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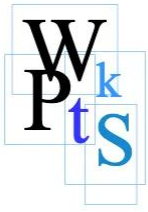
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Foreword

Working Papers Cultural and Sociotechnical Studies series is a forum for exchanging with early career researchers who have situated their seminar papers, theses or research papers within a primarily cultural and sociotechnical framework.

A perspective on technology and culture from the humanities and social sciences is characterized, among other things, by viewing the relationship between technical artifacts and the social contexts in which they are embedded as interdependent –constitutive to both sides equally. This characteristic of sociological perspectives on technology and culture is captured in the title of this series, which suggests that technology is shaped by sociocultural contexts and, in turn, leaves its own mark on society. As ambiguities emerge between the diverse contexts of research, development, manufacturing, embedding, and usage, it is evident that varying focal points and orientations influence the relationship between the social and technology. In highly differentiated societies, the relationship between the social and technology is marked by specific dynamics of disembedding and reembedding.

These dynamics can be appropriately deciphered through a combination of reconstructive and deconstructive strategies. Therefore, the series includes historical as well as visual and performing arts approaches to technical artifacts.

The series *Working Papers Cultural and Sociotechnical Studies* provides a forum for low-threshold exchange with colleagues and is open to artists, scientists, and students from all universities, disciplines, and institutes for the publication of their research and qualification papers. The thematic framework is intentionally broad and can be approached through various forms of presentation, ranging from essays to research outlines and articles.

The series has been published since 2008. Each issue can be accessed online (www.wpkts.de) as a PDF document.

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Automation Technologies and Machines in the Changing Workplace: A Review

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Keywords

Labour, technology, automation, work, STS

Abstract

This research provides a review of the Science and Technology Studies (STS) literature on how machines and automation technologies change the landscape of workplaces and human work. While STS scholars have increasingly placed an emphasis on including inequality and sociotechnical issues in their studies, the study of work and workplaces remains a relatively neglected research topic. This research strives to pinpoint specific debates in the discourse, with the aim of bringing perspectives from the literature together holistically. With this, the diverging proclivities of the examined journals in terms of research are also acknowledged and commented upon. The research method is that of a semi-systematic review. Literature from the following journals is investigated: *Osiris*, *Technology and Culture*, *Social Studies of Science*, and *Science, Technology, and Human Values*. The discourse is divided into four thematic clusters. The main argument developed in this research is twofold: First, the literature is fragmented and aligns largely with the High- and Low-Church distinction in how STS scholars research and teach. Second, considerations of power struggle and disempowerment appear as underlying elements throughout the literature in different forms. A large-scope replication of this research could yield more detailed results on the High- and Low-Church divide as well as debates on disempowerment. Along with STS scholars, this research could contribute to the studies of labour relations, organizational sociology, and machine ethics. For STS, this research could possibly assist in future attempts at theory-building.



Foreword

This research originates from my bachelor's thesis, submitted at the University of Freiburg in December 2023. Subsequently, I presented the study in two conferences: at the 10th STS Italia Conference in Milano in June 2025 and at the 4S in Seattle in September 2025. My experience as a bicycle courier during COVID-19 pandemic has laid the groundwork for my interest in how automation, machines, and labour are discussed. Over time, I realized that these topics concern us and perhaps invigorate us in our daily affairs. The research and the writing process have been an enriching experience, both personally and intellectually. I would like to thank my main thesis supervisor, Dr. Nicholas Buchanan, for enabling me to discover my interest and for providing me with various perspectives. And I would like to thank my second supervisor, Prof. Dr. Frieder Vogelmann, for his feedback and for pointing out that the thesis has publishable depth. Artificial intelligence was only used for grammar check and textual flow.

Introduction

Work and human labor occur through regular interactions with machines and various technologies. This interaction is the social reality of work. Technology enables societies to utilize novel artifacts, engendering new possibilities and social phenomena. Consequently, new types of work emerge. This expanded interaction between humans and technology has given birth to a set of methods, arrangements, and settings that is commonly referred to as automation. Through automation, human element in the workplace has been reduced in manufacturing, informational work, the service sector, and other areas. However, many questions arise when automation and mechanization of the workplace are considered: What types of technologies are used at work? How do such technologies alter the social composition and function of work? What are the underlying power dynamics in the workplace?

