were upfront about their agenda to replace human work:

> *When we install a robot somewhere [in the production line], people think they will lose their job. It is no secret here that efficient work is possible with fewer human resources (#F1).*

Not unexpectedly, some employees resisted the introduction of robots. At times the resistance was so extreme that the managers even referred to their employees as luddites, saying things like, "it was like an industrial revolution, when people went and broke machines" (#E24). Although no actual robots were broken, the manager explained that it seemed like they wanted to go and break the robots, based on their strong negative attitudes toward them.

As robots were introduced into the production lines, the workers felt threatened because they could see that one robot was capable of the jobs of multiple people, which made them feel insecure about their jobs and the need for human workers in general:

> *In the future, there will be only a few people in charge, while the machines [will be] doing everything. People will be fired (#F16).*

> *Now we have a great example of a freshly built robot that catches parts. Four people had been working in that place, now only one of them is needed (#F19).*

> *The robots are here, and people will not be needed. Yes, there is some fear around it. (#E13).*

In our interviews with the employees, it was obvious that using robots meant that fewer workers were now needed in order to achieve the same production volume: a situation that seems likely to result in some workers being made redundant. Consequently, most of the employees reported seeing robots as a threat to their jobs, and they struggled to make sense of what their introduction would mean for their work. The perspectives of these workers emerged even though, luckily, redundancies were not necessary in either of the case organizations due to an increase in company sales[1]. The employees' fears and uncertainty about the future arose mostly as a result of their general knowledge of robotization and their expectations of the effects the introduction of robots would have in their own workplaces.

The unreliability of robots. As the employees continued working with the robots, their focus gradually shifted from worrying about the robots taking over their jobs to disappointment and frustration about the unreliability of the robots. From the workers' perspectives, especially the operators whose daily tasks required interaction with the robots, the reality was that the robots were far from functioning as reliably as the company managers had envisioned before their installation, for example, the robots might stop unexpectedly and break materials or components. Robot malfunctions might be caused by faulty robot mechanisms, such as errors in its programming or broken hardware ("all the mechanisms break at some point," #F18); the operator's actions or lack of knowledge ("the robot does not make mistakes—he does what you tell him," #E22); environmental factors ("yesterday, the sun was shining straight into the [robot's] eye, and it stopped counting the parts," #F2); material-related imperfections (e.g., #F8); or even unknown

[1] As mentioned earlier, as per our knowledge during the time of our study, none of the employees had been laid off specifically due to robotization, but were instead upskilled and/or transferred to other departments.

causes (“the problems may look the same but the reasons are different,” #E40; “the robot stops out of nowhere… and what that was exactly [remains unclear],” #F2).

Irrespective of their source, the workers have to handle these interruptions: they have to recognize the causes of the unreliability (“you run and try to find what’s wrong,” #F6) and address the issues as quickly as possible (“I run to check it right away… time matters,” #F6). A speedy response to robot breakdowns is required because a failure in one robot could cause the whole line to stop, affecting many people and production processes (“if something gets stuck, then the whole line stops... there is pressure,” #F25; “[when something happens] everyone runs like mad,” #E19). The workers therefore experienced stress and frustration, worrying about the downtime caused by each incident and its impact on their individual work performance measures, which are contingent on the expected uptime of the production line and which have the potential to seriously impact their pay.

Ultimately, the unreliability of the robots became a defining characteristic of the workers’ workdays (“no two days are alike here,” #F18). The workers considered it a “good day” when the robots ran smoothly, and a “bad day” when the robots malfunctioned and stopped unpredictably, reinforcing the workers’ sense of uncertainty about how possible it even was to meet the production goals. When they described the various robot-related interruptions to their work, our participants told us the many ways the unreliability of the robots affected their well-being, including stress (“you get really nervous,” #E18); frustration (“it is pure misery to work with him [the robot],” #F34); exhaustion (“I get emotionally drained,” #F23); and bringing work-related problems and worries home (“I dream that [the robot] doesn’t launch… it is the worst kind of my nightmares,” #F24).

Altogether, the combination of unreliable and interdependent technologies, the performance-based payment system, and the pressure from the management to keep up the speed of production means that, for these employees, effective day-to-day robot management is central to both their work performance and their well-being. They reported seeking information to help them improve their abilities to address the issues caused by the robots' unreliability:

> *You have to deal with it, [with the] robots' breakdowns. […] you don't know exactly where to start. You search, you look at certain places where it happens most often, but it turns out not to be there, then you look for something else (#F31).*

A small proportion of the workers interviewed could not bear the burden of unreliable robots and experienced their work as lacking in meaningfulness ("as time goes on, the less meaningful work seems [due to having so many defective products]," #F34). These workers withdrew from the robotic production lines ("not everybody has to work with robots, someone has to do the other tasks too," #F47) and were allowed to take on other roles in the company that did not involve dealing with robots. The strategy of allowing the dissatisfied operators to move elsewhere, along with the fortuitous organizational growth in both companies, ensured that there were no job redundancies directly related to the implementation of robots ("here you see the robot, which replaced two people […], but then we needed even more employees in there [another department]," #E35).

Demeaning and Outsmarting Robots

Due to ongoing automation, workers saw preventing downtime and completing work without incidents as tantamount to their role in the production process. Our analysis revealed two overarching responses to robot unreliability that emerged over time. First, we identified that many operators engaged in demeaning robots as a response to their uncertainty, such as labelling robots as stupid. Second, and using the language of participants, we identified outsmarting as a key behavioral practice for dealing with robot unreliability, which involved both fooling robots and propping up robots. We identified that demeaning facilitated outsmarting robots, which in turn fed back to strengthen the inclination to demean robots. We suggest that demeaning and outsmarting explain the path by which employees constructed their work meaningfulness in this context.

