RESEARCH CONTRIBUTIONS TO ORGANIZATIONAL SOCIOLOGY AND INNOVATION STUDIES

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Artificial Intelligence and Social Action

A techno-sociological contextualization

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Organizational Sociology and Innovation Studies

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Abstract

This discussion paper contextualizes contemporary forms of artificial intelligence (AI) within the broader relationship between technology and society, and it compiles essential insights from the sociology of technology for interdisciplinary discourse. The paper begins with a concise overview of the history of artificial intelligence and situates AI within the co-evolution of technology and society. It then presents key perspectives on the interaction and distributed agency between humans and technology, identifying five fundamental levels of agency and relating these levels to the interplay of AI and social action. Throughout these considerations, it becomes evident that the expectations of human-technology interaction, as well as the concepts of intelligent technology, are continually evolving and contingent upon social change. Consequently, the development and diffusion of AI should not be viewed as a primarily technology-driven phenomenon but rather as a genuine socio-technological transformation process.

Zusammenfassung

Das vorliegende Diskussionspapier ordnet gegenwärtige Formen der künstlichen Intelligenz (KI) in das allgemeine Verhältnis von Technik und Gesellschaft ein und bündelt zentrale Einsichten der Techniksoziologie für den interdisziplinären Diskurs. Das Papier beginnt mit einer kurzen Geschichte der künstlichen Intelligenz und stellt diese in den Kontext der langfristigen Koevolution von Technik und Gesellschaft. Daran anknüpfend werden einschlägige Perspektiven auf die verteilte Handlungsträgerschaft von Mensch und Technik diskutiert, grundlegende Ebenen der Handlungsfähigkeit voneinander abgegrenzt und auf das Zusammenspiel von KI und sozialem Handeln bezogen. Dabei wird deutlich, dass sich sowohl die Erwartungen an Mensch-Technik-Interaktionen als auch die Vorstellungen von intelligenter Technik kontinuierlich weiterentwickeln und gesellschaftlichem Wandel unterliegen. Die Entwicklung und Verbreitung von künstlicher Intelligenz lässt sich insofern nicht als ein primär technologiegetriebenes Phänomen, sondern als ein genuin sozio-technischer Transformationsprozess verstehen.

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1 Introduction

With the launch of ChatGPT by the company OpenAI in November 2022, along with similar offerings introduced shortly thereafter, generative artificial intelligence chatbots based on deep learning have become a common feature of everyday life. These chatbots can generate text, images, videos, and computer code, offering a wide range of applications. For example, they can assist with routine office tasks, translate articles, create visual content, provide overviews of news and research, and help prepare for exam questions. The immediate utility and practicality of these applications has led to unprecedented excitement about the automation of cognitive tasks in public discourse, global financial markets, and various scientific fields, including the humanities and social sciences. Many voices see artificial intelligence (AI) as a key technology for driving societal change in the 21st century (Heinlein & Huchler 2024).

Recent discussions about the societal impacts of artificial intelligence reveal a strong fascination with the technology and encompass a wide array of expectations. These expectations range from the optimistic prospect that advanced AI systems could play a pivotal role in tackling grand societal challenges and achieving the sustainability goals set by the United Nations (e.g., Vinuesa et al. 2020; Kulkov et al. 2024) to concerns that large language models, such as GPT, may soon be capable of handling cognitively demanding work tasks, potentially ushering in a new era of mass unemployment (e.g., Cazzaniga et al. 2024). On the one hand, these visions are driven by predictions from the IT industry itself (e.g., Eloundou et al. 2024), which has a vested interest in promoting ambitious technological expectations. On the other hand, they are supported by neuroscientific studies indicating that existing generative AI models are already performing at levels close to humans in recognizing prompts, predicting actions, and engaging in conversations (e.g., Strachan et al. 2024; McLean et al. 2023).

The crucial question is, however, what exactly is being tested in these studies and what criteria are being employed to evaluate machine intelligence, or machine agency, given that the catchword "artificial intelligence," while seemingly straightforward, actually describes a wide range of disparate developments in information technology that are not readily comprehensible to laypersons, or even to researchers in neighboring fields. In light of these complexities, Lucy Suchman, a pioneering scholar in the field of human-machine interaction (Suchman 1987) and an early observer of the development of artificial intelligence (Suchman & Trigg 2000), argues that a primary task for the social sciences is "to challenge discourses that position AI as ahistorical, mystify 'its' agency and/or deploy the term as a floating signifier." (Suchman 2023: 1)

Against this backdrop, the aim of this discussion paper is not to elucidate the development dynamics underpinning the term "artificial intelligence." This is a domain that other disciplines, such as computational social science, are better equipped to address. Instead, the following sections seek to contextualize contemporary forms of AI within the broader relationship between technology and society and to compile basic insights from the sociology of technology for interdisciplinary discourse. To this end, the paper begins with a brief overview of the history of artificial intelligence (Section 2) and situates AI within the co-evolution of technology and society (Section 3). It then presents key perspectives on the interaction and distributed agency between humans and technology. Drawing on the work of Werner Rammert and Ingo Schulz-Schaeffer (2002, 2023), among others, five fundamental levels of agency are distinguished and related to the interplay of AI and social action (Section 4). Taken together, it becomes evident that the expectations of human-technology interaction, as well as the concepts of intelligent technology, are continuously evolving and contingent upon social change. Thus, the development and diffusion of AI should not be viewed as a primarily technology-driven dynamic but rather as a genuine socio-technological transformation process (Section 5).

2 A brief history of artificial intelligence

The history of modern AI, as outlined in Table 1, starts with the logician and mathematician Alan Turing (1912–1954), whose seminal paper “Computing Machinery and Intelligence” (1950), along with the concept of the “Turing Test” proposed therein, significantly shaped our understanding of artificial intelligence. Turing himself referred to his test as an “imitation game,” which involves a machine and a human engaging in a text-based dialogue. He proposed that if the communicative behavior of a computer appears no longer distinguishable from human behavior, we should speak of machine intelligence. From this perspective, a machine should be considered “intelligent” when it can successfully convince its counterpart of its human-like behavior.