With this said, Science and Technology Studies (hereafter STS) could offer much to the scholarly discourse on technologies in the workplace. STS scholars could also



benefit from positioning themselves in this discourse since their field covers a broad field of inquiry. The previous studies on workplaces in STS mostly revolve around the scientific workplace and “scientific labor” (Kleinman & Vallas 2001). Furthermore, social movements and the study of social inequalities through an STS lens have been noted by scholars (Felt et al. 2017; Moore 2021). However, questions regarding technologies in the workplace and their effect on labor remain understudied areas in STS. With these in mind, this research aims to map the existing research in STS by providing a review of the scholarly discourse. The following questions serve as a roadmap for the research:

- What are the debates in STS on machines and automation in the workplace? How does STS study the relationship between automation technologies and workplace dynamics?
- What theoretical concepts are utilized in these debates? What kind of theoretical links could be drawn within the literature?

Methodology

The research is laid out primarily as a semi-systematic literature review (Snyder 2019: 335). Further elements of an integrative review can also be found, which aims to critique and synthesize the literature on a topic in a way that enables new perspectives to emerge (ibid.). Therefore, along with reviewing the STS literature on the topic, this research also provides a critique of it.

Articles in the English language have been selected from four STS journals: *Osiris*, *Technology and Culture*, *Social Studies of Science*, and *Science, Technology, and Human Values*. These journals appear as core journals for social studies of science and technology. Relevant articles for research purposes were searched through the websites JStor, Project Muse, and Sage Journals. The search criteria for the articles included five main keywords: *work*, *workplace*, *labour*, *automation*, and *labour and technology*. Subsequently, the articles' relevancy for the research was determined



after a brief review of the abstracts. In total, twenty-eight articles were deemed relevant for the research. One of these articles, *Social Choice in Machine Design* by David Noble, is considered to be within the literature even though it is not published by any of the mentioned journals. The article relates closely to the purpose of this research.

The discourse is divided into four clusters, with both the first and final clusters containing subtopics. These clusters are named as follows: historical studies of labour and technology, technological determinism and machines, post-industrial workplace, and human-machine interactions. The subsequent sections cover the clusters in that order. These clusters were arranged according to topic and core arguments. While articulating distinct disciplinary and thematic characteristics, each of these clusters maintain an academic conversation on machines, the workplace, and labour. A significant portion of the articles have overlapping points, which are elaborated upon throughout the review.

1. Historical Studies of Labour and Technology

This cluster involves of two groups of historians in the debate: labour historians and historians of technology. Historians of technology mostly use a lens from the *top*, which revolves around management- and business-centric perspectives towards the workplace. According to Hafter, historians of technology have spent much effort defining technology and explaining how crucial inventions came to be made (Hafter 2003: 102). On the other hand, labour historians assume a lens from the *bottom*, emphasizing a shopfloor- and worker-oriented research. Their discussions revolve around child labour, sweatshops, women's work, and industrial safety (Scranton 1988b: 724). Interestingly, while having many similar areas of interest in their research, these historians mostly remained in their own domains until the 1970s.

During the 1970s and 1980s, a wave of critical historical work relevant to the worker culture and labour-management relations appeared (Smith 1991). This body of work is characterized as the "new social history" (ibid.: 555). This trend saw historians of



technology conduct studies on labour to uncover patterns of power dynamics in the workplace, investigating the relationship between machines and workers as well as unionization movements induced by automation. These studies acknowledge that labour has been long understudied among scholars of the history of technology.

A one-off publication by *Technology and Culture* in October 1989 relates to this. This special edition called *Labor History and the History of Technology* declares that the *intellectual region* of labour and social history needs further exploration by historians of technology (Scranton 1988a). This special issue aims to offer ample evidence that the convergence of labour history and the history of technology can yield provocative insights and future investigations (ibid.: 719). Smith (1991) is guided by questions that emanate from a similar line of thinking: Can historians of technology contribute to the discourse on technology, industrialization, and labour? Correspondingly, Hafter states that scholarly attention needs to shift its concentration to the workers' role in technology (Hafter 2003: 102).

Perhaps Misa's (1988) macro- and micro-perspectives could help us better understand how labour and technology have been studied previously. For Misa, there exists a division in how scholars study technology and social change: the extreme macro-perspective of scholars of technology and the determined micro-perspective of labour historians (Misa 1988: 309). While both try to justify their fields of research, Misa argues that the work of critical historians, an amalgamation of sorts, has the function of showing technology as socially constructed and society-shaping (ibid.: 319).

Critique of Scientific Management

A focal point for historians is the emergence of the *rational* factory setting. As factory production replaced workshop production in nineteenth-century cities, new forms of workplace organization emerged (Dierig 2003: 132–133). In this context, Lewis' (2001) research focuses on factory design during the interwar period in the USA. For managers and business owners, rationalizing the factory meant rearranging a factory's internal geography and production operations in a way that would speed up work and reduce the labour force (Lewis 2001: 665–666). In the early years of the twentieth



century, a growing number of engineers, architects, and manufacturers sought out methods to bring together machinery, labour, and materials more effectively (ibid.: 670). The transfer of material handling from workers to machines appeared as one of the core components of modern factory design (ibid.: 671). This shift from manual labour to conveyors and cranes enabled automobile companies, steel mills, and other routinized plants to reformulate the factory organization (ibid.: 671).