Demeaning robots

Although there are recognized advantages of working with machines ("of course, it is physically easier with robots," #F15; "faster with robots," #F40), when we asked the employees about their workdays, they often launched into complaining about the limited abilities of the robots and their failure to "understand" certain things that were obvious to humans:

> *The most reliable robot was a human being… Sure, it is physically easier with robots. However, you have to look after them intensively. Every error leads to another error… A robot grabs materials… goes off limits… and touches the wrong plank. […] When there were humans, they did it right the first time (#F5).*

Robots worked well only as long as the conditions of their work remained stable and the quality of the materials remained consistent; however, if anything and there was a need to adapt to changed or changing circumstances, which requires the ability to identify the source of the change and adjust to it, the robots were not reliable and, as a consequence, the workers began referring to them in demeaning ways, saying they are "stupid" (#E35), "scrap metal" (#F22), narrow-minded (#F2), or "dull" (#E45). As the workers observed the robots' lack of flexibility, they saw less value in the robots' input and their contribution to the manufacturing process. During the interviews, they rebuked the robots for starting to do a task which they "should know" they cannot accomplish:

> *Sometimes you launch [a robot], and you cannot do what you were supposed to do. Like yesterday, the robot picked up a box [and was supposed to seal it], and then… nope, [the display] shows that the robot cannot seal it. OK, I then went and changed the placement [of the box]. The robot grabbed it and bang! Dropped it on the floor. And so here he is. If you [addressing the robot] cannot pick it up, don't pick it up! But the robot still grabbed it and dropped it (#E35).*

Things that are common sense to humans are not so common sense to robots. The employees complained about the robots having little "understanding" of whether they are doing an appropriate thing or an incorrect thing. They observed that the robots would continue doing the same task over and over without recognizing that they were spoiling all the materials:

> *And here comes the robot—it doesn't understand that this is spoilage… it didn't stop, but moved forward [continued the task]. It couldn't care less—it does not see anything, it does not know anything. It only knows that here are the holes, here it grabs and releases, and that is it (#F38).*

They criticized the overly optimistic value of robots. Although they recognized that the robots were expected to make production much more efficient ("it is mass production, [they take] over most of the work that requires physical effort," #E24), the fact remained that, in practice, the robots frequently stop and malfunction, requiring human intervention to solve these problems—in other words, the robots needed humans in order to be useful ("there are things that robots just can't do," #E22; "a person has to stay with the robots all the time […] to manage them," #F39). Consequently, the robots, which were initially expected to be infallible, become the object of jokes and negative anecdotes due to their continual malfunctions and errors. For example, one of the technicians told us about putting a red hat on a robot, so that it looked like a rooster, or programming a robot to do a funny dance:

> *Sometimes, we mock [the robots and say]: let's put a crest on it [so that it looks like a rooster]. It is all just for fun. Or we say on the New Year, let's make him dance! It is possible to do so that the robot would look like it is dancing. We can do it (#F20).*

By mocking and making fun of the robots, the employees reinforced their views of the robots as being in a lower and less competitive position than the humans ("robots are childish," #F2), and also reduced their tension and fear of losing their jobs. Even the nicknames the workers assigned to the robots, which were human names popular in more rural areas or the names of silly cartoon characters, alluded to the fact that they viewed the robots as belonging to a different (lower) social class, one which they could make fun of and demean.

Outsmarting Robots

Fooling robots. The robots are sensitive to any deviations in the quality of the materials that are loaded into them, and often stop as soon as they identify a difference. To avoid producing waste, having downtime, and needing to relaunch the whole production process from the beginning, the workers figured out they could input false parameters into the program, changing the standard, pre-programed parameters. These changes meant that the robots would assume there were no deviations and therefore continue to work without interruption. Some of the employees even compared the process to a game that robot operators needed to 'play' in order to find ways of making the robots tolerate variations in the textures of the materials and ensuring they would continue working without stopping:

> *For example, it happens that we receive panels [production materials] and some of them may be defective. In such a case, the robots interrupt their work a lot, and you have to fiddle a lot. Otherwise, the robots, you know, slow down our work. […] You have to play with the settings. It is like a game: this way it works, that way… it does not; here, the robot broke a panel, and if you do it the other way, it goes well [the robot does not break panels] again (#E15).*

> *If you have a piece of sixteen centimeters [which the robots do not recognize], you have to trick the robot into thinking that it is nineteen or twenty centimeters thick… so [I need to change the parameters so the robot would] see the materials [with their laser "eye"] (#F16).*

To trick the robots' "senses" (laser "eyes") and change how the robots recognize the materials, the workers not only use false parameters, but also manipulate the ways in which the materials are loaded into robots. For example, in certain cases, the employees discovered that switching the order, modifying the distance between the components (#E39), or even loading some materials that were originally not supposed to be loaded (#F2) are smart ways to make the robots work with less delay. By fooling the robots, the workers not only have less spoiled production to be fixed, but they also came to consider fooling the robots to be their personal and significant input to the production process, which eventually contributed to their sense of being smarter than the robot ("it is not a robot who fools himself, but I fool the robot […] there are no robots without me," #E39).

Propping up robots. Another way the workers attempt to outsmart the robots is to step in as needed in robot-assigned tasks to increase production speed compared to how long it would take without the manual intervention of a human worker. For instance, when a robot malfunctions, the workers told us they would jump in and either manually finish whatever it was possible to finish while the robot was being repaired (e.g., screwing in some bolts with a screwdriver, #F38) or simply take over the robot's entire job, completing it just as they did before the robots were installed:

> *It happens sometimes that a robot's mind gets messed up—it should be catching parts as they move along the line, but it does not catch them. So, we see, we cannot fix it. Let's do it with our bare hands and that will solve the issue until […] the programmer comes, who knows well and understands the reasons behind [the malfunction]. […] We do it with our hands and we save ourselves from productivity loss (#F41).*

Here too, to ensure a smooth workflow, the workers acted based on their own knowledge and assessment of the situation, even though this does not necessarily align with formal work procedures. The employees attempt to prop up the robots, to "assist" them, in order to ensure the work can carry on without interruptions, bypassing the high-level security equipment (security fences) intended to protect humans by initiating an emergency shutdown if someone tries to enter a cage. One of the workers explained the rationale behind such practices:

> *It happens that we receive a set of materials which are not doing well [with the robot]. Then we just need to help robot [recognize the materials]. You grab that box … and fix it… If you*

get it [correcting the position of materials manually] right, you don't have to redo everything in sequence. So, if you managed to fix that one box, you don't have to fix another 10 boxes (#E7).

Likewise, in order to manually fix a glitch (e.g., to adjust wrongly positioned material), the robot operators enter the cages without switching the robots off, which is contrary to the safety rules:

Those among us who've worked here longer, we know various short cuts to make the job easier for us, so we don't have to stop the robot. You run from the other side, push the component with some kind of stick, so it goes smoothly… Alternatively, you squeeze through the lasers, so that they [the robots] do not see you, and don't stop. Because once the robot stops, you will have [a pile of] wasted materials (#F13).

As exemplified in the above quote, going as far as knowing how to get around the robots' various safety features is linked to more experience and greater proficiency in dealing with the unreliable work of the robots. In contrast, workers that had less experience and knowledge about the robots, acknowledged that they are not only wary of interrupting the robots while they worked but are also afraid to enter the cages even when the robots are stopped—they are therefore more likely to follow safety procedures ("I am afraid to get in [with the robot], I don't know enough […] and I can break it", #E19). Meanwhile, managers espoused being unhappy with workers who "[tried] to be smarter than robots" (#E8); however, managers did not undertake corrective actions to eliminate such practices, because they allowed workers to accomplish tasks more quickly and, thus, had enormous performance benefits.