The term “artificial intelligence” was first used in the proposal for the Dartmouth Workshop. During this workshop, a group of distinguished computer scientists convened for a period of two months to discuss “how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves.” (McCarthy et al. 1955: 1) The initial public hype about AI emerged with the release of the computer program ELIZA, developed by Joseph Weizenbaum (1966). ELIZA is capable of simulating conversational partners in a text-based dialogue by responding to keywords found in its thesaurus. Its role as a psychotherapist has received particular media attention. For instance, when a user inputs, “I have a problem with my mother,” ELIZA responds with a query such as “Tell me more about your family.”

Weizenbaum’s objective in developing ELIZA was twofold: first, to explore the possibilities of computer communication and, second, to demonstrate that a true dialogue between humans and machines is unfeasible. In fact, the experiment had the opposite effect. On the one hand, some test subjects began to attribute emotions to the software. On the other hand, the experiment generated considerable public anticipation regarding the future capabilities of artificial intelligence, including the possibility that psychotherapy could be largely automated in the near future. Weizenbaum was unsettled by these discussions because he was aware of the simple rules underlying the functioning of his program and the constraints of its operational logic. Consequently, he later cautioned against an unreflective use of AI and IT in general, noting that "our society is increasingly reliant on computer systems that […] exceed the understanding of those who work with them." (Weizenbaum 1978: 311, own translation)

Table 1: Milestones in artificial intelligence

1950	*Turing test*	Alan Turing addresses whether machines can exhibit intelligent behavior and devises a test for assessing machine intelligence.
1956	*Dartmouth Workshop*	The field of research and the concept of artificial intelligence are defined in detail for the first time.
1957	*Perceptron*	Frank Rosenblatt introduces the perceptron model, a simplified artificial neural network.
1966	*ELIZA chatbot*	Joseph Weizenbaum publishes the prototype for AI chatbots. By engaging users in a dialog, ELIZA demonstrated that computers can generate human-like responses.
1972	*Rule-based expert systems*	The first rule-based, application-oriented expert systems are developed for the medical sector.
1980	*Machine learning*	The first workshop on machine learning is held in Pittsburgh. In the same year, three consecutive issues of the International Journal of Policy Analysis and Information Systems are devoted to machine learning.
1986	*NETtalk*	The generation of spoken language becomes conceivable.
1996	*IBM Deep Blue*	In a 6-game match, the Deep Blue chess computer defeats the then-world chess champion Garry Kasparov.
2009	*Deep Learning*	Artificial neural networks are increasingly capable of processing and analyzing complex data sets.
2010	*IBM Watson*	The program Watson wins the US quiz show "Jeopardy!," in which the right question has to be derived from several ambiguous answers.
2011	*Virtual assistants*	Software programs such as Apple Siri or Amazon Alexa can respond to naturally spoken language.
2017	*Transformer architecture*	Google introduces Transformer, a deep learning architecture that uses machine learning to train a model on a large number of sample texts.
2022	*Generative AI*	ChatGPT and other generative AI systems are able to generate content, data, and computer code.

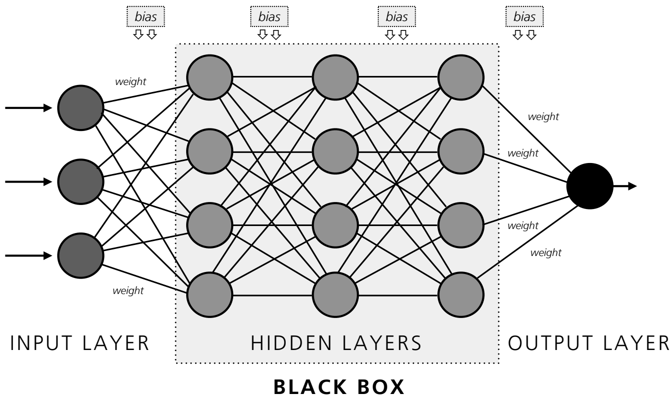
Source: own compilation

By the mid-1970s, it was evident that many development goals in artificial intelligence would remain unattainable for the foreseeable future. For example, a report from the British Science Research Council (Lighthill 1973) observed that "in no part of the field have the discoveries made so far produced the major impact that was then promised." This widespread sense of disillusionment led to a decades-long "AI winter" (with brief intermissions), during which the scientific interest and public funding for AI projects declined sharply. While there were, in fact, advancements in fields such as industrial robotics, rule-based expert systems, spoken language recognition, and machine learning during this period, most of these developments were no longer labeled as "artificial intelligence" (Hirsch-Kreinsen 2024; for a critical view, see Pasquinelli 2023).

In popular culture, the situation was different: From the late 1940s onwards, stories of human-like robots cognitively superior to their creators gained popularity. One example is the 1949 novel "Wing 4" by Jack Williamson, in which a rebel group rises against a robot collective that was originally created to prevent wars and has subsequently taken control of all of humanity. Following the success of Stanley Kubrick's "2001: A Space Odyssey" (1968), which depicted the sentient supercomputer HAL 9000, intelligent machines were increasingly featured in major films, including "Star Wars" (1977), "Blade Runner" (1982), and "Terminator" (1984), which also influenced social science discourse. For instance, these and other narratives inspired Donna Haraway to write her seminal essay "A Cyborg Manifesto" (1985). In this text, she challenges the conventional boundaries between humans and machines from a feminist perspective. As early as the 1980s, Haraway described her fellow humans as "cyborgs," that is, as beings who have a symbiotic relationship with the technology that surrounds them.

In contrast, apart from the 1996 victory of IBM Deep Blue, an expert system running on a supercomputer the size of several cabinets, over the then-world chess champion, application-oriented AI research did not attract broader public attention until the new millennium. Between 2009 and 2012, it became possible to make machine learning more effective by using artificial neural networks (Figure 1), which can be trained with large data sets in highly regulated environments and are able to extract abstract features from this data, a process known as "deep learning." Building on this, in 2017, Google introduced the Transformer architecture for natural language processing, which employs a soft-weighting attention mechanism designed to mimic human cognitive attention and to recognize the essential meaning in a given context (Vaswani et al. 2017). These advancements established the foundation for large language models such as GPT (by OpenAI), Gemini (by Google), Llama (by Meta), or Copilot (by Microsoft).