On a similar note, Frederick Taylor's principle of scientific management, which is laid out in his 1911 publication *The Principles of Scientific Management*, introduced a new genre of arguments about the industrial workplace (Frost 1988). This line of thought adopted a rationalized shopfloor through pacing, punctuality, and order (Smith 1991). The methods and principles of scientific management are heavily influenced by the ideology of engineers. Thus, the idea that society can be managed on engineering principles is at the heart of scientific management (ibid.: 132). In this context, Lerman (1997) unpacks the relationship between education and factory work in the late nineteenth century in Philadelphia. Many schools at the time included manual training to teach habits of accuracy, neatness, and obedience to adolescents so that they become adequate factory workers (ibid.: 54–55).

With this said, most scholars perceive scientific management as a blatant attempt to control the worker (Henderson 1991; Noble 1978). Here, *Labor and Monopoly Capital* by Harry Braverman and various works by David Noble emerge as influential sources. They argue that factories operating under Taylorist principles witnessed the skills and prerogatives of workers being deliberately transferred to automated machines. A main issue Braverman accentuates is the use of technology and managerially directed technical practices to capture control of work processes (Scranton 1988b: 736). More machines meant a dilution of skill in the worker, and thus, factories relied less on the worker.

Disempowerment and Skill

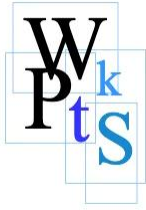
As mentioned previously, a conceptual quadrumvirate of rationalization, technology, disempowerment, and deskilling spearheaded by Noble and Braverman is widely

investigated in the literature. With this, historians often highlight the power dynamics between workers and management. It is argued that each side attempts to disempower the other through different strategies. However, the attempts from the top, that is, by the management, are considered restrictive. These attempts appear in mainly three forms: routinization of tasks, deskilling of the workforce, and intentional employment of certain technologies.

Perhaps the most influential work in the top-down disempowerment debate comes from Noble (1978), who primarily argues that the intentions and choices of particular people have informed the design and deployment of the new technology (Noble 1978: 315). Noble examines the consequences of numerical control (NC) technology in the workplace. He argues that even though there were alternative automation technologies in the metalworking industry at the time, NC was deliberately utilized because of its deskilling effect on the workforce. This provides context for how automation entered the workplace as a managerial attempt to exert control over the workforce. Hence, automation can be conceptually considered a logical extension of Taylor's scientific management (Taylor 1978: 335).

On the same note, Meyer (1988) states that dilution of skill had great benefits for the manufacturer in his case study of the Allis-Chalmers Company in the US during the first half of the twentieth century. He states that deskilling allows the management to reassert control and diminishes the role of labour in the work process (Meyer 1988: 846). To a certain extent, the new production methods rendered skills obsolete, enabling managers to employ less skilled production workers (ibid.: 851). Comparably, Frost (1988) investigates the workers in the French electrical power industry while noting Braverman's claim that technological innovation in the workplace always results in worker disempowerment. The shift in political conjecture in France resulted in the decline of labour's power to shape the implementation of new technologies (Frost 1988: 883). As an outcome, unions increasingly perceived computerization as a weapon of management used against labour and its skills (ibid.: 885).

Nonetheless, certain scholars argue that upskilling is the main challenge for labour, not deskilling. Frost (1988) associates disempowerment with upskilling rather than



deskilling. For him, the main concern for the workforce is not the skill level but rather the equal distribution of the extra wealth made through the newly implemented machines. New labour processes often require more sophisticated skills among workers. This changes the landscape of the shopfloor considerably.

Here, the influence of Karl Marx is observed. Adler's close reading of *The Capital* makes a case for upskilling (Adler 1990: 810). His main argument is that the skill-change process must be contemplated in terms of short- and long-term trends. He argues that upskilling is a more viable observation than deskilling under Marx's model of social change (ibid.: 783). Additionally, the spread of education poses a major upgrading force for worker skills, according to Marx (ibid.: 791). Whereas deskilling might be a common phenomenon in the short term, the long-term effects of technological development in the workplace results in upskilling. His primary conclusion focuses on Marx's account of two types of labour that emerge from increased automation and mechanization: machine supervision labour and scientific labour.

