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Research article

Doing Things with Words and Things: A Social Pragmatist View on the Language–Technology Analogy

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Abstract

This paper claims to show that the making of technology and the material agency of technical objects can be analyzed analogously to the making of meaning through words and speech acts. It proposes the development of a more comprehensive view on the making and working of technology that connects the social pragmatist approach of technical practice and symbolic interagency (Kant, Dewey, Mead) with the linguistic concept of pragmatics and speech acts (Peirce, Wittgenstein, Austin). Both, speech acts and technical acts can be considered as two modes of meaning-making in the social construction of reality. Furthermore, the paper exhibits some parallels between the objectification processes of language and technology. It emphasizes how both evolve from early stages of signs and tools in practical contexts to encoded collections of grammatical rules and technological tools later on. Doing things with concrete things (technology) reveals two different modes of "efficacy" (Jullien). There is implicit experienced efficacy in the language of directed material forces and causes and also an explicit ascribed efficacy in the language of instituted ends–means relations. The text explores the analogy between language and technology through the lenses of semantics, syntax, pragmatics, and grammar. It emphasizes the importance of such an extended pragmatist/pragmatics approach in the face of new technologies that exhibits a high degree of self-activity, more modes of intra-action between physical and digital objects, and a growing interactivity at interfaces with human actors and environmental factors. They can be more appropriately understood, conceptualized, and also designed as sociotechnical constellations of distributed agencies between people, machines, and programs.

Keywords: Technical practice; Material agency; Speech acts; Linguistic pragmatics; efficacy; Meaning; Interactivity; Digital objects

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Научная статья

Делать вещи с помощью слов и вещей: Прагматический взгляд на аналогию языка и технологии

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Аннотация
Статья претендует на то, чтобы показать, что создание технологий и материальное воздействие технических объектов можно анализировать аналогично созданию смысла через слова и речевые акты. Она предлагает развитие более всестороннего взгляда на создание и работу технологий, который соединяет социально-прагматический подход к технической практике и символическому взаимодействию (Кант, Дьюи, Мид) с лингвистической концепцией прагматики и речевых актов (Пирс, Витгенштейн, Остин). И речевые акты, и технические действия можно рассматривать как два способа создания смысла в социальном конструировании реальности. Кроме того, в статье показаны некоторые параллели между процессами объективации языка и технологий. В нем подчеркивается, что и то, и другое развивается от ранних стадий знаков и инструментов в практическом контексте к закодированным наборам грамматических правил и технологических инструментов на более позднем этапе. Делание вещей с помощью конкретных вещей (технологий) раскрывает два разных режима “эффективности” (Жюльен). В языке направленных материальных сил и причин присутствует неявная переживаемая эффективность, в языке установленных отношений “цель-средства” – явно приписываемая эффективность. В тексте аналогия между языком и технологией исследуется через призму семантики, синтаксиса, прагматики и грамматики. Подчеркивается важность такого расширенного прагматического подхода перед лицом новых технологий, который демонстрирует высокую степень самоактивности, большее количество способов взаимодействия между физическими и цифровыми объектами, а также растущую интерактивность при взаимодействии с людьми и факторами окружающей среды. Они могут быть более адекватно поняты, концептуализированы, а также спроектированы как социотехнические совокупности распределенной агентности между людьми, машинами и программами.

Ключевые слова: Техническая практика; Материальная агентность; Речевые акты; Лингвистическая прагматика; Эффективность; Смысл; Интерактивность; Цифровые объекты

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TECHNICAL PRACTICE: SPEAKING THROUGH THINGS IN THE LANGUAGE OF EFFICACY[1]

Technical knowledge is based on practical action and seeks more effective action. It differs from scientific knowledge in that it is ultimately not about recognizing and explaining abstract and isolated effects but about designing and creating concrete operations, objects, and interactions between them that have to function efficaciously in a sociotechnical context. This fact applies to the matching of screws and threads and their relations to national standardization systems as well as to the combination of partial material and digital technologies into complete global manufacturing, traffic, or communication systems. Technical practices require scientific knowledge about things and their causal links, for example, about the hardness of steel, its interaction with concrete, or the loss of information during signal transmission via the copper or fiber-optic cable. However, the use of this abstract knowledge depends on specific situations and is embedded in the thousand-fold rule-based knowledge of the respective technical sciences.

In the *first* instance, this pragmatist view of technical knowledge as technical practices that have been created, objectified, and compiled as rules and tools in the arsenals of technology and then work when enacted in use relations suggests the idea of developing a *pragmatics of technical acts* in analogy to the linguistic concept of pragmatics.[2] This pragmatist approach to technical knowledge would be analogously concerned with the capability, functionality, and efficacy of *technical acts* in certain cases and contexts in comparison to the competency, intentionality, and successful communication of the latter pragmatics of *speech acts*. The *second thrust* of this article can be summarized as follows: Even natural sciences make sense of the nature of things with 'words' when they use alphanumerical signs, visual representations, calculations, and lawlike formulations to give them a meaning that can be communicated and contested. The technological sciences, however, create new things, and, when doing things with *things*, they are at the same time doing *words* with things. They make significant statements with things; they invent new techniques and capabilities of effective expression, and they weave new sociotechnical textures by constructing media and technical infrastructures. Through things, the technological sciences are speaking in the language of "efficacy."[3]

To propose a combined pragmatism/pragmatics approach to the 'question concerning technology' (Heidegger, 1954/1977) actually seems to carry owls to Athens since the productive making of and practical doing with things can be regarded as the

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[1] This text is a translation of a modified and supplemented version of the key lecture "The Pragmatics of Technological Knowledge or: How to Do WORDS with Things" at the conference "Technological Knowledge" organized by the German Academy of Technical Sciences (Kornwachs, 2010). I thank Alfred Nordmann for his critical comments and Stephan Elkins from *Sociotrans* for final proof reading.

[2] The founders of a philosophy of language that induced the development of linguistic concepts like semiotics and pragmatics are Peirce (1970), Wittgenstein (1953), and Austin (1962).