Figure 1: A very simple artificial neural network



Source: own illustration

As a result, modern AI systems are now capable of performing tasks intuitive to humans but difficult to describe with formal rules. Such tasks include automatic facial and speech recognition, visual art processing, and medical image analysis. However, a substantial trade-off persists in that the outputs of these models are challenging to reconstruct and explain, even with considerable effort: Artificial neural networks operate with millions of opaque internal parameters, which are adapted to the training data through billions of arithmetic operations.

The release of ChatGPT in the fall of 2022, along with other applications of large language models capable of generating text, images, video, or code, signaled the arrival of deep learning-based AI in everyday life. As the responses of these systems often resemble human behavior, including the tendency to conceal knowledge gaps, a pervasive sense of technology fascination emerged in media coverage, on the stock markets, and across the social web. Indeed, it seems reasonable to assume that AI systems will increasingly serve as interlocutors in various domains, effectively giving the impression that they are not machines, and that society will have to navigate several painful learning processes in these respects (Esposito 2022; Katzenbach & Pentzold 2024).

That said, these advanced communication skills do not necessarily correspond with universal cognitive capabilities comparable to those of the human brain. In this regard, the distinction between strong (or general) and weak (or narrow) artificial intelligence provides a valuable initial point of reference (Fjelland 2020):

- *Weak artificial intelligence* refers to self-learning information technology systems tailored to specific tasks and problems. Its primary focus is the simulation of intelligent behavior in order to assist, or augment, human thought and action in particular domains, even beyond routine tasks.
- *Strong artificial intelligence* describes autonomously operating systems capable of understanding, learning, and performing any intellectual task at a level comparable to or exceeding that of a human brain. Depending on the definition, these systems are expected to have their own mind and consciousness or, at least, to behave as if they possessed these qualities.

The history of AI to date has been a history of weak AI; nevertheless, the development of strong AI represents the ultimate goal of numerous private-sector research initiatives. There is considerable debate regarding when, or even if, machines will attain the ability to control their actions intentionally. Predictions vary widely, ranging from a few years to decades or even centuries (Roth et al. 2024). In an interview, computer scientist Rodney A. Brooks offered a tempered perspective on the matter (Zorpette 2023): Since AI systems such as ChatGPT are based on artificial neural networks that correlate language data, they lack "any connection to" and "any underlying model of the world." According to Brooks, large language models are good at "saying what an answer should *sound like*, but that is different from what an answer should *be*."

3 Artificial intelligence as part of the co-evolution of technology and society

The history of technology can be viewed as a cumulative process in which each technological revolution builds on previous innovations and their use in society. For example, the establishment of infrastructure systems in antiquity was only possible because of earlier advances in agriculture and urbanization. The Industrial Revolution would not have been feasible without the social and technological developments in the early modern period. Similarly, modern innovations such as the internet, smartphones, or AI systems would not exist without widespread electrification. It is, therefore, imperative to recognize that technological and social change are inextricably intertwined. Technological development is rooted in social premises, is driven by social needs, and, in turn, influences the scope of social action. Thus, when we discuss the history of technology, we are actually discussing the co-evolution of technology and society.

From such a co-evolutionary perspective, the recent developments in the field of artificial intelligence, as well as the surrounding expectations, can be viewed as a further step in the digital transformation of society, which in turn builds on numerous sociotechnological premises, including the automation of labor and the gradual technization of everyday life (Schrape 2021: 41ff., 2025; Popitz 1995, [1992] 2017):

- The first data registers and forms of surveying, which facilitated coordination over larger areas, were already in use in antiquity. The standardization of time measurement and the advent of the printing press in the early modern period led to more complex forms of social coordination, accompanied by an *increasing focus on data*.
- The early *mechanization* of manual work, which began in Europe in the 11th century with the introduction of windmills and watermills equipped with camshafts, provided significant support for human labor in processing grain, textiles, metals, and other materials. Concurrently, the corresponding workflows were substantially influenced by the characteristics of the technological artifacts.
- The advent of *industrialization*, marked by the invention and societal adoption of steam, electric, and internal combustion engines that replaced wind and water power in many sectors, enabled the widespread use of drive motors and machine tools from the mid-18th century onwards. Many tasks could now be performed or supported by machines; mechanical and human work processes became increasingly intertwined in the production of material goods.
- This accelerated process of »technization« (Elias 1995: 7) went hand in hand with a comprehensive *rationalization* of world views and socio-economic exchange. This shift led to a belief in the calculability of nearly all phenomena in this world (Weber 1968), along with an omnipresent orientation towards efficiency and the capitalist economic order, which today is perceived as almost unrivaled.

- The development of microprocessors and low-cost sensors in the 1970s enabled the *automation of machine control* across various industrial sectors. In light of the growing use of industrial robots and semi-automated production systems, several popular books were already published at this juncture that examined the benefits and challenges of technological unemployment (e.g., Albus 1976; Noble 1984).

Following the industrialization of production, automated technological aids gradually entered the average private household, too. Household automation began, among others, with the refrigerator, which went into mass production in 1927, and the thermostatic radiator valve, which was introduced in 1952. This trend continued with cruise control systems, first marketed under the name "auto-pilot" in 1958, and sensor-based anti-lock braking systems for vehicles, introduced in 1971. The omnipresence of technology in modern daily life can, in turn, largely be attributed to the expansion of prosperity that accompanied industrialization: While sophisticated technical instruments were unaffordable to the majority of the population in the 19th century, complex technological devices became ubiquitous in developed countries in the 20th century.

Thus, long before the "digital revolution" was discussed as a societal transformation process, a level of automation had been achieved in many realms of everyday life that approached a well-known prediction of the ancient Greek scholar Aristotle (384–322 BC). In his work "Politiká" (book I, chapter IV, own translation), he sought to justify the institution of slavery that pervaded all antique civilizations, but he also speculated: "If it were possible that every instrument, by command or by perceiving our will, could perform its task, […] neither artists would need assistants, nor masters slaves."