MacKenzie, aligning himself with Braverman, states that deskilling is a tendency, not a definitive fact (MacKenzie 1984: 493). He argues that worker disempowerment manifests in various ways and is closely connected to the Marxist class struggle. According to his study of Marx's writings, large-scale machine usage was a milestone in history (ibid.: 473). Prior to the widespread usage of machines in production, workers owned and used their own tools, producing goods in their own accounts (ibid.: 482). The transfer of skills to the machine changes the relations of workers. MacKenzie also states that capitalism is founded upon the principle of labour subordination. Hence, centralization of the work, deskilling, worker alienation, and increased mechanization ultimately enhance the power and authority of the capitalist (ibid.: 483–484).

2. Technological Determinism and Machines

The literature investigates technological determinism from different angles. Scholars concentrate on three main questions: Is technology an autonomous force? How can technological progress be conceptualized? How political are machine design and implementation of technologies?

Technological determinism connotes a particular understanding of technology in its relation to history and society. It views history as an inevitable process dictated by the self-determining march of technology (Noble 1978: 314). Consequently, to be a technological determinist is to believe that technical change causes social change (MacKenzie 1984: 474). Formulated differently, social factors do not contribute to technical innovation. Such a deterministic viewpoint perceives technology as almost akin to a black box, changing and transforming autonomously with its own internal logic (Dafoe 2015; Misa 1988). Technological determinism appeared as a popular standpoint among scholars until the 1980s, at the outset of constructivist views.

Technological determinism has been consistently rejected by labour scholars and Marxist thinkers. From a Marxist perspective, technology itself does not constitute a problem, but the manner in which it is utilized in capitalist and bureaucratic structures should be questioned (Misa 1988: 311). It is also argued that technological development has always had a political dimension under capitalist relations of production (Delfanti & Frey 2021). Another notable criticism is that technological determinism does not allow room for human agency.

Below, Figure 1 depicts scholarly positions on technological determinism as a spectrum. Harder determinists place more emphasis on the autonomy and power of technology, and softer determinists allow for more social control and context (Dafoe 2015: 1052). It is also argued that the claims of technological determinism are macro-observations about patterns in history (Dafoe 2015: 1058). In accordance, one could argue that historical studies with bottom-up workplace perspectives do not engage in macro-level observations and, hence, tend to reject technological determinism.

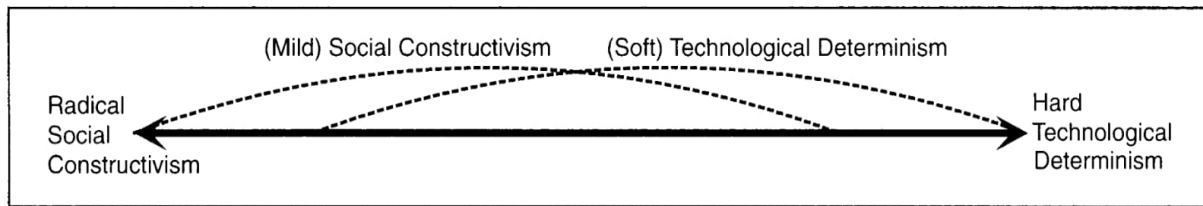


Figure I. A continuum of the scholarship in technological determinism (Dafoe 2015)

The constructivist perspective argues that technological practice is a social process, simultaneously socially shaped and society-shaping (Henderson 1991: 137). In line with this, Klein and Kleinman (2002) claim that the theory of social construction of technology (SCOT) has enriched the understanding of technology in STS. According to constructivists, technology development is a process in which multiple groups negotiate over its design, with different groups asserting their own definitions of a working technology (Klein & Kleinman 2002: 29–30). They frame this as a negotiated technological development (ibid.: 30). Hence, they conceive the relationship between technology and society as a co-constructive one (ibid.: 30–31).

Building a consensus for technologies in the workplace often begets questions of power imbalances and interests, much like the earlier debate on skill and disempowerment. It is possible for technological development to go against the workers' interests while benefiting those of the elite. When managerial elites participate in the design process, they might impose their own meanings on an artifact or technology (Klein & Kleinman 2002: 38). Here, being able to encourage a discourse of labour-management cooperation on the issues of technological implementation, or a form of techno-corporatism, is vital (Frost 1988: 885). In this context, machine design is widely discussed (Berg 1998; Garrety & Badham 2004; Noble 1978).

In sum, the implementation of technologies, machines, and other artifacts in the workplace and the production process is political and social. Increased utilization of technology cannot simply be attributed to technological innovation. Questions of what to use and how to use it take place through social negotiations. As mentioned above, it becomes a question of power. Nevertheless, the matter of power in the workplace transcends the employer-employee dimension as the discourse moves away from industrial work and manual labour.