To summarize, by outsmarting the robots, the workers aimed to ensure a stable production process, despite the many possible and hardly predictable causes of robot malfunctions. Their actions paid off because they succeeded in reducing both downtime and the associated waste, and they continued to meet their performance goals. As a consequence, the employees felt even more powerful and even more inclined to demean the robots. Beyond the more obvious outcome of making the robotized production process more reliable despite the unreliable robots, we further identified that through outsmarting and demeaning the robots, the workers also rationalized their own sense of work worthiness.

Consequences for the Meaningfulness of Work

As the workers realized that they were capable of outsmarting the robots to get them to work, it also helped them realize the worth of their own work in the production process. Our analysis revealed two important components of the employees' perceived sense of work meaningfulness as an outcome of outsmarting the robots: namely, a sense of being smarter than the robots and a sense of the relevance of humans on the shop floor in general.

Sense of being smarter than machines. The operators' successful attempts to outsmart the robots, and thereby quickly avoid or solve technological issues, helped them gain a real sense of pride and meaningfulness due to feeling more intelligent than the robots. Given that the robots continuously stopped and broke down, the workers quickly learned that the robots could not ensure the production flow without them ("someone needs to operate the robot," #F32, #E10; "we ensure that they work correctly," #F11) and that they needed to outsmart the robots to meet their production goals. Outsmarting the robots fueled worker's sense of self-reliance on the shop floor, as they not only saw employees' input as significant but also considered outsmarting the robots to be one of their duties, as well as a sign of a competent operator ("the most important thing is to keep the line moving… if the line stops, what kind of employee are you?" #F15). This rhetorical question from one of robot operators illustrates the sense-making process that many workers described, eventually coming to see managing and preventing robot incidents as their personal responsibility. For instance, one of our interviewees even adapted Julius Caesar's famous words, "veni, vidi, vici," to express how his job is to "fight" the challenges related to the robots' malfunctions and "conquer" them:

You can't flee from [the robots' malfunctions]. You have to come here every day and make sure that [the robot] properly functions. There's no way around it. […] Something is broken? For God's sake, your job is to make it work! […] You came, you did it, and you conquered (#F43).

Being able to outsmart a robot so that a production line does not stop despite the various technological uncertainties made the employees proud of their superior abilities in comparison to the machines ("I can make him [the robot] work, so I am so smarter at this point," #F11), also strengthening their personal sense of their personal work significance ("we are old wolves, we know [how to sneak into the robot]," #F34). Additionally, they began to view the various methods of outsmarting the robots (e.g., going inside the security fences) as "professional secrets" (#F13) that they had proactively acquired or would come to acquire through experience and seniority. In essence, their sense of the meaningfulness of their work was strengthened by being able to outsmart robots, along with the recognition that mastery to outsmart is really what the job is now all about.

Sense of human relevance. We further identified another aspect of the meaningfulness of work, which is more generally related to the role of humans at work. Handling robot interruptions by outsmarting the robots made the workers feel that humans in general are instrumental and relevant even in a highly robotized workplace because robots are not perfectly reliable. Outsmarting the robots led people to think that human input is crucial on the shop floor because "robots get out of order" (#F4) or "they break things" (#E28) and "need to be repaired" (#F19). Accordingly, the experiences reaffirmed the workers' doubts about the robots' ability to replace them—"we thought that the robots would take our jobs, but we are still needed" (#E35).

Through our follow-up interviews, we were able to observe some nuanced accounts of how the outsmarting practices changed the operators' attitudes to human worthiness at work. For example, one operator (#E15) told us during the first interview that workdays with robots can be extremely unpredictable ("I cannot trust the robot"), and that close monitoring of the production line is required ("something wrong may happen any time"), which made her lose the sense of human contribution and feel like she is just "another robot": "I need to be here [with the robot] all the time, need to look out about materials, and it is the same every day—I feel I became a robot myself, didn't I?" (#E15). Yet, a year later, during our second interview with the same operator, she demonstrated a sense of confidence in her job's relevance due to the ability of workers to deal with the robots ("there are many problems [I can solve]"). This is quite the opposite to how she felt a year ago—she now sees her work, and her human ability, as more significant than that of robots.

This sense of human significance is also highlighted in other accounts, in which the operators illustrate how dealing with robot-related incidents and outsmarting the robots helped them to recognize the human value in comparison to the machines:

> *A robot can't make the more important decisions on its own, it can't make decisions at all… In that sense, when you work with a robot, you are its brain (#E41).*
>
> *Robots make human work easier, but the human factor is more important (#F16).*

Moreover, despite the fact that most of the employees initially felt threatened by the robots due to ongoing labor replacement in their organizations, many of them also discovered that the robots cannot fully replace humans (#F24, #F40, #F9) and that the role of the human worker remains vital in the production process, just as it has been before the robotization:

> *I think a person is needed. A human being is necessary next to the robot… the robots themselves can't make things properly, we see it in the broken materials (#E6).*
>
> *My work is absolutely needed. Only another human can replace me. If I came to work and didn't do anything [to make my robot work], my line would stop very quickly, and materials would block the line (#F40).*

In summary, robot unreliability became an occasion for employees to recreate the meaningfulness—the significance and the relevance—of their work. The workers were able to make sense of their roles at work as being unique and crucial even in the context of robotization. Simply put, because robots did not function as intended, workers developed capacity to handle the interruptions and keep the production line running; in turn, this enabled them to realize the strong mastery (in comparison to robots) and appreciate the unique human role that both remain crucial in the workplace even when robots are present.

IMPLICATIONS FOR FUTURE THEORIZING IN MANAGEMENT

Because various automation technologies are increasingly being used in organizations to take over human tasks, understanding employees' responses to these technologies has implications both for future theorizing and for organizational practice. In our in-depth case study, we observed a paradoxical situation: even though the aim of the robotization was to replace humans, or at least to reduce their role on the shop floor, people working with the robots felt even more vital to the manufacturing process. This research opens a new arena for theorizing about the role of the uncertainty of technology in the workplace, as our discoveries suggest important new insights about the meaning of human work, as well as the acceptance of robots in organizations.

The Meaningfulness of Work

The need for meaning is considered "a central human concern" (Lips-Wiersma & Morris, 2009: 493), while meaningful work refers to "work experienced as particularly significant and holding more positive meaning" (Rosso, Dekas, & Wrzesniewski, 2010: 95). Despite the extant research on various antecedents and mechanisms leading to meaningful work, the role of technology and automation has thus far been largely neglected. Thus, we believe that the findings of our study offer new insights to the literature on work meaningfulness.