Although automation was primarily focused on physical processes for most of the 20th century, the long-term developments outlined above paved the way for the rise of digital technology in recent decades. First, trust in technological systems—which often operate beyond immediate comprehension—has become integral to everyday life. Second, modern society is not only critically dependent on functioning technology, but, as Lewis Mumford (1934) noted early on, our understanding of the world is also substantially shaped by technological logic and the belief that we can overcome most challenges by applying appropriate technological solutions. Third, technological systems for structuring and organizing data have developed into a crucial factor in the coordination of economic and social exchange processes.

By the beginning of the 20th century, data-driven calculations had already become such a fundamental basis of orientation that Max Weber (1864–1920) arrived at his seminal thesis on the *disenchantment of the world*. According to Weber, the collective belief in modern society no longer pertains to transcendental forces but rather to technology, calculability, and predictability. This conviction—"that one can, in principle, master all things by calculation" (Weber [1919] 1946: 386)—can, however, also be described as a "re-enchantment" of the world by other means (Jenkins 2000: 11), since no individual or organization alone can fully comprehend the calculations underlying our worldview, but at best in segments. During Weber's lifetime and in the subsequent decades, the collection, structuring, and systematic use of data was a highly demanding task; until the late 20th century, data processing remained a resource-intensive process that could hardly be carried out by individuals without organizational ties.

This has changed with the penetration of computers into more and more areas of society since the 1980s, the broader digitization since the 1990s, and especially the rise of smartphones and digital platforms since 2007 (Dolata & Schrape 2023; Schrape 2025; Kappler et al. 2018): Today, it is not only organizations that are characterized by a strong data orientation but also an increasing number of daily routines and social action spheres. The diffusion of smartphones has led to an *informatization of everyday life*, and the orientation towards real-time data has become a matter of course in developed countries within just a few years. Thus, people who are integrated into today's digital society can indeed be described as "cyborgs" in the sense of Haraway (1985) since many of their action horizons are only made possible through the use of technology. In other words, whether or not virtual reality solutions or more sophisticated forms of AI will prevail, we are already living in an "augmented reality," an IT-enhanced reality in which individual perception is supplemented by real-time data access.

The comprehensive informatization of everyday life was a prerequisite for the development of artificial intelligence and its societal diffusion in several ways. First, many companies (e.g., Alphabet, Microsoft, Apple, NVIDIA, Meta) that are currently propelling AI development have emerged within consumer-oriented IT markets. Second, much of the data used to train contemporary AI systems has been generated through the extensive day-to-day use of digital communication media over the last 20 years. Third, the rapid social adoption of generative AI is, to a certain extent, predicated on prior experiences with the IT-based support of daily routines and everyday data orientation. From a long-term perspective, it can be argued that the impetus for the automation of cognitive tasks, as well as the concomitant hopes and fears, is rooted in the societal experiences in earlier phases of technization and the collectively established trust (or mistrust) in technology and technologically mediated services.

Since the first mechanical devices, physical work has been subject to technization, and since informatization, cognitive tasks have also been affected, provided that the use of technology appears to be more cost-effective than human work. From the perspective of the sociology of technology, although, the course of socio-technological change around artificial intelligence is less a question of technological capabilities than a reflection of how society responds to them (Häußling et al. 2024; Heinlein & Huchler 2024; Lindgren 2023). The current phase of diffusion and ongoing innovation, in which new patterns of technology use and economic exploitation are consolidating around AI, is accompanied by multi-faceted appropriation processes, in which society is only gradually becoming aware of the ambivalences of the new trajectories of socio-technological development and their repercussions on the social order.

4 Technology, artificial intelligence, and social action

4.1 Distributed agency between humans and technology

Technological and social processes are thus inextricably interlinked, from development and production to application and use, and cannot be viewed in isolation. In the early stages of socio-technological transitions, this regularly becomes a matter of public awareness, for example, when novel technological solutions are not yet reliable or when society has not yet adapted to them. However, once a new technology has been established and its use has become habitual, the conditions of its genesis and function, its action-shaping effects, and its impacts on the social order are rarely scrutinized.

In contrast, sociology, particularly regarding its foundational question ("How is social order possible?"), is perpetually obligated to investigate the relationship between social and technological structuring processes. Within the sociology of technology, three main perspectives prevail in this regard, describing technology either as an infrastructure that shapes society as a whole, as an institution that shapes social action or as a more or less independent co-acting player (Schrape 2021: 26–30, 2025):

- Concepts of *technology as infrastructure* focus on large infrastructure systems that profoundly influence the scope of societal possibilities (Mayntz & Hughes 1988; Hughes 2004; Silvast & Virtanen 2016). Without elaborated communication networks, for example, many forms of modern co-existence would be infeasible. Such infrastructure systems are not merely understood as technological conglomerates but as socio-technological interdependencies, wherein technological, economic, legal, and political processes are intertwined. Since the Industrial Revolution, new infrastructure systems, such as railroads, power grids, and the internet have greatly expanded the range of societal exchange. At the same time, this expansion has also given rise to new socio-economic power asymmetries that have been analyzed by numerous critical social scientists since the works of Karl Marx (1818–1883).
- Notions of *technology as an institution* highlight the action-shaping effects of technological structures within situational and organizational contexts. Émile Durkheim ([1895] 2003: 84) has described rigidified regulatory structures as institutions that can impose an "external constraint" on social actors, including traffic rules, the educational system, and the economic order. This also applies to technology: Similar to social norms, the characteristics of technological systems shape the rules of the game within their fields and create distinct incentive structures. For example, the introduction of assembly lines in factories changed both the pace of work and organizational structures. Similarly, internet platforms such as TikTok and Instagram, by design and settings, encourage specific modes of communication while impeding others (Dolata & Werle 2007; Dolata & Schrape 2023).

- Descriptions of *technology as an actor* refer to technological systems as more or less independently acting entities that co-constitute social situations. Bruno Latour (2005) has posited that in modern society, human and non-human actors interact symmetrically in various ways and that social figures such as “the soldier” or “the influencer” only emerge through the interplay of humans and technology (e.g., humans and weapons; humans, smartphones and social media platforms). More pragmatic approaches focus on the situational involvement of technology in specific actions and how humans and technological devices interact within hybrid constellations of “distributed action” (Rammert & Schulz-Schaeffer 2023: 40). Everyday examples of such constellations include driving a modern car equipped with sensor-based assistance systems and creating content using of AI tools.