[3] Cf. the comparisons of the Western and Chinese concepts of "efficacy" as a direct strategic act of an autonomous agent (subject) or as an indirect transformation of different agencies over a long time (Jullien, 2004; Hui, 2016).

core of the modern technological sciences.[4] Three ideas and interests, however, give this new undertaking of a social pragmatist theory of technology its particular appeal and justification:

First, the paper is intended to counteract the overemphasis on the semantics of technical knowledge that accompanied the sweeping scientification of the engineering arts. The drive to win the reputation of the natural sciences also strengthened the belief in the perfect programmability of complex technical systems and displaced the non-explicit knowledge that is objectified in techniques and technological artifacts, stored in the habits of the respective communities of practice, and incorporated in the specific technical practices themselves.[5]

I argue that the linguistic concept of pragmatics will redirect the focus back to the practical activities during various phases and places when the stored technical knowledge is enacted. This process comprises a) the designing, planning, constructing, and programming of specific functionalities; b) the development and testing of technically effective devices and user-friendly interfaces; and c) the integration of these functionalities, devices, and interfaces into existing production facilities and company structures, into large technical infrastructures, and into social, ecological, and economic contexts of use.

Second, the reasoning presented here seeks to overcome the self-imposed limitations of a dualistic view[6] of technology and society. According to this dualistic view, the making of technical things has nothing to do with social action and meaning-making; and vice versa, social action and doing things with words has nothing to do with doing things with real technical things. This paper argues that the social pragmatist view makes it possible to understand “the technical construction as part of the social construction of reality” (Rammert, 2006/2024, chapter 3). In consequence, the meaning (“words”) of a new technology (“things”) develops from three kinds of social interaction: when people or communities are doing things with words a) by naming, classifying, and negotiating the attribution of meaning to things; b) by experimenting with things, producing artifacts, installing physical and digital infrastructures; and c) by using and repurposing things and thereby creatively and constantly changing both how they work and what they mean.

Third, I argue that the combined view of philosophical pragmatism and the linguistic concept of pragmatics might also facilitate the interdisciplinary collaboration between technical and social scientists, which is urgently needed in light of interactive “digital objects” (Hui, 2012), “artificial communication” with “generative language systems” (Esposito, 2017), “human-brain interfaces” that translate neural signals into sentences (Nicolelis, 2001), and “social robotics” (Breazeal et al., 2016; Muhle, 2023).

[4] Other concept transfers can be found under the names “material semiotics” (Latour, 1987; Law, 2009), “new materialism” (Barad, 2007; Lemke, 2015), “performance theory” (Mackenzie & Millo, 2003), or “narratology” (Czarniawska, 2004; Joerges & Czarniawska, 1998).
[5] Cf. Hickmann (2001) on the difference of techniques, technologies, and technosciences and Rammert (1999a) on the three modes of technization: habitualization of human corporal and cognitive activities, mechanization of physical operations, and algorithmizing of symbol processing.
[6] Cf. the critique by Rorty (1991), also Rammert (1997) and Schulz-Schaeffer (2000).

Thanks to modern information, communication, and sensor technologies, actual technical systems and environments are designed as more or less 'autonomous agencies' (Rammert, 2008a). They are equipped with software programs of 'intelligent behavior' and personally tailored to their users to interact with them. The elements are 'loosely' rather than 'tightly coupled' (Weick, 1988; 1995). Sociological models of social interaction and social institutions lend themselves to the construction of such complex cyber-physical or "socionic systems."[7] And vice versa, if nearly all kinds of social agency in society are increasingly distributed between different entities such as people, machines, and programs, then the social scientific analysis as well as the institutional design of society's infrastructures require the knowledge and experience of the engineering and planning sciences.

The paper is divided into two parts. The next section introduces some problems of the nature and status of technical knowledge and the idea to approach them with a fresh view that combines philosophical pragmatism with the linguistic concept of pragmatics and draws on an analogy between speech acts and technical acts. First, I ask how the pragmatic aspects of technical knowledge were repressed and what problems the technical sciences have encountered as a result. This is followed by outlining the social pragmatist perspective on technology and the linguistic concept of pragmatics to show how they could be used to address both the problems of doing technology and of material agency. The third section exposes four characteristics of the actual technostructure that challenge the technological sciences to adapt their knowledge: self-activity, complexity, heterogeneity, and ubiquity. The fourth section uses the question of "technology-in-action" (Rammert, 2006; 2008a) to demonstrate that the approach to combine the pragmatist perspective on technology with the linguistic concept of pragmatics is especially fruitful for analyzing and shaping the actions and interactions of technical objects in various sociotechnical constellations. The article closes with a short summary and some conclusions on the pragmatics of technical skills, as they result from the previous considerations on sociotechnical agency. These considerations relate to the practice of engineering education as well as to the projects of interdisciplinary research and development.

PROBLEMS WITH THE NATURE OF TECHNICAL KNOWLEDGE AND THE PRAGMATISM/PRAGMATICS APPROACH

Technical Sciences: From the Recognition to the Adaptation Problem

Two problems affect the technical sciences with regard to the value and usefulness of their knowledge: first, the problem of recognition, which has led to a reinforced scientification and a suppression of the pragmatic character of technical knowledge, and second, the problem of adapting to quickly changing structural requirements. Addressing these two problems suggests a return to the pragmatic core of the technical sciences and

[7] See the early inter-disciplinary DFG research program "Socionics: Inquiry and Design of Artificial Societies" (1999–2005) that connected computer science and sociology (Malsch, 1998; Rammert, 1998; 2012).

a fine-grained analysis of the pragmatics of technical agency.