3. Post-Industrial Workplace

This thematic cluster marks a discursive shift from labour (manual/factory) to information work, mental work, and technical work (occupational/professional). Different types of technological systems and artifacts, such as computers and artificial intelligence (hereafter AI), are frequently discussed in the workplace. Scholars in this cluster attribute these shifts to several phenomena. With the decline of manufacturing, economies have become more knowledge- and information-based; that is, the percentage information-related services make up larger portions of economies. This resulted in more people taking up positions as clerics and information processors. Concomitantly, the types of tasks automated by machines change. As a result, perspectives on workplace in post-industrial settings emerge.

This focus on post-industrial machines and automation is contrasted with what constituted *work* during the industrial era. As discussed in previous sections, automation was intended to transfer worker skills into machines, attempting to decrease the influence of the human element and enabling management to assert more control over the worker in the process. The main reason for this is that workers provided considerable physical input into the production process in factories (Delfanti & Frey 2021: 659). In a post-industrial setting, the amount of physical work is greatly diminished. Despite this, Perrolle (1991) argues that professional workers face the same problems as manual labourers in the information age, albeit in different forms. She states that information workers expend mental effort for their work since their jobs revolve around producing and processing information. This leads to automation and deskilling in different manners. The use of computers and AI at the workplace has the potential to embody knowledge in programs, enabling a less-skilled person to achieve expert results (Perrolle 1991: 198). This means further routinization of mundane tasks. Allegedly, routinization and automation enable people to perform more interesting activities (ibid.: 199).

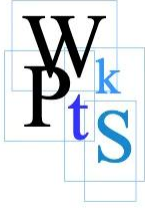
Similarly, Kraft and Siegenthaler state that computers automate information work since they are themselves information processors (Kraft & Siegenthaler 1989: 195). This has two significant results: task fragmentation and the emergence of skill levels. Lower-



level workers, who carry out fixed tasks, can be controlled, whereas higher-level workers are allowed considerable autonomy (ibid.: 199). Middle-level workers fall in between. While their work is expected to reach a certain quota or a specific aim, they possess greater liberty in their means than the lower level. The article also makes a case for the gendered division of labour with increased computerization in informational work. Utilizing Braverman's arguments, the authors state that computerization entails deskilling in clerical work, which is mostly filled by women. However, they also express that clerical work contains room for more decision-making by workers since information-based work might include uncertainties regarding inputs and outputs (ibid.: 199).

Another juxtaposition of skill and work in the post-industrial setting revolves around technical work. In his anthropological study, Orr (1998) perceives technical work as a form of non-industrial but skilled work. He argues that sorting out humans and machines in terms of what each can do helps researchers better understand technical work. Work in general is inextricably linked to technique and practice. Practice is socially charged; it is imbued in the human knowledge and experience of *know-how*. On the other hand, technique refers to the application of principles and even the use of specific tools (Orr 1998: 446). A vital claim of the article is that the industrial era abstracted technique from practice, separating most of human knowledge from the context of its possible application (ibid.: 446–447). Machines are critical to this abstraction. The technique is attributed to machines, and human practice becomes obsolete. Hence, *skill* in the post-industrial context pertains to abstracted technique. Conversely, work that is based on interpretive activity and behaviour remains out of reach for machines (ibid.: 449–450). This is why it is argued that Taylorist management prefers technique over practice.

From this perspective, a recent article by Delfanti and Frey (2021) research contemporary applications of Taylorism, a digitalized version of it. The scholars' account of Amazon's worker control strategies in large warehouses stems from a thorough investigation of 243 selected patents owned by the company. According to the scholars, Amazon has a clear motivation for consolidating its power in the digital



workplace through surveillance, intensified labour, datafication of tacit knowledge, and “humanly extended automation.” (Delfanti & Frey 2021: 661) Similar to the abstracted technique, Amazon envisions a digitized warehouse in which workers act and serve on behalf of the machinery (ibid.: 675). Wearable glass technology, which was originally designed for surveillance purposes, can observe and codify the way a human grasps and picks items from shelves (ibid.: 667–668). Incorporation of living labour’s tacit or embodied knowledge in software is used to optimize machinic processes in hopes of achieving a fully automated warehouse (ibid.: 669). Even though the construction of a workplace in which machine capability surpasses tacit knowledge and practice appears to be a priority for Amazon, a fully automated warehouse seems unlikely in the foreseeable future.

4. Human-Machine Interactions

This thematic cluster focuses on singular human-machine interactions and its social considerations. Anthropocentric approaches to the human-machine relationship, the replacement of human elements at work, and nonhuman agency appear as crucial points. In perceiving machines as nonhumans, this body of literature is also entangled in debates concerning actor-network theory. Hence, Bruno Latour’s conjectures on human-nonhuman relationships are observed throughout this cluster.