All perspectives emphasize that technology is deeply embedded in socio-economic contexts, from its genesis to its implementation and use, and that once established, socio-technological interdependencies stabilize patterns of social order, significantly influencing human agency and social action. This applies to digital platforms, which have assumed a substantial role in structuring public communication and socio-economic exchange. It applies to large infrastructure systems that have become indispensable for modern society. And it applies to the myriad of technological systems that today assist individual, collective, and organizational action.

In order to explore the interplay between artificial intelligence and social action, however, perspectives that focus on technology as a co-actor in human-machine interactions appear particularly instructive, not least concerning the question of accountability for the actions resulting from these hybrid constellations (Beckers & Teubner 2021). Pioneering work in this field was conducted by Sherry Turkle (1984: 13ff.), who described computer technology not only as a tool but as a constitutive part of our world, serving as a catalyst for changes in both our actions and our thinking. Concurrently, Lucy Suchman (1987) laid the groundwork for the study of human-machine interaction, demonstrating in several video studies that even highly educated users—including Allen Newell (1927–1992), regarded as one of the parents of AI—could experience cognitive overload when operating simple devices such as copy machines. Her research revealed that performing tasks on technical devices cannot be viewed as a fully plannable process; rather, it is a complex situational interaction between humans and technology.

At the latest, the work of Bruno Latour (1990, 2005) has raised awareness of the ubiquity of socio-technological entanglements within sociology and contributed considerably to the development of interdisciplinary science and technology studies (STS). A substantial body of research on the interaction between humans and technology has emerged across these disciplines (see, for an overview, Felt et al. 2016; Blättel-Mink et al. 2025; Schubert & Schulz-Schaeffer 2023) and in related fields. Within the broader context of actor-network theory (ANT), numerous studies have explored hybrid constellations in various domains, including robotics and generative AI (e.g., Gutiérrez 2023; Venturini 2023;

Hajli et al. 2022, Michael 2016). In media studies, a comprehensive discourse on the interplay between algorithmic structures and social dynamics in public communication has developed in the face of further informatization (e.g., Jarke et al. 2024; Esposito 2022; Airoldi 2021; Hepp et al. 2024). In cognitive science, a growing number of concepts, such as the theory of "distributed cognition" (Hutchins 2020, 1995), assume that cognitive processes conventionally attributed to the individual are, in fact, distributed across brains, socio-cultural contexts, technological artifacts, and their use over time.

Latour (1988: 300–308) himself initially illustrated the entanglement of social action and technology using the example of the automatic door closer, which became common at the end of the 19th century and ensured that the doors of public buildings were closed again after people had entered. Previously, this task was carried out by porters, incurring high personnel costs. The advent of mechanical door closers offered a more cost-effective solution but also placed new demands on users, who were required to wait for the right moment and pass through the door in a specific time frame. The example highlights a principle dynamic: technological systems invariably impose expectations on their users, while users, in turn, impose functional expectations on technology. This reciprocal relationship is also evident in modern-day phenomena, such as self-service retail checkouts and driver assistance systems. In light of this, Latour (2005: 71) defines "any thing that does modify a state of affairs by making a difference" as an "actor." In other words, Latour assigns actor status to an artifact on the basis of its observable effect in changing a social situation; the question of how this effect comes about seems secondary.

At the same time, however, even though an escalating proportion of individual and collective action horizons are realized through technological means, it is evident that mechanical door closers, self-service checkouts, or driver assistance systems do not possess the same capacity for action as humans do. Consequently, the broad and indiscriminate attribution of agency to technology appears to be only partially fruitful (see already Winner 1993). To clarify this issue, Werner Rammert and Ingo Schulz-Schaeffer (2002, 2023) have proposed to distinguish between several distinct levels of agency when observing constellations of distributed action between humans and technology.

4.2 Fundamental levels of agency

In their analytical model, referred to as the "concept of gradual action," Rammert and Schulz-Schaeffer (2002, 2023) outline three levels of agency and complexity of action: (1) the ability to effect changes in material, symbolic, or spatial terms; (2) the ability to choose between alternative courses of action; and (3) the ability to control and explain actions intentionally (Table 2). A salient feature of this model is the recognition that both human actions and technological operations can, in principle, be situated at all three levels of agency. Hence, determining when this is actually the case and how agency is distributed between humans and machines in specific situations is rendered a genuinely open empirical question (Muhle 2013: 83–90, 2023).

Table 2: Levels of agency in the "concept of gradual action"

Intentional explanation	Intentional control of actions, from the attribution of simple dispositions to coordination by means of complex intentional semantics
Being able to act differently	Selection between alternative courses of action, from predefined options to the self-generation of selectable alternatives
Effecting change	Performance of tasks according to predefined procedures; modification of action contexts, from temporary to permanent alterations

Source: Rammert & Schulz-Schaeffer 2002, 2023

At the level of *effecting change*, it hardly matters in modern society whether tasks are performed by humans or machines, provided there are no malfunctions. As Rammert (2008: 75) notes, "agency of this kind means an efficient behavior, a behavior that exerts influence or has effects, as in the Latin term 'agere' or in Latour's term 'actant'." For example, whether a standard banking transaction is automated or handled by a human is often not discernible to the customer—or even relevant. Many taxpayers will not care whether the tax office uses software or employees to verify their tax returns. Likewise, whether a cable car is operated automatically or by a person seems to be of secondary importance. In these situations, both humans and technological systems follow predefined procedures, thereby modifying their environment.

At the level of *being able to act differently*, the agent is not only able to induce modifications in material, spatial, or symbolic terms but also has the ability to choose among alternative courses of action. Simple mechanical devices, such as a door closer, lack this ability. Software-controlled systems, on the other hand, have the capability to choose between different reactions depending on the input. For instance, car assistance systems can initiate varied responses depending on the traffic conditions. Rammert and Schulz-Schaeffer (2023: 44) cite navigation systems as an example of more sophisticated forms of the ability to act differently. Such systems proved feasible "when it became possible to provide them with the necessary information about the route network, with the relevant criteria for evaluating possible routes, and then to let these devices calculate and select the available options for action themselves." Similarly, today's aircraft autopilots are capable of responding to any conceivable environmental condition (Collinson 2023). These more complex forms of the ability to act differently are driven by knowledge, leading to the emergence of human experts or IT expert systems.