First, our findings shed new light on how people achieve the meaningfulness of work by identifying outsmarting as a key mechanism to work worthiness. Organizational research on meaningfulness has been based—either explicitly or implicitly—on one of two perspectives (for an overview, see Lepisto & Pratt, 2017). The prevailing perspective of "realization" focuses on poor job design and/or bad working conditions as the core barrier to meaningfulness (Parker, 2014; Wrzesniewski & Dutton, 2001). From this perspective, influenced by self-determination theory (Ryan & Deci, 2000), meaningful work is achieved by having one's needs fulfilled at work, such as the need for autonomy, competence, or belonging, and being able to fully express yourself at work, for example, by job redesign (Grant & Parker, 2009; Hackman & Oldham, 1980; Parker, 2014) or individual job crafting (Hulshof, Demerouti, & Le Blanc, 2020; Wrzesniewski & Dutton, 2001). The less dominant perspective of "justification" suggests that the core problem of meaningfulness is "focused on the subjective experience of uncertainty and ambiguity regarding the value or worth of one's work" (Lepisto & Pratt, 2017: 106), which may trigger sense-making to account for the value and significance of one's work. For instance, previous work suggested that work worthiness is promoted by transformational leadership, as good leaders can articulate an inspiring vision and generate a compelling purpose for work (Grant, 2012); ritual emotion-related work in organizations (Lepisto 2022), or the way organizational performance is measured (Beer 2022). Both types of meaningfulness assume that the need for human work is taken for granted, which does not hold in the context of job replacement by automation technologies. We propose that it is possible—yet not considered in most of the literature—that workers' perceptions of human work as being worthy may depend upon the degree of reliability of the automation technology itself. Our findings reveal that due to the unreliability of technology, people engaged in a downward comparison of the value of their own work with the value of machine work by demeaning and outsmarting the robots. As such, this new mechanism explains why - since robots occasionally fail, and are limited in various ways – people recognize their human superiority in relation to the machines and reclaim the value of humans, emphasizing the salience of human work in ensuring effective performance.

Second, our findings challenge the existing conceptualization of work worthiness in the context of labor replacement by automation technologies. Despite the prevailing warnings that ongoing automation decreases the value of human work (Frey & Osborne, 2017; Tschang & Almirall, 2021), the way how work meaningfulness is understood has been rarely addressed in this academic literature and remains vague. Although several recent reviews warned that automation technologies can, in some cases, impair the value and meaning of human work (Brison et al., 2022; Parker & Grote, 2022; Wang et al., 2020), their key assumption is that work meaning is mainly facilitated if their psychological needs (Ryan & Deci, 2000) are fulfilled. For instance, Parker and Grote (2022) proposed that automation technologies can reduce job autonomy and thereby create alienation and meaninglessness, and they recommend ensuring that technology is designed and implemented in ways that allow for enriched work. Indeed, finding the meaning and worth of one's own work may be challenging as "work worthiness is not predetermined by the nature of one's tasks nor by broader social structures" (Beer, Micheli, & Besharov, 2022: 1925); therefore, people rely on multiple sources to come to a decision about the worth of their own work. Our findings suggest that work meaningfulness in the context of automation covers a new, previously unconsidered, perspective about the relevance of human capabilities and contribution *in comparison* to machines. Our study shows that witnessing labor replacement by robots induced the reexamination of the value of human work on the shop floor and enabled workers to generate "accounts" (Lepisto & Pratt, 2017) for the significance of human input, based on what the robot-related experiences say about humans ("I am smarter [than a machine]") or human relevance in production ("my work is important [beyond the machines]"). Although our findings about the worthiness of work resonate somewhat with the fulfillment of employees' basic need for competence (Ryan & Deci, 2000), and, thus, the opportunity to "realize" the self through work (Lepisto & Pratt, 2017), they go beyond it: the worthiness of work in the context of automation underscores the comparison between humans and robots, including the recognition of the unique and distinctive capabilities and contribution to work that human workers can make.

Third, our findings point to the role of seeking meaningfulness in one's work in engaging in unsafe working behaviors. Paradoxically, because outsmarting robots had many benefits for the employees we studied, such as upgrading their own sense of meaningfulness and resulting in higher pay for them, due to performance-based pay schemes, it also implied increased risk-taking among employees. Previous work has shown that employees' willingness to risk or sacrifice their own well-being may be a side effect of experienced meaningfulness of work, and it is considered a consequence of seeing work as a calling or having a "place in the occupational division of labor in society" (Bunderson & Thompson, 2009: 39); however, scholars have not considered that people may be willing to take risks in order to *attain* a sense of worthiness at work in the context of the division of labor between humans and machines. The astonishing observation was that the employees, being completely aware of the risks, felt pride in their ability to outsmart the robots by engaging in unsafe work behaviors because these signaled their vital role in handling robot malfunctions and proved the significance of their work in keeping the production line running. Given the multiple layers of uncertainty due to experiencing the unreliability of the robots and witnessing job replacement, the employees turned to their own sense-making mechanism (here, that the robots needed to be outsmarted to get the work done) to guide their behavior in uncertain situations. Uncertainty creates "weak" situations (Mischel, 1973) that may involve safety concerns. We believe these insights call for future research about the role of seeking human worth at work in employees' willingness to take risks.

Robot Reliability and Acceptance

Our research underscores the importance of uncertainty associated with robot unreliability on potential positive outcomes for workers, which have thus far rarely been discussed. Flawless performance is what we typically expect from robots (Ragni et al., 2016); accordingly, the dominant perspective on the uncertainty of technology is that robot failures cause short-term performance interruptions and negative affect (Ayyagari et al., 2011; Hancock et al., 2021; Parker & Grote, 2022). Despite this, perfectly reliable technology may also have negative upsides, such as complacency amongst employees (Parasuraman, Molloy, & Singh, 1993; Wright, Chen, & Barnes, 2018) and diminishing capabilities to detect or prevent errors once they occur (Wall, Corbett, Martin, Clegg, & Jackson, 1990). Thus, in contrast to the prevailing view, which is mostly based on experimental research designs, our observations in a high-stake setting suggest that, in the long run, having opportunities to handle occasional robot failures (thus, experiencing uncertainty) may have important benefits for workers, enabling workers to learn how to outsmart and fostering the development of mastery and expertise. In this way, our investigation joins other very limited research studies suggesting that handling the unreliability of technology may have important benefits for employees, such as increased professionalism (Barrett, Oborn, Orlikowski, & Yates, 2012) and self-confidence (de Visser & Parasuraman, 2011).