The recognition of technical knowledge as socially highly valued and later as scientifically founded knowledge is an old problem that has persisted from Antiquity to modern science at the end of the 19th century. In ranking forms of knowledge, technical knowledge always remained in last place. In ancient society, the skills of master builders, lawmakers, and surveyors were considered necessary and useful for the domestic, urban, and military economy. Nevertheless, it was not granted the status of well-founded knowledge. Excellence was sought and seen in philosophical knowledge. From medieval to modern times, this hierarchy of forms of knowledge was largely maintained at the universities: Religion ranked before philosophy, philosophy before the natural sciences, even when the latter slowly detached themselves from theology and philosophy after the Enlightenment. The technical and engineering arts ranked at the bottom of the status pyramid. Technical knowledge was passed on outside the universities at special military, mining, and craft schools and at the academies of architecture, construction, and fine arts. The trend has reversed since the end of the 19th century, when the technical arts began forming into technological disciplines and transforming into sciences based on axiomatic theories. They formalized practices, simulated processes, and mathematized relations, following the example of physics. This 'catch-up scientification' visibly advanced the technical arts to academic sciences, also in terms of social recognition. In the industrial modern age, the secular belief in technical and scientific progress has ranked far ahead of religious beliefs. Engineering schools and construction academies were renamed and upgraded to the status of 'technical universities' with the right to award doctorates and habilitations. At present, technical knowledge no longer has any problems of recognition in the system of sciences. A look at the current technologies of the computer sciences, genetic engineering, or material sciences as well as at the high reputation of institutes and institutions of technology (MIT, CalTech, EIT, acatech) even suggests that the science-based production of technologies has risen to become the dominant model of research.

However, the successful solution to the problem of recognition through consistent scientification of technology has caused some barely noticed side effects: The orientation towards the model of natural science has pushed the pragmatic basis of technical knowledge into the background. Abstract knowledge has displaced the value of concrete experience; mathematized relationships have become more important than case-related knowledge of rules; and system designs purged of context ignore the art of 'piecemeal engineering' and the intuitive handling of "not well-structured problems" (Star, 1989) that, in complex sociotechnical constellations, cannot be neatly separated into parts. As long as technical systems can be relatively easily encapsulated and delimited from the natural and social environments and as long the subsystems can be integrated internally in a stable hierarchical manner, abrupt changes in the environmental dynamics only resulted in isolated problems at most. However, the more permeable the boundaries between the systems become and the more the technologies themselves approximate the model of human agency, the more urgent it becomes to return to the constructive and active aspect of technical knowledge and its relationship to the pragmatic conditions that make it successful. Otherwise, the one-sided view of technical knowledge will lead to systematic problems in adapting the technological sciences to the future emerging digitized technostructures of society.[8]

[8] Cf. Nassehi (2024) for an operational and system theoretical approach to the digital society.

The View of Philosophical Pragmatism

Technical knowledge is generated ‘in pragmatic terms’ (“in pragmatischer Hinsicht”) and has to prove its efficacy in a practical context. The focus is on ‘shaping the world’ (“Weltgestaltung”), not explaining the world, and this kind of knowledge must be applied to ‘real people’ (“wirkliche Menschen”) and ‘for use in the world’ (“zum Gebrauch für die Welt”) and has to take into account the changing states of the world and the purposes of life, as Immanuel Kant’s (1778/1998) *Anthropology from a Pragmatic Point of View* (*Anthropologie in pragmatischer Hinsicht*) already stated. It is also remarkable that he mentioned technique/technology (“Technik”) in the context of the terms “habits,” “methods and machines and among these the distribution of work.” If one sees technical knowledge mainly under the aspects of perfecting it toward the scientific ideal and achieving complete causal explanation and total mastery, it is easy to lose sight of the gap between ‘pure’ semantics and ‘dirty’ pragmatics: The purified parts of technological knowledge, which of course have contributed to the progress of the modern technological sciences, must ultimately be incorporated into the messy end–means relationships of concrete environments.[9] As *real* constructs, they must be fitted into the variety of different technologies that actually exist and operate locally. As *practica*l constructs, they are by definition blended with economic, political, and cultural purposes. All aspects, practical skills and technical experience, implicit knowledge and experimental testing, are therefore not residues of the imperfection of technical knowledge that need to be remedied; on the contrary, they are and always will be necessary components of the technological sciences in spite of any scientification.

The pragmatist view was systematically developed in American philosophy. Philosophical pragmatism, as elaborated by Charles Peirce, John Dewey, and George Herbert Mead, was essentially a response to continental rationalism and idealism. It begins with the *primacy of practice in* dealing with questions of thought, knowledge, and cognition. It emphasizes *solving concrete problems*, such as how certainty can be established under specific conditions, over abstract questions of truth. Dewey’s pragmatism especially refers to the *principle of experimental action* when solving theoretical and practical problems (Dewey, 1925, chapter 1; Hickman, 1990, p. 60).

The proponents of pragmatism thus turn the tables of knowledge around: They take the approach of practical and everyday problem solving and the model of laboratory and engineering sciences as a model for philosophical thinking. They use the pragmatics of technical knowledge as a basis and model for solving problems of scientific, linguistic, and social theory. Truth, knowledge, and meaning are based on practices of ‘making true,’ of solving concrete problems, and of observing the interactive behavior between bodies. The concept of an object is not defined in an essentialist way but on the basis of operations to be carried out and as the epitome of the consequences that result when the object is acted upon in a certain way (Peirce, 1907/1970 and Dewey, 1929, chapter V). The meaning of a word can be derived neither from an intrinsic sense of the word nor from its structural position; rather, it emerges from the context of cooperation and physical

[9] Cf. Mitcham (1994) for a detailed history of philosophical thinking about technology and a critique of Bunge’s (1966) outdated view on “Technology as Applied Science.”

interaction in which the participants both expect and observe what consequences a gesture or a sign has for themselves and the other (Mead, 1934/1968, p. 155). Just as an *interobjective* order of causes and effects is inferred from the observed interaction between two physical objects in experimental systems (Mead, 1932; Rammert, 1999b), George H. Mead's social pragmatist theory derives the emergence of an *intersubjective* meaningful order from the interaction among two bodies equipped with senses and organs (Mead, 1934/1968, p. 72; Joas, 1985).