At the level of *intentional explanation*, the emphasis is not only on the ability to act differently but also on the capability to interpret and control actions in a meaningful way, either by attributing simple dispositions or through complex intentional semantics. Conventionally, this capacity for intentional action has been associated primarily with human individuals, as in Max Weber's ([1921] 1968: 4) notion of social action:

> "Sociology […] is a science which attempts the interpretive understanding of social action […]. In 'action' is included all human behaviour when and insofar as the acting individual attaches a subjective meaning to it. […] Action is social insofar as, by virtue of the subjective meaning attached to it by the acting individual (or individuals), it takes account of the behaviour of others […]."

However, Rammert and Schulz-Schaeffer (2023: 46) argue, in line with sociological and psychological insights, that "our intentions and goals are, in their overwhelming majority, far less individual than we are inclined to believe" and that human actors "not only have intentions and goals they are (or might become) aware of, but also intentions and goals for which this is not true." In this sense, human actors often align their behavior with established situational definitions, cognitive frames, and action scripts in everyday interactions, drawing on cultural knowledge when interpreting their own actions and the actions of others (see already Goffman 1959). If such patterns of interpretation exist in a culturally objectified form, Rammert and Schulz-Schaeffer (ibid.: 47f.) see no compelling reason why similar action-guiding patterns should not also exist in a "technically objectified form" and why it should not be possible "to identify and analyze similarities and possibilities of mutual substitution between human action and technical activities also at the […] level of intentional action."

The aim of Rammert and Schulz-Schaeffer's "concept of gradual action" is to facilitate a more nuanced comparative investigation of human and technological agency within constellations of distributed action between humans and technological artifacts. The objective is to ensure empirical openness across all levels of agency, attributing the capacity for intentional explanations through objectified interpretation patterns not only to humans but also, in principle, to technology. Nevertheless, in addition to intentional actions oriented towards cultural knowledge and social norms, various kinds of human action can be identified that cannot be fully explained by cultural patterns alone. This is particularly true for actions that deviate from social expectations and provide unexpected solutions arising from remote contexts of action.

Thereby, it is essential to recognize that human actors, while admittedly having access to far less systematized training data than modern AI systems, acquire a vast array of individual perceptions throughout their lives, which they process according to subjective criteria and consciously or unconsciously incorporate into their actions. In contrast to technological systems, every human individual is an intersection of innumerable "social threads" (Simmel 1890: 103, own translation) and related experiences, which they draw on in their behavior and actions in an idiosyncratic—and often even for themselves opaque—manner. Since the 1950s, the field of cognitive science has thoroughly investigated the intricacies of human thought but still remains far from fully grasping the scope of human intelligence (Bermúdez 2023).

In this respect, the history of technological innovation itself provides numerous examples of the flexibility of human cognition and surprising transfers from other areas of experience. For instance, John Boyd Dunlop (1840–1921) developed the air-filled bicycle tire after years of working with rubber materials as a veterinarian. As a secretary in the 1950s, Bette Nesmith Graham (1924–1980) drew upon her experience as an amateur painter to invent correction fluid for typewriter mistakes. In a similar vein, Apple Inc. founder Steve Jobs (1955–2011) remarked in a 1996 interview that creative problem solvers are "able to connect experiences they've had and synthesize new things." (Wired 1996) However, some of the most remarkable examples of experience transfer can arguably be found in music. Early on, it became possible to create scores in the style of famous composers using computers, and today, AI systems can generate entire audio tracks that mimic popular hits. However, truly epoch-making songs have not yet been produced by these systems. This requires a cognitive transfer from other areas of experience, much like the social relevance of a song stems from those references.

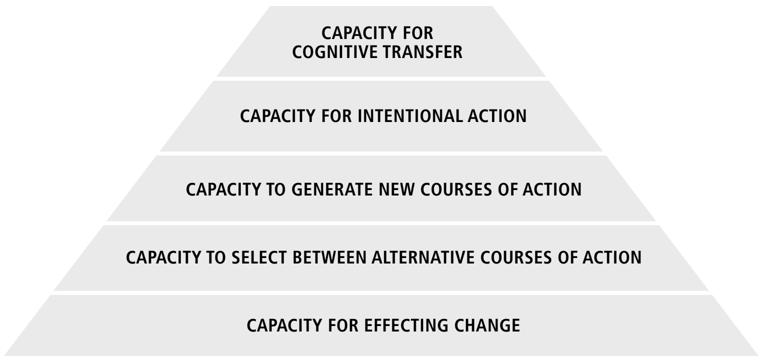
In cognitive science, this capacity to invent new concepts by integrating elements from various contexts of action is reflected in the theory of "conceptual blending," developed by Mark Turner and Gilles Fauconnier (2002). While this approach has been met with criticism in detail (Glebkin 2015; Gibbs 2000), the basic premise of this model is widely accepted. "Conceptual blending" describes an unconscious yet pervasive process integral to human thinking. Based on the abstract structures that have been learned throughout an individual's life ("generic space"), specific concepts from two or more "input spaces," representing different domains of experience and action, can be interconnected. This interaction creates a new "blended space" that includes features from the generic space as well as some elements from the input spaces that are mapped onto this space by selective projection. This process gives rise to novel concepts with emergent properties within the blended space that cannot be found in the original input spaces (Turner & Fauconnier 2002: 39–59; 139ff.; Turner 2014).