Finally, our observations of employee responses to the unreliability of technology challenge some fundamental assumptions on robot acceptance in organizations. For several decades, mostly inspired by the influential Technology Acceptance Model (Davis, 1989), a large stream of the literature seeks to explain the antecedents of human trust in technology, including reliability as a key component of trust (Glikson & Woolley, 2020; Hancock et al., 2021; Hancock et al., 2011b; Hoff & Bashir, 2015). The pertinent finding is that humans trust in, and are more willing to work with technology if it is reliable and, therefore, evokes cognitive trust (e.g., Ross, 2008; Wright et al., 2020), or if it occasionally makes mistakes and facilitates affective trust through being human-like in nature (e.g., Mirnig et al., 2017; Ragni et al., 2016). Our findings contest this dominant reasoning by switching the research focus from trust in technologies as the key outcome that the technology acceptance scholarship seeks to explain to a distinct question – what is the role and worth of humans when technologies are introduced in organizations? Our findings support the prevailing view that robot unreliability initially causes mistrust among workers; yet, in the long run, we show that unreliability also strengthens the worthiness of human work and make automation efforts more acceptable – irrespective of trust. As such, imperfect technology signals a lower risk of job automation, and it also implies that humans do not "feel unnecessary to the system as a whole" (Hancock, Billings, & Schaefer, 2011a: 28).

IMPLICATIONS FOR PRACTITIONERS

Our research has several important practical implications, as scholars and practitioners alike are calling for urgent research on how to realize the benefits of emerging technologies whilst simultaneously leveraging human prosperity (Fine & Kanter, 2022; Maddikunta et al., 2022; Parker & Grote, 2022). Automation technologies continue to be used to replace humans to avoid human-related productivity constraints such as the limited physical capacity of human workers; inconsistent human performance during a shift; fatigue; health-related work ability; and absenteeism. As this happens, the value of human work seems to depreciate compared to technology, and shifting the prevailing view from a technology-centric approach to a human-centric approach to automation seems to be more relevant than ever before (Breque, De Nul, &

Petridis, 2021). In this way, our study resonates with the initiatives like Industry 5.0 in Europe (Renda et al., 2022), which highlights, for example, that automation efforts should prioritize human capabilities and job satisfaction, and our study provides insights for technology developers and policy-makers.

Additionally, knowing that humans play a key role in addressing robot unreliability even if it means risking their own safety, robot designers could use the feedback from the users of their robots and improve the design of robots so people can intervene more safely, so they do not have to engage in practices that go against safety procedures.

Finally, in our study we observed that the operators' interventions are tolerated because they are seen as necessary to reach the required productivity; however, this is not explicitly acknowledged. We suggest that the managers could be more explicit about the value of the human role in handling uncertainty when implementing robots, making it a clear and legitimate part of the robot operator's role. Along with this, the issue of safety should be acknowledged, and safe behavior proactively rewarded, even when it slows down the production line.

LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Our cases focus on contexts with a medium level of technological unreliability. It is possible that the relationship between technological unreliability and outsmarting might follow a curvilinear trajectory, with a moderate level of unreliability being optimal for positive results. Extremely high technological reliability might generate boring and meaningless work with few opportunities for human intervention, whereas severe unreliability might cause such a level of hassle and chaos that emotional arousal would inhibit any learning to outsmart robots. Both extremes diminish the stimulating value of a job, in which it might be impossible to gain any mastery, thereby reducing an employee's ability to solve technological problems when they occur

(Parker & Grote, 2022). Thus, the curvilinearity of the effects of unreliability remains an intriguing future research question.

Our analysis hints at job autonomy and performance pressure as important contextual boundary conditions that require further research. Specifically, the workers studied had relatively high autonomy, which fostered a flexible role orientation and eventually enabled them to develop outsmarting practices in the face of technological unreliability. It may be that autonomy is a critical boundary condition of outsmarting in the face of technology breakdowns. This conclusion is supported by work design research showing the value of autonomy in prompting the development of more flexible role orientations amongst operators (e.g., Parker et al., 1997), although our study goes further to suggest how this process interacts with technology breakdowns to spur employees to adopt new proactive and exploratory behaviors. In addition, performance pressure was fostered by the managers, who strongly articulated that a good robot operator would be able to ensure robot incidents either never occur or are reduced to a minimum. Performance pressure was further influenced by a compensation system that was based on monitoring and rewarding minimal machine downtime, and this was reinforced by coworkers in a sort of team coercion (Barker, 1993) to keep the machines running. Without this level of performance pressure, it is unknown as to whether the same level of outsmarting might have occurred. Moreover, yet another potential boundary condition might be economic growth because this would ensure (as exemplified in our study) that no jobs would actually be lost, possibly giving workers greater confidence to engage in outsmarting. Although our data allows us to speculate that the link between robot unreliability and outsmarting practices was strengthened by these boundary conditions (i.e., high employee autonomy, strong performance pressure, and perceived job security despite ongoing labor replacement with robots), further research is needed to investigate and test these assumptions in a context with variations in these boundary (moderator) conditions. For instance, it might be that the demeaning process that we identified becomes significantly more negative and even harmful if individuals lose confidence that their jobs will continue to exist.

Our findings also suggest another research question around the further development of technology toward increasing its reliability and how this may further reduce the perceived meaningfulness of human work. Interestingly, in consonance with the observed role of robot unreliability in gaining a sense of human significance and relevance on the shop floor, some of our research participants also spoke of how they imagine the future at their factories, for example, thinking about scenarios in which robots might become reliable and people more obsolete—"robots will be protected better and will not make any mistakes" (#F19). Related to this change, they predicted that the more reliable robots will become the reason for the fading significance and relevance of human work—"no workers left, robots will work alone" (#F15). This imagined possibility, however, was quite far off in most operators' minds given the current criticality of human intervention for robot effectiveness. Therefore, longitudinal studies in organizations are needed to better understand the theoretical propositions presented in the current paper.

Our insights further relate to the growing literature on dehumanization at work, suggesting that due to technological advancements, employees' status increasingly resembles that of machines (Brison et al., 2022; Haslam & Loughnan, 2014) or even worse (Nolan, 2023, January 25th), while people continue to complete the "leftover" (often low-skilled) tasks that are not worth automating (Fleming, 2019). Moreover, our study findings, particularly related to demeaning and dehumanizing robots, are thought-provoking, as they invite to think about the long-term detrimental impact that engaging in competition with robots can have on the well-being of employees. We believe that our findings invite future research for a more systematic investigation of how employees use new emerging technologies to feel more "human" at work.

CONCLUSIONS

Automation technologies are taking over human work, often leaving employees with doubts about the worthiness of their input compared to machines. Our discovery in the manufacturing industry reveals that, triggered by uncertainties stemming from both robot unreliability and the threat of labor replacement, employees working along with robots developed practices to demean and outsmart the robots in order to achieve their performance goals, which, in turn, were conducive for experiencing their work as meaningful and vital in the production process.