This pragmatist perspective[10]– despite all the differences between the respective elements under observation – not only places the production of technical artifacts and the generation of moral facts on a common basis, thereby rendering them comparable in terms of identity and difference, but also draws attention to the trying, tinkering, and testing that is necessary to transform technological knowledge into concrete devices, real machines, and operational digital programs. It examines the experimental trial and error between intended effects and observed adversities, between explicit means and implicit possibilities that act like a "mangle of praxis" (Pickering, 1995). In an ongoing process of "re-configuration" (Suchman, 2007), these experimental interactivities mutually create the respective competencies of people and the respective capacities of technology of an epoch. They form the glue between artifacts and knowledge that make up our society and its technologies. Pragmatism thus enables a new perspective to overcome the dualism of technology and society. It also intensifies the cooperation of the technical and social sciences, which are fighting on different fronts for the same cause: to advance "the substance of things hoped for" (Rorty, 1999, p. 27). Pragmatist inquiry is always guided by the demand for practical solutions in order to develop methods and programs as well as to create new combinations, insights, and instruments. Technical knowledge that arises in the form of technical rules and tools refers to the aspects of both the cause–effect relations between interacting entities in terms of efficacy and the intended end–means relationship in terms of expediency.[11]

The Linguistic Concept of Pragmatics

Pragmatics is first and foremost an area of linguistic language theory. While *semantics* deals with the meaning of words and *syntax* with their position in sentence structure, *pragmatics* is concerned with meaning-making through practical use in various contexts. Since Wittgenstein's (1953) philosophy of normal language, scientific interest has shifted from the rules of grammar to the practices of speaking. The meaning of words cannot be understood without understanding their practical use in certain contexts and under certain circumstances. People do not apply the rules of grammar in the well-structured way that computer programs do.[12] Even generative artificial intelligence programs work with statistically measured relations to other words or pictures instead of

[10] For a similar idea for blending the pragmatist theory of action with the analytical theory of social mechanisms, cf. Gross (2009).
[11] For similar interpretations, cf. Hubig's, version of pragmatism (2006) and the ones that have been combined with hermeneutical and phenomenological views (Ihde, 1990 and Verbeek, 2005).
[12] Cf. Rammert et al. (1998, "Knowledge Machines") on the limits and failures of knowledge-based expert systems.

following grammatical rules. Therefore, they need human assistance for training, debugging, and abolishing errors in semantics. When people use words in everyday life, they are producing meanings and patterns that can be reconstructed as rules only in retrospect.

John L. Austin's lecture on "Words and Deeds" (1952–54) was groundbreaking for the theory of language because he moved this aspect of doing when uttering words to the center of the entire humanities and social sciences. The title of his legendary book "How to Do Things with Words" (Austin, 1962) could also be translated as 'making things happen with words.' In the case of performative utterances, when speech is intended to achieve something, uttering words becomes an action. Sentences not only *say* something; they also *do* something. Such "speech acts" do something by giving it a name, for instance, they can marry two people, or they can sentence someone to some form of punishment. Their function is not merely to state what *is* the case but also to practically bring about what *will be* the case. These "performative speech acts" neither describe nor represent reality; instead, they construct reality with all its social consequences, for spouses, heirs, debtors, or prisoners.

This performative aspect of 'doing things with words' is actually self-evident if we compare the pragmatics of language with the pragmatics of technology. One aspect of the analogy, however, could shed new light on the theory of technical action and knowledge. We can see it when we slightly modify Austin's title into 'How to Do *Words* with Things.' 'Saying something with things' means that, whenever things are made or something is done with real things, words are also formed, statements are made, and above all new meaning is created. Similar to speech acts, *technical acts* create a universe of technical forms of meaningful expression. A language of technology emerges with its own grammatical rules, its own dictionary that collects the semantical translations, and its own syntax of functioning technical combinations. This means that technical agency cannot just be understood as a meaningless 'how to do things with things,' which is dressed up only subsequently by attaching cultural meaning as one would put on an item of clothing. It implies much more, namely,

- that technical agency makes things and meaningful statements *simultaneously*,
- that it *objectively* and *meaningfully* orients, restricts, or enables the actions of others, and
- that the *real texture* and *architecture* of technical systems co-shape the "constitution" of society and the culture of an era much more than the attributed symbolic meanings.[13]

Pragmatics as a concept and program for the analysis of technical knowledge and practice thus always implicates two aspects at the same time:

First, one should examine technology as "objectified culture" (Simmel, 1900/1983, p. 96) and technical acts, artifacts, and systems as a form of human expression that is similar to speech acts, words, and language structures. The philosopher and anthropologist Ernst Cassirer had already regarded technology as a fourth "symbolic

[13] Cf. Langdon Winner (1980), who uses an analogy between the political and technical "constitution," and Bruno Latour (2005), who speaks of "assemblies" of both people and things.

form” alongside myth, logos, and art. He argued that through the form of technology people express themselves in the” medium of efficacy” (“Medium des Wirkens”; Cassirer, 1930/2012, p. 24[14]; “language of efficacy”, Rammert, 1999a, p. 276). A pragmatics of technical knowledge then examines technology as a ‘technical act’ from the point of view of the generation and purposeful use of artifacts in specific contexts and under historical circumstances. It is only the use of a thing or a configuration of things in a certain constellation that ultimately turns it into an expedient means and meaningful tool. In this wake, technical rules – in which the knowledge of efficacy and finality is inscribed – can gradually establish themselves as a set of rules similar to grammar. The pragmatist view on technical construction can learn from the pragmatics of language that technical acts can also be organized in concrete expressive and objectified forms in a similar way that speech acts and syntactic constellations of words can. Another analogy exists between linguistic grammar and the “technological archive” (Groys, 1997): Both are collections and frameworks of successful practical solutions that are generalized in terms of rules and tools to fall back on. They are themselves also ever-changing storage and memory places that are the basis for the construction of new acts and artifacts, different configurations, and extended sets of rules and tools when new problem situations require creating and testing new answers.[15]