Due to its symbolic foundation, the model of conceptual blending can, in principle, be implemented in IT architectures, as has been attempted in limited domains (e.g., Schorlemmer & Plaza 2021; Wang et al. 2023). Nevertheless, current AI systems still lack the extensive experiences and rich social references that humans accumulate throughout their lives, often unconsciously. In light of this, I propose to distinguish the capacity for cognitive transfer from the intentional explanation of action based on objectified scripts and frames, and thus to differentiate between five fundamental levels of agency when analyzing constellations of distributed action (Figure 2):

- At the level of *capacity for effecting change*, human actors and technological systems have the ability to modify their environment in material, symbolic, or spatial means, thereby influencing social action contexts in the short or long term. Even the use of simple tools, such as hammers and passive mechanical devices, can significantly alter social action contexts and, from the outset, have had a substantial impact on the corresponding coordination and work processes.
- At the level of *capacity to select between alternative courses of action*, actors also possess the capability to choose from various predefined courses of action based on the respective input. In an ideal formal bureaucratic organization (one devoid of informal parallel structures), employees adhere to those predefined paths in performing their tasks. Technological artifacts gained this basic flexibility, in principle, with the advent of the first algorithmically controlled hardware systems.

- At the level of *capacity to generate new courses of action*, acting entities can additionally draw on the ability to create new pathways to achieve a given goal. Networked IT systems that integrate data sets from different sources in real-time (e.g., navigation systems) have been capable of doing this in their specific domains for several decades. Generative AI architectures, designed to model the »fuzzy« logic of human reasoning and decision-making, have this capability as well.
- At the level of *capacity for intentional action*, actors possess the ability to explain their actions intentionally, linking them to subjective meaning structures that are oriented toward culturally objectified patterns of interpretation and the behavior of others. Recent studies suggest that contemporary AI chatbots may exhibit this capacity to some extent (see Section 1); however, if this is the case, their capabilities to date remain constrained to specific interaction contexts.
- The level of *capacity for cognitive transfer* further encompasses the ability to relate knowledge and experience across context and time. This capacity has been considered a hallmark of human cognition and a prerequisite for "cumulative cultural evolution" (Tomasello 2009, 2022). Notwithstanding the ongoing efforts to technically model processes of cognitive transfer, the respective systems still require a high degree of external control and operate in relatively narrow domains.

Figure 2: Fundamental levels of agency



Source: own reflections

All of these types of agency can conceivably be executed by both humans and technology. At present, however, publicly known AI systems exhibit limited capabilities compared to humans at the levels of intentional action and cognitive transfer. This may stem from the fact that the human brain itself is not yet thoroughly understood (Roth et al. 2024: 69ff.). Moreover, while some AI systems can operate and learn autonomously in their domains, they lack the autopoietic, i.e., self-sustaining and self-organizing, properties inherent to the human brain. These systems do not maintain themselves; they are created in specific social contexts and shaped by socio-economic interests and expectations contingent upon social change—a dynamic that is evident in digital technologies in general (Schrape 2024, 2019) as well as in the field of AI (Hirsch-Kreinsen 2024).

4.3 Intelligent technology and augmented social action

Given these complexities, the pivotal question to consider today may not be so much whether technology can operate autonomously at all levels and potentially pose a threat to humanity as an independent entity, as often imagined in popular culture (see Section 2). Instead, from a techno-sociological perspective, the focus shifts to understanding how social actions and social action spheres are *augmented*—i.e., enhanced, coordinated, and regulated—by intelligent technology and its characteristics. These characteristics are not inherent to the technology itself; they, in turn, result from multi-faceted decision-making processes within the relevant socio-economic contexts of research and development (R&D), as well as they emerge from the variety of appropriation processes in the individual, collective, and organizational use of these systems.

Concerning the technological augmentation of social action, Anna Beckers and Gunther Teubner (2021: 45–137) identify three scenarios of liability from a legal-sociological standpoint: (1) constellations in which intelligent systems assist human actors as "vicarious agents;" (2) human-machine associations in which the interactions between individuals, organizations, and intelligent machines are so closely intertwined that they must be considered as cohesive socio-technological networks for which the company at the core may be held liable; and (3) interconnected AI architectures that operate through self-interacting algorithmic structures, embodying a form of artificial distributed cognition. Their outputs and automated decisions, such as in infrastructure management, increasingly impact social action and communication dynamics. In events of damage, compensation would need to be provided through pre-established funds or insurance, as it is no longer possible to attribute responsibility to a single entity.

From legal and ethical perspectives, the main concern in circumstances of technology-augmented social action revolves around accountability and liability. This issue was discussed early on regarding fully automated driving systems (Misselhorn 2018; Hansson et al. 2021): While a human driver reacts instinctively to hazardous situations on the road without having the time to consider all possible responses, in the case of autonomous vehicles, these decisions must be determined during the design process. For instance, there is an ongoing debate about the criteria a self-driving car should employ when faced with a life-or-death dilemma: Should the system prioritize saving a young mother with a child over an elderly pedestrian? Should the system be allowed to endanger the lives of its occupants? Who should be held liable if the system fails? All of these discussions center on the extent to which society is willing to delegate responsibility for actions to autonomous systems, a question that has been debated since sci-fi author Isaac Asimov (1920–1992) introduced the "Laws of Robotics" in 1942.

When discussing the attribution of responsibility, however, the ultimate issue pertains to the social embeddedness of technology *in its entirety*. This social embeddedness includes both the socio-economic contexts in which technological structures are developed, designed, and configured, along with the interest-driven decisions made throughout these processes, as well as the question of how individual action horizons and social action spheres are influenced by the use of the respective technological systems—which are, in turn, shaped by the prevailing political, regulatory, and socio-cultural conditions. From a techno-sociological perspective, it is therefore essential, in addition to observing the genesis of AI systems, to systematically investigate the complex, ambivalent, and often contradictory effects in the diffusion of intelligent technology, how these effects are addressed in various areas of society, and to closely examine the characteristics inscribed in the technology that give rise to these effects.