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TABLE 1

Characteristics of the studied organizations

Organization	Furniture (F)	Electronics (E)
Industry	Furniture manufacturing	Electronic tracking and networking devices
Location	Lithuania	Lithuania
Robot types	Industrial robots	Industrial robots
Number of employees	~ 800	~ 600
Operation history	~ 40 years	~ 20 years
First robotic devices	~ 14 years	~ 11 years
Primary purpose of robotization	Efficiency, labor shortages	Efficiency, precision and quality enhancement
Performance monitoring and management	Performance-based pay Just-in-time	Performance-based pay Just-in-time

TABLE 2

Interviews by job function and socio-demographic information

Job Function/No. of Interviews	**Year 2018**		**Year 2019**		**Total**						
	Furnit Total No.	**Electro** Total No.	**Furnit** Total No. (repeat interview) *	**Electro** Total No. (repeat interview) *	**Furnit** Total No.	**Electro** Total No.	Total No.	**Age at the time of interview**, years min–max (mean)	**Employee tenure**, years Min–max (mean)	**Gender** Female	Male
Robot operators (OP)	15	10	9 (0*)	10 (6)	24	20	44	24–28 (39)	0–16 (6)	13	31
Other workers (WO)	5	13	11 (2)	9 (8)	16	22	38	22–66 (41)	1–18 (6)	19	19
Line managers (MAN)	3	6	1 (1)	5 (5)	4	11	15	30–36 (33)	1–12 (8)	0	15
Directors & department managers (DIR)	2	5		3 (2)	2	8	10	29–51 (35)	1–17 (8)	0	10
HR & training managers (HR)	4	2	3 (1)	1 (1)	7	3	10	26–37 (32)	1–16 (7)	9	1
Total	**29**	**36**	**24 (4)**	**28 (22)**	**53**	**64**	**117**	**22–66 (38)**	**0–18 (7)**	**41**	**76**

**In 2019, some of the interviews were repeat interviews (i.e., with the same person already interviewed in 2018; the number of repeat interviews is indicated in brackets.*

FIGURE 1

Examples of industrial robotic arms*

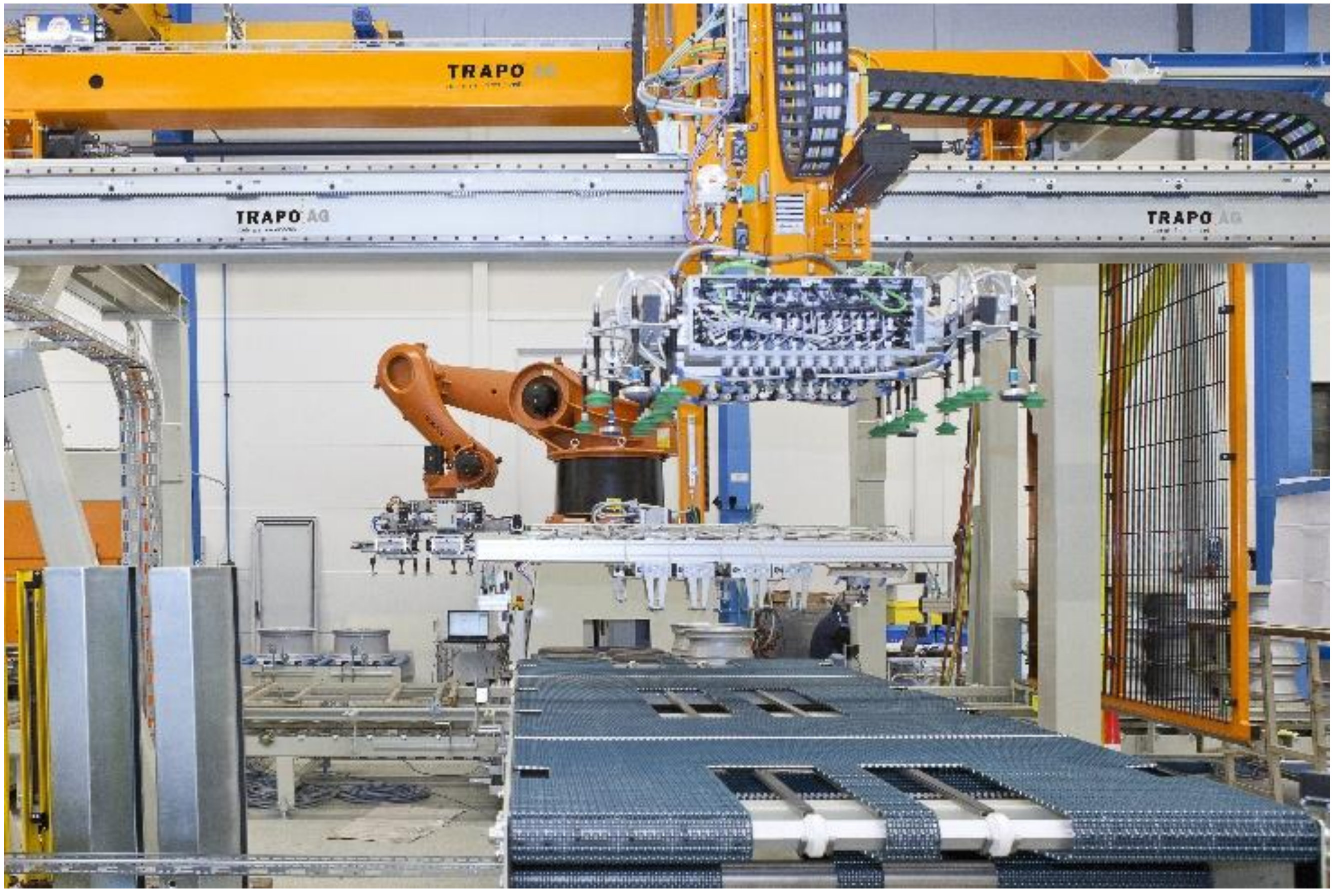
Source: Jo Teichmann, Augsburg, Germany, Public domain, via Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Industrial_robots-transparent.gif

Source: PFEIL GmbH, CC BY-SA 3.0 http://creativecommons.org/licenses/by-sa/3.0/, via Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Nietanlage_1.jpg

**For confidentiality reasons, we could not use photos of robots at the actual locations.*

FIGURE 2

An example of a robotic production line*



Source: TrapoAG, CC BY-SA 3.0 https://creativecommons.org/licenses/by-sa/3.0, via Wikimedia Commons. https://commons.wikimedia.org/wiki/File:F%C3%B6rderanlage_Heute.jpg