Second, one might find new ways of expressing expectations by doing things and thereby create new possibilities for action through technical construction in the same way that thoughts arise when speaking.[16] This similarity challenges us to inquire and test existing technical acts and technological designs in practice and to revise them until they work (Dewey, 1938, chapter VI). It is crucial to adapt them to the technological, economic, ecological, and social conditions that will be encountered in future situations of use. Methods have to be provided that are sensitive to the interdependencies of these conditions to develop innovations that are not only technologically up to date, ecologically sustainable, and economically profitable but also widely accepted by people.[17]

Looking at “technical construction as part of the social construction of reality” (Rammert, 2006/2024, chapter 3), we can characterize the gradual development of the objectification of both knowledge (language) and technical action (technology) in an analogous way:

At the *first* stage of development, language begins with “indices” (Schütz & Luckmann 1974, pp. 326-331; Berger & Luckmann, 1966/1969, p. 38) for something which – in the practical context of *interaction* – turns traces, events, or gestures into meaningful signs and symbols. Accordingly, technology begins with “samples” and

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[14] See the entire quote: “All mental handling of reality is bound to this double act of ‘grasping’ – ‘comprehending’ reality in linguistic-theoretical thought and ‘gripping onto it’ through the medium of efficacy. This is true for both mental and technological forming” (Cassirer 1930/2012, p. 24).

[15] Cf. Leroi-Gourhan’s (1964/1993) seminal work on the similarity of relations between techniques, language, and the arts and the parallel developments of “Gesture and Speech” in history.

[16] SeeHeinrich von Kleist (2009) “On the Gradual Formation of Thoughts while Speaking.”

[17] On the implications of this pragmatist view for “Innovation Society Today,” cf. Passoth & Rammert (2018; 2023).

"problems," which in the practical context of "inquiry," tinkering and "experimental interactivity" (Dewey, 1938, chapter I and III; Rammert, 1999b, p. 291) turns things, forms, and forces into effective technical means, operations, and installations. They remain substantively tentative, temporally episodic, and spatially localized.

At the *second* stage, the uses of signs are transformed into "products." They are decoupled from their initial places and purposes of origin but remain tied to typical situations as significant signs and symbols. In the case of technology, the designs then acquire the status of 'tried and tested installations' for specific contexts. Their descriptions are collected in books on technology and machines as detailed procedures, effective artifacts, or useful probes. In their function as exemplary solutions to problems, they are detached from their places of origin in mills, mines, or irrigation systems. However, at the stage of simple or combined machines, they still require embedding in the professional and customary repertoire of mechanics or engineers.

At a *third* stage, the language elements are completely detached from their initial contexts. They form their own "sign system," a well-structured grammar of language with explicit rules of use and a semantic collection of a vocabulary. As in the case of language, a universalized archive of technology emerges in a similar fashion. Its corpus consists of all the specific rules that originate from successful technical solutions. It combines them to a 'state of the art' body of decontextualized principles and effective "schemata of technization" (Rammert, 1999a, p. 277).

This parallel modeling of linguistic and technical action opens up a research program that analyzes technology – analogous to language – under the aspects of semantics, pragmatics, and syntax in a more refined and systematic way. The research program of pragmatics in particular identifies the single 'technical act' as the smallest unit of investigation in the overall context of technical action. This concept allows a more fine-grained analysis of the making *of* technology, the making *with* technology, and the *active* participation of technology in the respective situations.[18]

At the same time, the grammatical perspective allows us to understand technology as an arsenal of objectified technical acts as well as an archive of encoded schemata of mechanization. The use of this recorded and stored potential – this is also a lesson from linguistic pragmatics – always requires "enactment" in practical situations.[19] Just as every uttered sentence cannot be derived from the rules of grammar alone but requires considering the situation, every act of technical construction remains a more or less appropriate utterance only under specific contextual conditions, despite any recourse to existing sets of rules or states of the art of technological expertise. The more manifold the contexts become to which technical action must relate, the more they differ (such as economic efficiency, sustainability, security, data protection), and the greater the range of settings in which such action is institutionally integrated (economy, politics, science, law, aesthetic design, etc.),[20] the more strategically important such a program geared

[18] Cf. Rammert (1997) on "new rules" and Rammert (2008b, p. 344) on the theory and method of "technography."
[19] Cf. Weick (1995), Schulz-Schaeffer (2000, p. 64), and Orlikowski (2002) on the concepts of enactment and sense-making.
[20] Cf. the contributions on "intelligent objects" in Herzog and Schildhauer (2009) and on future

toward a detailed analysis of technical knowledge becomes that is based on technical acts and experiential situations.

TECHNOLOGY IN ACTION: CHARACTERISTICS OF CHANGING TECHNOSTRUCTURES AND THE CONSEQUENCES FOR THEORIZING

So far, we have dealt with the production and use of technical artifacts by pointing out the experimental and meaning-expressing character of the technical act. Now we shift our focus from the generation, design, and installation of technology to the functionality and *agency* of the technical objects themselves. The new social pragmatist view in conjunction with the pragmatics approach also facilitates the analysis of changes in technological objects and their external activities and interactions. For a long time, technical objects could safely be understood as passive and fixed means that silently and constantly fulfill their function as unchanging components. Current technostructures of production, transportation, and communication, however, exhibit four conspicuous changes:

The *self-activity* of technical objects has increased significantly and in more diverse ways than in the traditional forms of mechanization and automation. The objects operate as “agents” and are designed as bundles of agencies or “autonomous” systems (Wooldridge & Jennings, 1995, p. 116). Concepts of instrumentality are no longer sufficient for dealing with them. The higher level of autonomous activity also requires an analytical concept that is better capable of taking into account the reciprocity between humans and technology. For this purpose, I proposed the concept of “interactivity” (Rammert, 2008a, p. 71) to describe the relation between these two sides.