With a view to the co-evolution of technology and society to date, three fundamental characteristics of technology, or more precisely: socio-technological (infra-)structures, can be identified in the augmentation of social action, which can also be applied to AI and intelligent technology (Dolata & Schrape 2018: 14–23; Schrape 2021):

- First, technological structures have *enabling characteristics* that expand the possibilities for individual action, social coordination, economic production, and collective collaboration. Intelligent technologies that are capable of generating alternative courses of action or operating at even higher levels of agency offer the potential to automate action, communication, and coordination processes, thereby making the management of repetitive tasks more efficient (e.g., in production, design, data and information processing), as well as they facilitate the discovery of novel solutions and the exploration of alternate ways to achieve a given goal.
- Second, technological structures develop *structuring and regulating characteristics*: Through their modes of operation, default settings, and inherent action orientations, they structure situations, channel interactions, shape work environments, and contribute to stabilizing patterns of social order. For instance, generative AI chatbots have greatly expanded the possibilities for automated communication, task processing, and information retrieval; however, their widespread use has also reoriented numerous work routines and daily practices and given rise to new forms of socio-economic dependency, particularly toward the major AI providers.
- Third, technological innovations engender new means of *social control*. Regarding mechanical devices, this mainly applies to production processes; in the case of IT and AI systems in particular, this influence extends to social coordination and cognitive processes as a whole. Due to their action-shaping effects, digital systems facilitate the observation and positive or negative sanctioning of social actions. In the context of generative AI chatbots, this sanctioning is based, among other things, on the selection of training data, the terms of use, and the interface design, as well as is evident in the weighting and presentation of the system's responses.

However, as Carlota Pérez (2010) and others (see, e.g., Deranty & Corbin 2024; Pfeiffer et al. 2024) have pointed out, the emergent functions and effective ranges of application of technological innovations typically become apparent only through long-term social adoption and appropriation processes. Consequently, it is crucial to reiterate that these characteristics and their impacts in augmenting social action are not predetermined by technology; instead, they stem from a complex interplay of social decision-making processes in the development, implementation, and use of the respective systems. Thus, it remains imperative to closely examine the socio-economic conditions and the decisions of the relevant actors, along with their motivations, throughout the entire institutionalization process of AI systems and intelligent technology.

Such a high degree of contextualization is of particular importance in the present phase of simultaneous diffusion and further development of AI systems because once socio-technological interdependencies, as well as the associated action-shaping effects and the expectations surrounding the technological augmentation of social action, have become entrenched, they are difficult to ignore or override without facing disadvantages (Dolata & Schrape 2018, 2023). For example, just as submitting a handwritten job application, term paper, or manuscript today may cause irritation compared to a printed or digital document, it may soon become uncommon in many professional settings to perform certain tasks without leveraging the time-saving services of generative AI. As Heinrich Popitz ([1992] 2017: 16) noted early on, once novel technological solutions such as AI chatbots are widely adopted, they become a new *datum* within societal reality, profoundly shaping various spheres of social action, which is accompanied by a considerable "power of producing and of the producer" of these systems.

5 Conclusion: artificial intelligence as a socio-technological transformation process

In the overall picture, the phenomenon of artificial intelligence can only be comprehensively understood as a genuine socio-technological transformation process—from its invention to its conversion into an applicable innovation, its subsequent diffusion and socio-economic institutionalization, and the ensuing socio-economic impacts. This processual social embeddedness of technological innovations is evident, inter alia, in the evolving expectations and R&D objectives regarding AI and human-machine interactions over time, the shifting perceptions of agency in situations of distributed action, the historically developed willingness to trust in complex technological systems in everyday life, and the dynamics of political negotiation and regulation surrounding the (potential) use and consequences of intelligent technological systems.

From a long-term perspective, many socio-economic fields are still in the early stages of the diffusion and adoption of generative AI and autonomous systems. This phase is characterized by a dynamic interplay between ongoing technological development processes and diverse interpretative perspectives, as well as distinctive early adoption patterns among various social groups, which often perceive different benefits and risks associated with the broader societal integration of this innovation. Importantly, these perceptions are not static; they evolve over time and are profoundly influenced by their socio-economic environment, including exogenous shocks such as political upheavals, wars, disasters, or pandemics (Schrape 2021: 30–41; Pinch & Bijker 1984). Notwithstanding, the state of observation suggests that the forms of intelligent technology currently available to the public have not yet reached the degree of autonomous capacity for action often attributed to them, whether viewed positively or negatively.

In any event, from this stage of early diffusion, there is typically a considerable journey ahead before substantial transformations in socio-economic fields and social action spheres will become manifest, and before it will be possible to assess whether the institutionalization of generative AI represents either a further step in the overall digital transformation or a fundamental change in the technical-economic paradigms of society, as was the case with electricity or microelectronics, for example. This complexity stems from the multi-faceted nature of socio-technological transformation processes, which are marked by a complex interplay of numerous direct and indirect social influencing factors, including established and newly emerging power asymmetries, organizational and political path dependencies, the incremental embedding of the innovations into differing socio-economic contexts, the restructuring of actor relations within specific sectors or fields, the recalibration of legal frameworks, as well as the cultural reappraisal of these socio-technological reconfigurations, which, in turn, can have a significant impact on the development of the technology itself.

All of this takes time and is part of the long-term institutionalization of new socio-technological interdependencies, which frequently results in innovations having entirely different patterns of use and societal impacts than were initially anticipated. This underscores the importance of understanding the multi-step and intricate nature of socio-technological transformation processes, which can vary widely depending on the socio-cultural context. In other words, it is crucial to acknowledge the inherently gradual nature of socio-technological transformation processes, as comprehensively discussed by Ulrich Dolata (2013, 2025). A key insight from his research is that technology-driven change does not manifest as a series of abrupt disruptions and reorganizations; rather, it unfolds—as evidenced by the development of AI—as a long-term socio-technological search and selection process, often spanning several decades and eventually leading to a profound transformation of the structures, institutions, and actor figurations within societal fields (see also Geels & Turnheim 2022: 44ff.).

In order to explore these gradual dynamics of the socio-technological institutionalization of artificial intelligence and intelligent technology, process-oriented case studies have proven exceptionally valuable. This approach already has its roots in classics, such as Max Weber's (2001 [1930]) analysis of the emergence of the "spirit of capitalism," and is today referred to as "process tracing" (e.g., Vennesson 2008; Bennett & Checkel 2015) or "causal reconstruction" (Mayntz 2004; Héritier 2008). Rather than attempting to assess the broad societal impacts of artificial intelligence in an abstract manner, process-oriented case studies are particularly effective for conducting comparative analyses of the diverse institutionalization dynamics surrounding intelligent technology, which, similar to earlier fundamental technological innovations, are likely to unfold very differently across various societal contexts and social action spheres.

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