** For confidentiality reasons, we could not use photos of robots at the actual locations.*

FIGURE 3

The data analysis process

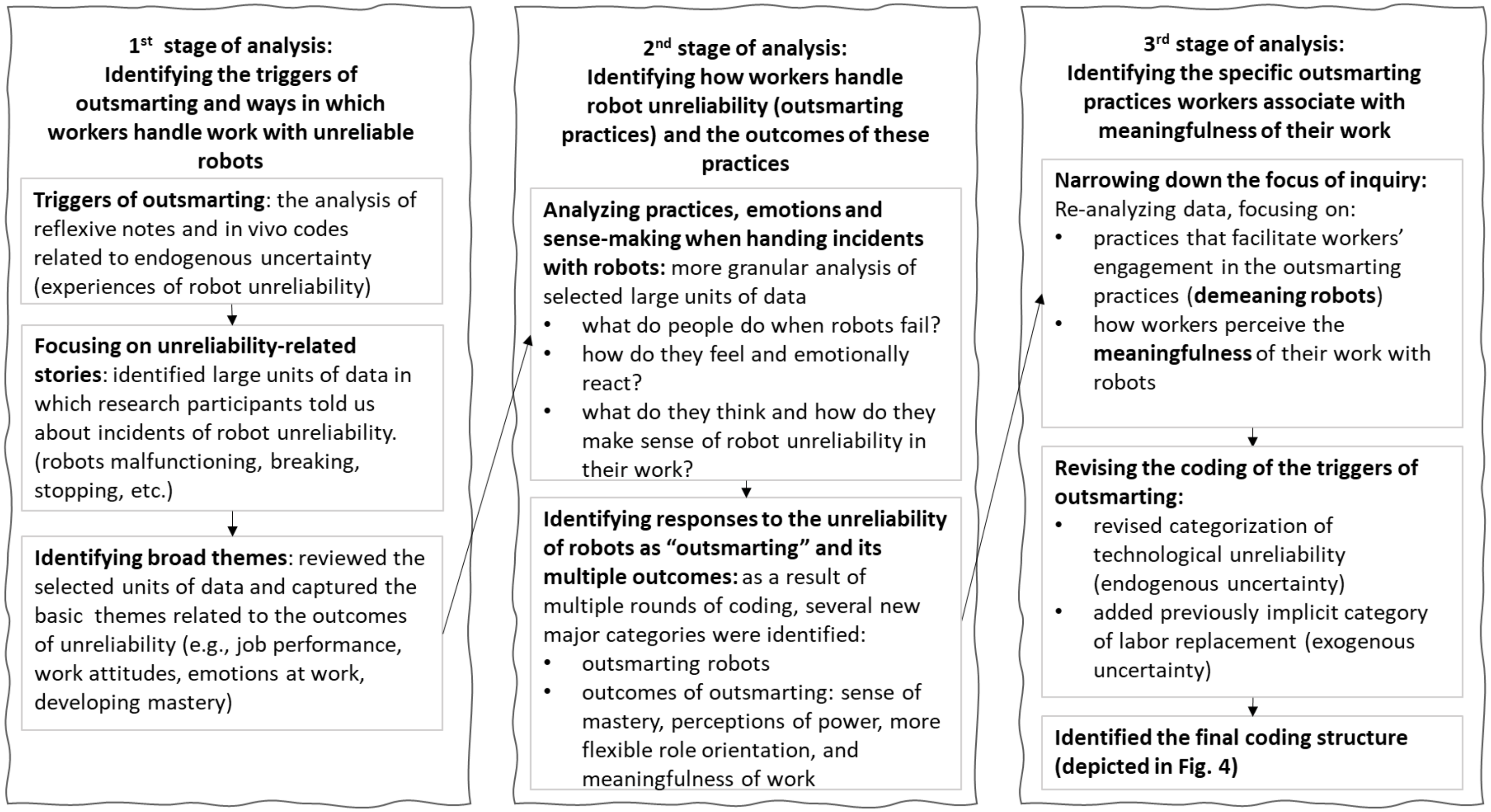
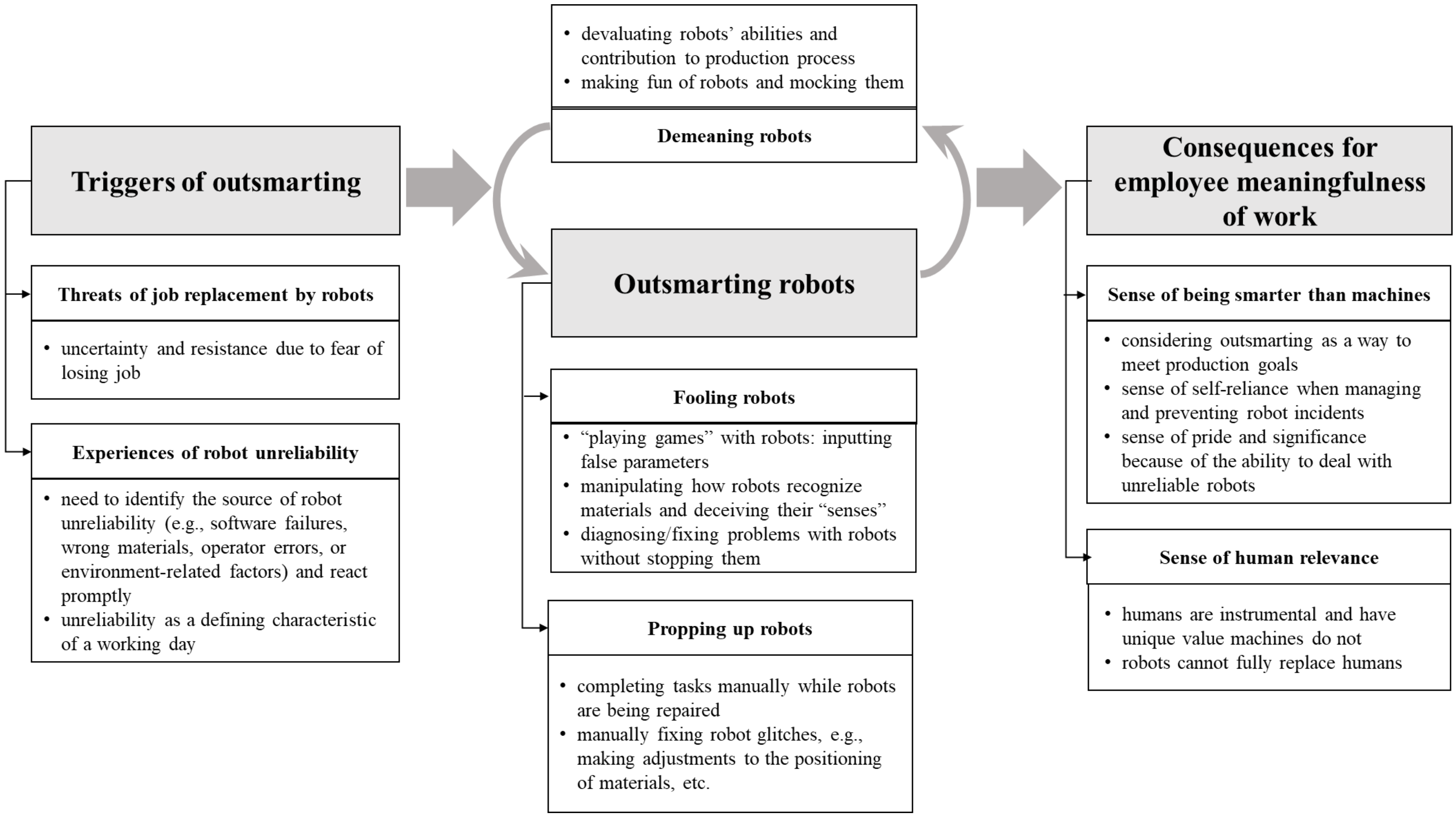