The *complexity* of the objects’ technical configuration has grown rapidly. The number of material components and their coupling relations – for instance, in a car – has not only been multiplied; the number of functional systems for ignition, stabilization, computer-mediated optimization, as well as for connection with control and information systems in the environment has also increased. The focus has already shifted from the simple and single artifact and its modular aggregation to a multi-layered and complicatedly nested cyber-technical system.

The *heterogeneity* of the elements that must be considered in the design of such highly complex systems requires a more comprehensive and particularly more diverse conceptualization and modeling: Such designs must not only pay attention to the proper functional alignment of material systems and systems of human action but also align digital systems and environment-sensitive systems in a functional relationship that takes their respective characteristics and different activities into account.

The *ubiquity* of technical services is taking a leading role: Technical infrastructures are increasingly being set up in such a way that all artifacts can be accessed everywhere in the world. from anywhere at any time. The cell phone and “ubiquitous computing”

constellations that can be expected to change in the wake of emerging artificial intelligence technologies (Lee & Chen, 2021).

(Greenfield, 2006; Fleisch & Mattern, 2005) are examples of this shift from stationary to mobile technology use.

The technological sciences already feature some important conceptual responses to these changes, for instance, a shift from artifact-centered to process- and systems-oriented science (in chemical engineering, mechanical and plant engineering, or in architecture and urban design). Above all, the greater self-activity of objects now suggests an additional widening of the perspective on technology that concentrates on the activities and interactions of objects in heterogeneous sociotechnical constellations.

Objects in Action: Dimensions and Levels of Self-Activity

Compared to purely mechanical processes, technical objects are increasingly achieving higher levels of autonomous activity. The latest information and communication technologies indicate a qualitative change in the four dimensions of motorics, action, sensorics, and informatics. Technical objects are being transformed from stationary devices into mobile agents, from hard-wired artifacts into programmable agents. Sensor technologies transform what was once a stubborn device into reactive agency. And the methods and means of computer science can elevate a technological object from the status of a passive instrument to the role of pro-active agent.[21] Taken together, these tendencies toward increased self-activity suggest that the instrument and machine concept of technical means should be replaced by a more appropriate concept: that of technical agents and systems of agencies.

The concept of pragmatics can also be applied to how we assess the activity levels of technical agency. Initial analyses of the new production, programming, and information technologies have proven the following classification of activity levels to be useful for the time being (Rammert, 2012, p. 96):

1. passive: objects that are moved or changed in any way from the outside in order to have an effect (tool, index card, price tag)
2. active: object combinations that perform certain operations in the four dimensions automatically (drilling machine, punch card, barcode scanner)
3. re-active: object combinations with feedback mechanisms for simple adjustments (sensor-controlled drilling machine, help agent, RFID checkout)
4. pro-active: distributed systems that coordinate themselves by means of mutual coordination (autonomously cooperating rescue robots, multi-agent systems, ‘smart objects’; ‘Internet of things’)
5. trans-active: intelligent systems that independently reflect on and change means–ends relations with regard to their own actions, others’ actions, and the aggregate results of action (so far only human teams or hybrid sociotechnical constellations).

As long as the activities fall into the first two categories, the traditional concepts are sufficient for analysis and modelling. Only once the qualitative changes mentioned above take hold do we see a shift toward the more sophisticated levels of classification. A social pragmatist concept of distributed agency makes the differences between the

[21] Cf. Wooldridge & Jennings (1995, p. 117) and Rammert (1998, p. 99).

levels visible and their consequences addressable.[22]

Objects, Intra-Action, and Interactivity: Increases in Internal Complexity and Heterogeneity at the Interfaces

Once we have become familiar with the social pragmatist view and its specification along the lines of the linguistic concept of pragmatics, two further consequences become apparent: the first one concerns the change in the internal structure of the technical systems and the second one the interchanges at the external boundaries, the so-called interfaces of the technical systems where technical acts and human acts intersect.

The history of the engineering sciences is no longer just about single artifacts or simple machines such as levers, wheels, and inclined planes. Its extended objects are the effective combination of individual artifacts into complex machines and ultimately their optimal configuration into large plants as well as into entire production and distribution facilities. The standard view of technical systems actually includes the whole hierarchical nesting of technical infrastructure systems with large technical production systems and how these combine with drive, processing, transportation, and control subsystems. The latter are again made up of smaller subsystems and further elements.

However, when the fixed relationships of such systems are set in motion by the increasing self-activities of individual objects and especially by the activities of programmed and mobile digital objects, the encapsulated hierarchical systems of machinery are transformed into *open systems* with internally interacting subsystems. Tightly coupled process systems are then transformed into *loosely coupled networks* of various tightly coupled subsystems with buffers and variable possibilities for reacting to dynamic environments (Perrow, 1984). The more objects, the more dimensions of object activity; and the more different types of objects and their relationships come into play, the more appropriate it is to use the vocabulary of action and interaction for describing the individual and overall behavior of such technical objects and systems. The concepts of instrumental function and fixed structure can no longer capture to a sufficiently differentiated degree the internal complexity of interrelated multiple agencies.

If technical objects gain greater scope for autonomous behavior, the requirements for *interfaces*, especially those between people and technology, must change too. When people use tools or operate machines, we can describe this as *instrumental use relation.* The shape of a handle or the design of levers and cranks reflect the intended mode of employing the technical device. When machines and systems are set up for intended processes, when even the computers controlling them are variably programmed, and when digital objects, such as search engines, become active and search relatively independently in files ('re-active'), then the direct instrumental relationship of use is transformed into a *mediated instructional-triggering* relationship.