Emerging from a governance-oriented and legal perspective, Jones (2017) offers an account of what personhood constitutes amidst the automated treatment of individuals. She contrasts two legal standpoints in this context, one taken by the EU and one by the US. European political culture holds that treating an individual in a wholly automated way, or to provide only automated treatment, is to dehumanize the individual because a machine can only treat a human in a computational manner (Jones 2017a: 231). Thus, to treat a human in such a manner reduces the individual’s dignity, and restoration of dignity can be provided by a human in the loop (ibid.: 232). She asserts that automated treatment of individuals causes workforce concerns as

well and concludes that automation issues have revolved around people being replaced on factory floors (ibid.: 225).

Narrowing their focus on the workplace, Lisle und Bourne (2019) investigate what they formulate as *automated borders*. The article aims to examine the hierarchical conceptualizations of human-machine interactions and draws from interviews, discussions, ethnographies, and observations at a large UK airport and a medium-sized European airport throughout the year 2016. Here, automated borders refer to increased usage of automation technologies in the making of actual borders between countries, such as e-gates, e-passports, *live* biometrics, and various databases for the purpose of making border decisions at airports more accurate and reliable (Lisle & Bourne 2019: 683). Against this background, anthropocentric workplaces are defined as those where the superiority of either side (the human element or technology) is assumed to be an inherent conviction. The main argument is that both pro- and anti-automation positions insist on separating humans from machines, resulting in a dilemma of human action being either delegated to machines or withdrawn from them (ibid.: 685).

Contrastingly, Hartland's (1996) research on automated blood pressure measurement is guided by the following question: To what extent can computers undertake *human* tasks, and what role do people play when computers begin to do *their* jobs? (Hartland 1996: 71). The computerized device produces acceptable results through an automated process that renders the human, who listened to the sounds through the stethoscope, redundant (ibid.: 87). This research states that automated machines have altered the division of work. The machine only performs a portion of the total task using a standardized procedure because it is designed to do so (ibid.: 87–88). Hartland concludes her article with two general inquiries: Could other parts of the blood pressure recording process be delegated to a machine? Can the role of computers be expected to extend to other human-performed tasks?

Berg (1998) article intends to conceptualize humans and machines along with their relation to workplaces. To carry this out, he conducts research on how social theorists imagine *better* technologies for more democratic and worker-oriented workplaces



(ibid.: 457). His analysis revolves around the involvement of the user in information technology design. Citing Noble and Braverman, he states that information technology designed in a Taylorist fashion ultimately works against workers' interests (ibid.: 459). According to Berg, this is reflected in *traditional systems design*, a common system development method in engineering. Traditional systems design sees human work as describable, akin to engineer-like logic: as consisting of clear-cut, well-circumscribed tasks, executable in a predictable and predesigned sequence (ibid.: 467). Since this viewpoint overlooks the social dynamics of the workplace, it is characterized by a large gap between those who design the technology and those who use it (ibid.: 458). Democratic workplaces require new technologies that acknowledge the tacit skills and knowledge of workers (ibid.: 465).

Correspondingly, Garrety and Badham (2004) discuss how to bring the normative politics into the workplace. The researchers attempt to implement user-centred design (UCD) in an Australian factory from 1996 to 1998. UCD is formulated as a set of principles and practices that aim to privilege the needs and aspirations of users in technology design and implementation (Garrety & Badham 2004: 192). The normative claim of UCD asserts that technological systems should be designed and implemented to support the capabilities, needs, and aspirations of their human users (ibid.: 194). The way researchers justify their focus on UCD is twofold. First, the introduction of UCD is related to normative discussions of technology in STS research (ibid.: 192). Second, considerations for UCD are based on Latour's conceptualization of the relationship between humans and nonhumans. The authors express that humans and nonhumans cannot be thought of separately in isolation from one another (ibid.: 194). The research concludes that practical implementation of UCD methods is challenging; however, they have the potential to render the workplace more worker-oriented (ibid.: 208–209).

Can Machines Have Agency?

Since artifacts and machines that perform routine tasks at work do not possess human traits, they become a study subject for actor-network theory (ANT). At its core, ANT emphasizes relationships between actors in the social domain and perceives

participants in these relationships as *actants*, suggesting that social networks consist of interactions. Originating from the writings of Bruno Latour, ANT is considered a controversial social theory (Sayes 2014). The literature pinpoints ANT as part of a contemporary research trend called *new materialism*, which is conducive to the rise of *thing* studies in STS and underlines the relevance of the study of material culture (Jones 2017b; Sayes 2014).

Perhaps the most prominent premise of the theory is the claim that nonhuman actants possess agency. The term *nonhuman* functions as an umbrella term used to encompass a wide range of entities, such as animals, tools, texts, and economic goods (Sayes 2014: 136). In this respect, material artifacts utilized in the workplace, such as industrial machinery, computers, robots, or even tools, can be considered nonhuman entities.