FIGURE 4

Outsmarting robots as a path to the meaningfulness of work



APPENDIX A. INTERVIEW AND TRANSLATION PROCEDURES

Interview procedures

The employees were presented with the aim of the research in the statement: "we are interested in how people work in the companies, where robots were introduced."

We carried out all the interviews at the research participants' workplaces, during their working hours (as permitted by their HR manager).

We assured the research participants of the confidentiality of their responses, and sound-recorded the interviews with their permission.

The design of the research study was created with a broad research question in mind (how people adapt to and work with robots) in order to understand the change in work design due to robot introduction.

We had several versions of the questionnaire that were adapted for workers on the shop floor and the specifics of managerial work. We followed a semi-structured interview guide when speaking with the robot operators and the other workers. We used a similar semi-structured interview guide when interviewing the managers; however, we probed them more about the history of how robots were introduced, what they know about the workers' practices and the issues of robotization at their firms, depending on their specific area of responsibility.

Major topics discussed during the interviews in wave 1 (2018):

1) Experience with robots.
2) A typical day at work.
3) Changes at work due to robotization.
4) The process of adapting to work with robots.
5) Individual experiences with robots in terms of change of identity, workplace relationships, etc.
6) Organizational support.

Major topics discussed during the interviews in wave 2 (2019):

1) What changed since the last interview (for repeat interviews).
2) Experience with robots.
3) A typical day at work.
4) Changes at work due to robotization (*probed for more specific topics identified as important themes when analyzing wave 1 interviews, e.g., to provide examples of robot unreliability and how the interviewees deal with it; to ask about safety issues and whether the interviewees occasionally break the rules)*.
5) Individual experiences with robots in terms of identity change, workplace relationships, etc.
6) Organizational support.

Translation procedures

We conducted the interviews in two languages, depending on which language the research participant preferred. The authors responsible for coding and analyzing the data are fluent in both of the interview languages, as well as in English. Therefore, the interviews were not translated, but transcribed and analyzed in the original language in which they had been conducted. During discussions with the international team members, we presented selected quotes that had been translated into English. We also discussed any translation issues as they arose, and decided on the best translation that would allow us to preserve the authenticity of the responses whilst conveying the original meaning. All translations used in this article were done by the authors themselves and proofread by a professional proofreader.

APPENDIX B. ILLUSTRATIVE QUOTES

Triggers of outsmarting	
Threat of job replacement by robots	[Some people] think that soon we will not be needed anymore, because robots will replace us […] we will lose our jobs […] and will have no chance at all (#F26). At the beginning […] they [the workers] were probably afraid […] that they might lose their jobs. [they were saying] something like “the robots will come, one person will be working, and everybody else will be laid off” (#E24). I think [some people] are hostile because [they are worried] about their workplace. Because [when new robots are installed], automatically, some people become redundant [...] A person is used to doing their work for so many years and now suddenly they have to go do something else (#F7).
Experiences of robot unreliability	When you’ve tuned up all [the settings of a robot] and it still somehow suddenly goes off, and everything is wrong again. […] [I get frustrated], why does it get out of control so suddenly? (#F38). These robots beep, beep, beep and beep. And we know it is bad, there is probably spoilage, but there is nothing we can do about it, robots continue doing it the same way, anyway. So, there it is, this is how our bad day looks (#E27).
Mechanism	
Demeaning robots	That [robot] sometimes does not take the boxes from the shelves, or something else is going wrong […] As we say [about the robot] then, it’s acting stupid (#E10). Sometimes you have to keep your cool if the robot fails and gets crazy […] it happens to them, that they lose track and do stupid things (#F13). The robot drops materials and stops. And you go to reprogram it … it does not understand that. […] and when he gets it wrong, he stops and then stops the whole line (#F2).

Outsmarting robots	
Fooling robots	Okay, I'll give you an example […] it happens that the robot doesn't put [materials] all the way down to their place, but goes like this: bam [visually demonstrates how a robot drops materials] […]. So, what we do is we switch it off […], we count to ten […] we reboot it, we switch it on, […] Or we try to adjust the settings and change them to different ones [and see if that works] (#F40). Well, it is possible to fool the robot into fixing the box. It is possible. […] I have to go into its cage, somebody from outside have to launch the robot and I do the trick. The engineers who come in to fix something, they do it the same way (#E4). Sometimes we cover the sensors so that robot will not detect when we've opened the lid, and this way fool the robot so that we can observe what is going on [inside of it] and figure out what is wrong with the robot, why it is tossing [the materials] (#E41).
Propping up robots	If something goes wrong with the robot, we have to use our hands [to continue working] to keep production going while it's being repaired. We might be doing it for half an hour or an hour while [the technician is] repairing it ((#F5). Well, sometimes we need to fix a tray, a board or some materials that did not run close enough to the robots [laser] "eye". […] Well, I then push the material to the end (#F36).
Consequences for employee meaningfulness of work	
Sense of being smarter than machines	My job is to ensure the smooth, productive work of the robots, and eliminate technical issues. […] If the packaging or other [robotic] lines stop, we don't make money. […] It's my job to prevent those breakdowns (#F3). I've started to think of myself as… I don't even know how to say it... I am proud as a peacock, smarter, maybe. […] I had no idea I would be able to work with these two machines, with these two robots (#F6).
Sense of human relevance	The fact is that robots will replace people in some processes; however, [humans] have to look after the robots, they have to program them, [and do other] highly skilled jobs (#E3). You know, we thought that we'd buy a robot and it would work. But in reality […], while a human being can easily adapt, for a robot, it is an impossible task (#E7).