If technical systems enter into a dialog with the user asking him or her for input or offering help on their own initiative ('pro-active') and these objects become active as communicative agents, then the interface develops into an *interactive-communicative*

[22] Cf. Rammert & Schulz-Schaeffer (2003) and chapter 7 on "Technology and Agency" in Rammert (2024) and Schulz-Schaeffer & Rammert 2023 for a revised version.

relationship that ties in with the signs, sounds, gestures, and other media that constitute interpersonal interaction. Writing and reading, speaking and listening, pointing and following, touching and triggering within the context of expedient symbolic framings and iconographies each form the activities between the two sides in a specific way. The greater the degree of self-activity of the technical elements, the more the relationship between people on one side and physical or digital objects on the other shifts from instrumentality to interactivity. In comparison to interpersonal interactions and internal technical intra-actions, *Interactivity* refers to the particular form of relations between humans and technology. A para-social communicative process emerges by the reciprocal nature of the activities that engenders a sense of trust and by the capacity of the technical media to show reactions and give answers in real-time and in dialogical form.

This technical mediation of control and communication also means that the interface is no longer tied to the local workstation of a machine nor to the location of a plant or an archive. Via the various media, the interface can provide access to the functionalities of production, ordering, and information systems from nearly any location. These are the new characteristics that were referred to above when speaking of the shift from the locality to the *ubiquity* of technology use (Greenfield, 2006). In addition, the increase in design possibilities apparently strengthens the performativity and connectivity of the interface with nearly all gadgets anytime and anyplace. These shifts from instrumentality to agency, from material to digital processing, and from activity to interactivity are increasingly developing dynamics of their own and require a more detailed approach when we analyze the agency and inter-agency of material and digital objects in such “synthetical situations” (Knorr Cetina, 2009). This is because technical acts take place as intra-actions within a cyber-physical system; furthermore, technical acts transform machine language into pictures, texts, speech, and sounds when they react to human speech acts via voice or keyboard.

Distributed Activities in Sociotechnical Constellations

These developments will change the nature of technical design in two directions: First, the object of design will grow in size and complexity. Second, it will increase in the variety and heterogeneity of the entities and relations involved. These trends require an approach that is also capable of decomposing complexities into smaller units and distinguishing between diverse relations of inter-agency.[23]

Let us briefly look at automobiles as a case in point. For a long time now, the design of cars has not been limited to a focus on engines and mechanical engineering only. Rather, it has involved the design of an entire vehicle system including mechanical, hydraulic, electrical, and electronic subsystems. The latter are equipped with interfaces to external information and communication systems. In view of the increase in the number of human–machine interfaces and their change from directly transmitted instructions (turning the steering wheel, pressing the brake pedal) to computer-mediated, video-assisted, or even the automated control systems of autonomous driving, the relationship of interactivity with material and digital objects as well as the *intra-actions* between them

[23] Cf. Law & Mol (2002) for a similar view on heterogeneity and complexity but a different approach.

has become more important. This has given rise to a broader view of the whole driver–vehicle system. The more interactions take place between driver, vehicle, and technical infrastructures through radio contacts, relays, and traffic control systems, the more appropriate the concept of large technical systems (Mayntz & Hughes, 1998) seems to be to properly comprehend the driver–vehicle environment. If we also include other technical systems of mobility – say, the mobility behavior of people and the programs of traffic design and management – we arrive at a highly abstract but differentiated view of the entire *sociotechnical constellation* of traffic with all its interactivities between people and material or digital objects, the intra-actions between the latter, and all its interdependencies between the various installations and institutions of the entire traffic system.[24]

Some things will, of course, not change. Technical knowledge will continue to be applied in a proven manner to the design and optimization of machines, equipment, and systems. It will also be extended to the design of electronic gadgets, computer programs, and architectures of intelligent systems. And it will continue to be applied to the design of human–machine interfaces. However, in view of the differences between material objects ("hardware"), digital objects ("software"), and human actors ("humans"), it is no longer sufficient only to aggregate the bodies of technical knowledge, for instance, of "mechanical," "electrical," "software," and "human engineering" in a modular way. As technical complexity increases, so does the need for a multi-level system engineering that deals with the interactive coupling of the various parts and levels. As the sociotechnical interactivity between humans and technologies is changing, this requires us to adopt a more comprehensive view that connects the two modes of meaning-making through technical acts and through speech acts.

The social pragmatist approach of distributed agency (Rammert, 2024) can contribute to this endeavor when it asks the overarching question: How do we distribute the activities between the various agencies of humans, machines, and programs to ensure efficient, sustainable, and safe mobility? This view then leads to more detailed questions: For example, how much of keeping a distance or hitting the brakes should be left to the car driver, delegated to the automatic cruise control, or a traffic guidance system that is connected with the environment via sensors and video cameras? Or how should the transparency at the interfaces be designed: in favor of the individual user of a central traffic control via cameras, or in favor of opportunities for external intervention at the interfaces?

If we approach these questions from the particular perspective of pragmatics, we gain a more differentiated view of these activities and their distribution. For instance, a common response to human shortcomings in the operation of technology is to replace human with technical agency, say, to avoid accidents. The irony in this is that it induces a trend toward increasing the complexity of technical systems via ever more sophisticated automation while this increasing complexity makes these systems more vulnerable to human shortcomings, be it in their design or operation. A pragmatist approach would break with this blind reflex of responding to insufficiencies by increasing complexity in

[24] Cf. Rammert (2002 and 2024, chapter 8) on distributed intelligence among traffic systems.

favor of a more reflexive response by adopting a more dynamic and distributive approach that examines the respective shares of agency and balances intervention and automation depending on the specifics of the situation or the function of the task that the system is supposed to perform.

Such an analysis would allow us to more accurately assess the advantages and disadvantages of the respective agencies and make better use of a differentiated understanding in shaping the constellation. For instance, the disadvantage of human proneness to error is paired with the advantage of the human capacity for high flexibility in dynamic and opaque situations. By contrast, the stability and predictability of material systems is the basis for their security and efficiency, while it is also the source of catastrophes in the case of unexpected deviation or interference. Digital systems, on the other hand, are excellently suited for the construction and simulation of different designs of single objects and variants of entire production systems at almost no cost; yet, they are mostly blind to resistance from the environment or to the wear and tear of physical material systems, while they also come with often underestimated risks of abusive manipulation by unauthorized persons or criminal users.