To elaborate on nonhuman agency, Sayes (2014) provides an overview of four of the contributions that nonhumans make to social life (Sayes 2014: 135). These include nonhumans as enablers for society, mediators, members of moral and political associations, and gatherings of actors (*ibid.*: 136). Out of these four main contributions, the first two are the most crucial for machines in the workplace. The first one argues that the actions and capacities of certain nonhumans are seen as a condition for the possibility of the formation of human society (*ibid.*: 137). The second one asserts that nonhumans are more than intermediaries that stand in for more real and meaningful actors (*ibid.*: 138). In both contributions, nonhumans possess the ability to make a difference in the network they reside in. According to Sayes, this is the real meaning of nonhuman agency (*ibid.*: 141). His conclusion is twofold: it is almost certain that nonhumans will never have inertia by themselves, but this does not mean that they do not possess agency (*ibid.*: 143). On the contrary, since action is always interaction in ANT, nonhumans have agency by virtue of constant interaction with other actors (*ibid.*: 144).

Emanating from an ANT-related approach, Jones (2017b) delves into the topic of nonhuman agency by asking whether robots can be perceived as social agents and, if yes, how they acquire their social character (Jones 2017b: 557). The discourse

surrounding *social* robots is indicated as the intersection of STS and social robotics (ibid.: 556). As its empirical basis, the article critically examines the works of Morana Alec and inspects an educational robot called RUBI that is designed to interact with toddlers and children. The social agency of RUBI is discussed through two notions. First, any action that takes place in the dialogical space between humans suggests a unique human capacity to co-construct interaction and action (ibid.: 565–566). However, this human dialogicality is perceived as rather unobservable and unanalysable (ibid.: 565). Second, dynamic interaction underlines interactional patterns that progress in time: the actions of both operator and machine flow together to perfect the performance of the task, during which the operator becomes more skilled, and the robotic system adapts to its user (ibid.: 560). When discussing sociality criteria for robots, Jones underlines different ways to ontologically conceptualize these. The *strong* ontological claim is that future robots will become human, and the *weak* claim is that humanoids will remain fully artificial despite appearing to be human (ibid.: 562). The main conclusion of the study suggests that a robot will become truly social only if it autonomously partakes in dialogical action.

Results and Critical Overview

At first glance, the contribution of the following scholars to the discourse should be acknowledged:

- Langdon Winner (cited 6 times throughout the literature)
- Harry Braverman (cited 12 times)
- David Noble (cited 10 times)
- Bruno Latour (cited 9 times)
- Lucy Suchman (cited 6 times)

There is a pattern between these scholars and the thematic clusters. Winner, Braverman, and Noble are mentioned frequently in the first two clusters. On the other hand, Suchman and Latour appear noticeably in the third and fourth clusters. This

observation could be interpreted in terms of disciplinary tendencies between the clusters. Winner, Braverman, and Noble study prominently the ideological, political, and historical aspects. For instance, Misa (2011) perceives Noble's work as involving a radical historiography (Misa 2011: 362–363). His critical and historical appraisal of technology is conducted from a Marxist perspective (ibid.: 361). In addition, Winner's cited works in the literature (his book *Autonomous Technology* and article *Do Artifacts Have Politics?*) reverberate his conceptualization of technological development and implementation as an inherently political one. On the other hand, the influence of Suchman and Latour outline anthropology- and sociology-oriented perspectives. According to Berg (1998), Suchman's book *Plans and Situated Actions* is a fine-grained study of human-machine interactions (Berg 1998: 460). Bruno Latour's contribution to the social studies of science is well known.

These disciplinary differences can be assessed through journal tendencies too. A substantial majority of the investigated literature comes from two journals, namely *Technology and Culture* and *Science, Technology, and Human Values*. The articles from the other two, *Osiris* and *Social Studies of Science*, make up a quarter of the investigated literature. At first glance, *Osiris* and *Technology and Culture* concentrate on the industrial revolution, technological determinism, factory work, and manufacturing. Both journals are rooted in history, conducting historical research on science and technology, respectively. Hence, the content of the first two thematic clusters is predominantly derived from the literature taken from these two journals.

In contrast, *Social Studies of Science* and *Science, Technology, and Human Values* lean more towards interdisciplinary perspectives, including an emphasis on sociology and anthropology. Even though the articles from these two journals influence the third and fourth clusters strongly, they contribute to debates on technological determinism and the historical study of technology as well. In the end, the orientation of thematic clusters and the journals reiterate a well-known STS analogy.