Thus, the development of a social pragmatist view on technical action and knowledge that unites productive pragmatism with linguistic pragmatics not only proves to be an epistemic advancement but also to be a suitable approach to finding practical answers to the questions posed above. Finding such solutions requires constructive and coordinated action and the interweaving of technical, ecological, and social facts. This means that the existing skills from the relevant disciplines must be brought together, not only in theory but also, and above all, in practice by actively trying out and mixing the different methods, tools, and findings as well as developing a common view by translating between the specific languages and by co-constructing sociotechnical solutions that work in society.

THE PRAGMATICS OF TECHNICAL AGENCY

The pragmatist perspective has shown that overcoming the problems of heterogeneity and complexity requires continuous action and mutual adaptation. The black-boxing and fixation of technical agency only works to a limited extent. This is because ‘technology in action’ means – as I have argued – that technical objects actually feature higher levels and higher grades of agency. This agential capacity changes the objects themselves as well as their relations with each other and their relations with people at the interfaces. The complexity of the technical systems that make up the subject matter of the technological sciences is growing. The task is no longer mainly limited to the construction of individual machines, specific plants, or special kinds of buildings; it is rather increasingly extended to include the cyber-physical design of complete energy, production, and distribution systems and the integrative planning of urban and regional districts. To come to terms with complexity of this magnitude, the engineering sciences of the future will have to place greater emphasis on participative planning processes and multi-optional experimental engineering.

If the object of technological development is no longer just the spatially, temporally, and materially fixed object but instead increasingly the mobile, self-active, and interactive object, then this activation of technologies also requires a different understanding of systems. The idea of blending the perspective of philosophical pragmatism on doing technology with the linguistic concept of pragmatics seems to be fruitful to grasp these shifts toward more autonomy, hybridity, and inter-agency of sociotechnical constellations. Through the pragmatics of technical agency, one first and foremost gains a new dimension for the analysis of technology beyond materialist approaches that emphasize the determinative nature of productive forces and neglect the dimension of meaning-making in shaping it. At the same time, the pragmatics approach also goes beyond cultural approaches that overstate the force of speech acts, discourses, and attributions of meaning and underrate corporally experienced and inscribed agency.[25] The core concept of technical agency concentrates on the observation, recognition, and theorizing of single acts, sequences of acts, and configurations of acts that simultaneously produce and reproduce meaning through the language of efficacy. This being the case, an appropriate modeling of technological systems must include the systems' capacities to change themselves via *intra-action* within the technical system and by means of *inter-activities* with people at its interfaces.

The whole complex of material, digital, and human inter-agencies takes on the character of a sociotechnical constellation that places different demands on the control and management of these heterogenous systems. In the future, engineering sciences will therefore have to enrich themselves with logistical, linguistic, and social-scientific knowledge on the management of complex systems and on the governance of mixed systems to be able to balance the technical, legal, economic, and cultural aspects appropriately.

If the point is not only the effective design of the *material* objects and their intra-actions but also the design of the *symbolic* objects ranging from agent programs to architectures of distributed intelligent systems, then completely new mixed constellations will arise in which the activities of the various material, symbolic, and human agents will not only simply intra-act in a purely mechanical way; rather, they will influence each other via interactive relationships between humans and technology.

The appropriate management of this heterogeneity of sociotechnical constellations requires the technological sciences to have an extended concept of *socio-technical design* and a competence for *reflexive innovation* in which the distributed agencies and the expected interactions are already included in the processes of developing and testing technology instead of improving it after the fact through ergonomics, technology assessment, or user responses. Technical knowledge has to be enriched with psychological, aesthetic, linguistic, and sociological knowledge if it is to be appropriately understood as experimental knowledge of action in order to become fit for the specific task of designing interfaces of human–technology interactivity. In terms of the pragmatics approach, this means that human speech acts have to be translated into both digital and material acts and, vice versa, technical acts in turn into meaningful speech acts via observable material behavior or signs on a screen.

[25] Cf. Rammert & Schubert (2023) on the human and technical embodiments of the social.

There is no identity or symmetry between human programs and technical programs as, for instance, actor–network theory assumes with its reference to Greimas' semiotics when stating that anything that can be in a speaker or subject position of a sentence can be the actor ('actant') both in a sentence and in material reality.[26] According to our pragmatics approach, doing things with things and doing things with words exhibit differences in their modes of efficacy (e.g., forcing things and people to do things versus influencing their inclinations or dispositions to do things. This approach refers to technical acts and speech acts as the smallest analytical units and enables a more comprehensive analysis of the meaning-making in different sequences, situations, and constellations.

We come full circle at the end. We began by looking at technology from the pragmatist point of view of doing things by applying skillful techniques, tools, or technological rules to achieve effects. From the linguistic perspective of pragmatics, I defined this doing of things as 'technical acts' that create constellations of efficacy and simultaneously give rise to processes of meaning-making. Then I demonstrated that the products – the technical objects themselves – actually become increasingly pro-active and, especially, interactive with users. The more the objects actively participate in bringing about the desired overall action, like traffic navigation or knowledge distribution, and the more humans enter into a relationship of meaningful interactivity with them, the more the efficacy and the comprehensibility of sociotechnical constellations are created through coordinated and distributed interagency between people, programs, and machines.

It might become apparent in the future that the new technologies will be made to function only through interaction between the technical acts of the manufacturers and the technical acts of the users, as is already sometimes the case in the niches of open forums on the Internet. Just as the music industry, the film industry, and the press are currently reconfiguring themselves, we might see the renewal of the design and development of entire technical systems as well. Regardless of where such transformation takes place now and in the future, both the pragmatics of technical agency and the levels and grades of autonomous action given to technical objects will be of particular importance. Blending the social pragmatist perspective with the linguistic concept of pragmatics, we are well equipped to observe and practically accompany the production and use of technology as an endeavor that combines meaning-making with words as well as with technical things at the same time. This will hopefully turn out to be a fruitful approach to study the new constellations once even the doing of words becomes the object of AI-generated texts and chats.

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