The tendencies of the inspected journals and thematic clusters can be juxtaposed with the High-Church and Low-Church distinction (Fuller 1997; Sismondo 2008). Coined and conceptualized by Steve Fuller almost thirty years ago, this distinction argues that

STS sustains two sub-traditions. It is argued that these two parts differ in goals, styles, and attention (Sismondo 2008: 13). High-Church mainly utilizes methods of the humanities and social sciences to study technology and science (Fuller 1997: 181). Whereas Low-Church is oriented towards underlining public interests in science and technology (Sismondo 2008: 18). With this background, one could argue that *Osiris* and *Technology and Culture* lean towards High Church. As an essential journal for STS, *Social Studies of Science* is traditionally characterized also as High-Church journal (ibid.: 21). On the other hand, *Science, Technology, and Human Values* lean towards Low-Church. Nevertheless, perceiving the High Church as purely academic work and the Low Church as political or advocacy work creates further duality in STS (ibid.: 20).

I would argue that academic comprehension as well as policy relevance are both vital in the context of studying work. The purpose of studying the interrelation between workplaces, human effort, machines, and automated processes is to ultimately conceptualize and create human-oriented, socially sustainable, and egalitarian workplaces in the twenty-first century. And deciphering these interrelations requires input from both Churches, especially at a time when workplace and labour subjects are acknowledged as either understudied or somewhat nascent areas.

With this said, several topics in the workplace context still appear to be under discovered. One instance of this is the emergence of so-called neo-Taylorist workplaces. Here, Delfanti and Frey's research is valuable since it describes how multinational companies such as Amazon are fusing digital technologies with Taylorist principles in the twenty-first century. This is quite relevant amidst the increased (and future) usage of AI technologies in the workplace. Studying this would be well within STS' field of inquiry. Unfortunately, no other article in the investigated literature establishes a link between new forms of Taylorism and digital technologies. AI technologies in the workplace pertain to novel discussions of skill shifts as well. More prominently, the effect of AI on managerial work or *high-level* skill positions could be explored. This skill and occupational transformation are studied by business and management journals and economists (Agrawal et. al 2019; Brynjolfsson & McAfee

2016). *Social Studies of Science* has considerable research on AI, but the focus is more on the ethical and social ramifications of AI technology and how scientists concretely develop AI models.

The crucial aspect of AI in the workplace can be discussed in the context of automating decision-making itself. However, the investigated literature implies that automation does not necessarily eliminate the human component at work. But it alters the way one works. It replaces a certain chunk of one's work, specifically certain tasks in a given job description. Nevertheless, this does not mean that automation, as a sociotechnical process, is devoid of any power in the workplace. People's work is imbued in various technologies. Hence, automation becomes a nonhuman mediator in a broad network of workplace relations.

Conclusion

This research conducted a review of twenty-eight articles chosen from four prominent journals in STS with the aim of summarizing and evaluating the discourse of machines and automation technologies in the workplace. The review argues that the discourse appears in four thematic clusters. The first one, historical studies of labour and technology, is concentrated around two journals: *Technology and Culture* and *Osiris*. Discussions in this cluster revolve around the role of technological change during industrial development, highlighting Taylorist management model and deskilling. The second cluster focuses on an eminent theory in STS, technological determinism. Although determinist perspectives originate from large-scale historical studies and contain teleological views of history, debates are enriched by non-historical journals as well.

The third cluster marks a shift in the discourse by moving from industrial and manual work to post-industrial settings such as offices, modern warehouses, and information work. Offering anthropological perspectives to the discourse, this cluster argues that human work is entangled with more sophisticated technologies like computers, AI,



digital spaces, and algorithms and should be studied accordingly. The influence of *Science, Technology, and Human Values* is significant in this cluster. The final cluster concentrates on sociological investigations of human-machine interactions. Human interactions with devices and automated processes, as well as machine design at work, are covered. The discussion of machine agency in the context of nonhumans and actor-network theory is elaborated upon.

This review remains limited in its scope. A future replication of this research can combine additional journals and search criteria. This could result in a more detailed account of the scholarly discourse. The clusters attest to the claim that STS literature on workplaces, automation, and technology is fragmented. When the literature and the clusters are placed side by side with the High- and Low-Church distinction in STS, the fragmentation becomes visible. This can be understood by the research inclinations, journalistic aims, and disciplinary backgrounds of the articles. However, this research asserts that studying technology and the workplace within the STS area of sociotechnical issues must consider perspectives from both Churches.

With the growing body of research in STS on inequality and sociotechnical issues, new conceptualizations of human work and technology might emerge. In such a setting, the review at hand could be utilized for theory building and holistic conceptualization. Such a theory would allow scholars to work with a concise analytical framework when studying relationships between technology, society, science, and work.



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