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Making worlds: epistemological, ontological and political dimensions of technoscience

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Abstract This paper outlines some of the new epistemological and ontological assumptions of contemporary technoscience thereby reframing the question of an epochal break. Important aspects are the question of a new techno-rationality, but also the constitution of a 'New World Order Inc.', with its new 'politics of life itself', the reconfiguration of categories such as race, class and gender in technoscience, as well as the amalgamation of everyday life, technoscience and culture. Given the difficulties of 'proving' a new episteme (or even epoch), I change perspective by reflecting on the epistemological vantage point from which the interpretation of technoscience as a new episteme or epoch becomes (im)plausible—confronting traditional approaches of philosophy and history of science and technology assessment (TA) with interventional approaches, such as postcolonial and feminist cultural studies of technoscience.

Zusammenfassung Mein Beitrag diskutiert die Frage nach einem epochalen Bruch zwischen der wissenschaftlich-technischen Kultur der Moderne und der Technoscience bzw. einer neuen Technowissenschaftskultur. Um klassische Probleme der Epochendiskussion zu vermeiden, wird die Frage nach der Technoscience mit Hilfe des Foucaultschen Episteme- und Dispositiv-Begriffs neu gerahmt. Wichtige Aspekte der Episteme bzw. des Dispositivs Technoscience werden vorgestellt—wie die Ausbildung einer neuen Techno-Rationalität, die Konstitution einer'New World Order Inc.' (Haraway in Modest_Witness@Second_Millenium. FemaleManc_Meets_OncoMouse™. Feminism and technoscience. Routledge, New York, 1997: 2) und einer 'politics of life itself' (Franklin in Encyclopedia of

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bioethics, vol 3. Macmillan, New York, 1995), die Neukonfiguration zentraler Kategorien wie Geschlecht, Ethnizität oder Klasse sowie die Amalgamisierung von Alltagsleben, Technoscience und Kultur. Abschließend werden die Unterschiede der Rezeption des Technoscience-Begriffs in eher traditionellen Ansätzen der Wissenschafts- und Technikphilosophie, -soziologie und -geschichte und der Technikfolgenabschätzung mit der in eher interventionistischen Ansätzen wie postkoloniale und feministische Cultural Studies of Technoscience herausgearbeitet, um epistemologische, ontologische und politische Differenzen der Ansätze deutlich zu machen.

Résumé En reformulant la question d'une rupture d'époque en terme d'épistémè et d'appareil, je vais souligner certaines des hypothèses épistémologiques et ontologiques de la technoscience contemporaine. Les aspects importants sont la techno-rationalité mais aussi la constitution d'une culture entrepreneuriale internationale («New World Order Inc.», Haraway in Modest_Witness@Second_Millenium. FemaleManc_Meets_OncoMouse™. Feminism and technoscience. Routledge, New York, 1997: 2), avec sa nouvelle «politique de vie elle-même» (Franklin in Encyclopedia of bioethics, vol 3. Macmillan, New York, 1995), la reconfiguration dans la technoscience de catégories telles que la race, la classe et le genre ainsi que la combinaison de la vie de tous les jours, la technoscience et la culture. Etant donné les difficultés de «prouver» une nouvelle épistémè (ou même une époque), je change de perspective en réfléchissant au point de vue épistémologique à partir duquel l'interprétation des technosciences en tant que nouvel épistémè ou époque devient plausible ou non—en confrontant les approches traditionnelles de la philosophie, de l'histoire des sciences et de l'évaluation technologique avec des approches d'intervention telles que les études culturelles postcoloniales et féministes de la technoscience.

1 Technoscience: from messy science to new world order

By 1987, Bruno Latour had already coined the term 'technoscience' to emphasize that his research centres on "the *activity* of making science" (Latour 1987: 174, emphasis in the original)—*not* on *descriptions* of scientific discourses and practices by philosophers and scientists themselves. According to Latour, the term 'science and technology' supports the myth that science and technology are the products of a few scientists, while the term 'technoscience' is supposed to indicate the messy networks of research and development, industry and society:

> To remind us of this important distinction, I will use the word technoscience from now on, to describe all the elements tied to the scientific contents no matter how dirty, unexpected or foreign they seem, and the expression 'science and technology', in quotation marks, to designate what is kept of technoscience once all the trials of responsibility have been settled. (Latour 1987: 174)

Writing in the late 1980s, Bruno Latour was navigating between Scylla in the guise of the social studies of science (SSS), respectively, the Edinburgh School

(Barnes 1974; Bloor 1976; MacKenzie 1981; Shapin 1982), which focused on the *societal conditions* of the production of science and technology, and Charybdis in the guise of traditional philosophy of science (Popper 1934/1959; Kuhn 1962), whose proponents mainly engaged in the *analysis of texts about science and technology*. Doing empirical fieldwork, Latour claimed that he was occupied with ‘science in action’, with ‘following scientists and engineers through society’[1]—searching for a theoretical grounding that can explain the activity of making science, as well as its objects, beyond social or technological determinism. Latour claims that technoscientific research is an open, fluid and ever-changing network of various agents and actors. In his view, research is only successful if it involves and mobilizes not only powerful structures and partners such as economic and political resources and infrastructures, but also organisms or machines. This is the basis for the permanent hybridization of nature and culture, for the production of hybrids, cyborgs and chimeras, which has accelerated in the present. According to Latour, however, this is not a new phenomenon but *has always been* a central feature of modernity (Latour 1993).

In 1985, Haraway was already analysing the implosion of traditional dualisms, such as nature/culture, human/machine, subject/object and body/mind through the discourses and practices of contemporary science and technology:

> High-tech culture challenges these dualisms in intriguing ways. It is not clear who makes and who is made in the relation between human and machine. It is not clear what is mind and what body in machines that resolve into coding practices. In so far as we know ourselves in both formal discourse (for example, biology) and in daily practice (for example, the homework economy in the integrated circuit), we find ourselves to be cyborgs, hybrids, mosaics, chimeras. Biological organisms have become biotic systems, communications devices like others. There is no fundamental, ontological separation in our formal knowledge of machine and organism, of technical and organic. (Haraway 1985/1990: 177)

Both Haraway and Latour stress the crucial role of hybrids in high-tech culture and technoscience, respectively. But while Latour is interested in the more academic question of a ‘proper’ description of technoscience and an epistemological approach beyond SSS and traditional philosophy of science, Haraway focuses on the analysis of the epistemological, ontological and socio-material aspects of technoscience from a perspective of *intervention*. She thematizes the emergence of a ‘new world order’ that comes not only with radical epistemological, ontological and socio-material changes but also with enormous socio-technical upheavals and restructuring of society and the symbolic order. Therefore, she considers “it less epistemologically, politically, and emotionally powerful to see that there are startling hybrids of the human and nonhuman in technoscience—although I admit to no small amount of fascination—*than to ask for whom and how these hybrids work*” (Haraway 1997: 280, emphasis added).

[1] The subtitle of Latour (1987).

While Latour is convinced that technoscience has always been modern, that science was always about the production of hybrids (Latour 1993) and dependant on rich economic and political resources, good infrastructures and cooperative organisms and machines, Haraway claims that technoscience not only signifies the fusion of science and technology and the practices of hybrid production, but also marks a new *era*. In her view, this epochal break started after WW II and can be described as a movement from industrial to the information society:

> I argue for a politics rooted in claims about fundamental changes in the nature of class, race, and gender in an emerging system of world order analogous in its novelty and scope to that created by industrial capitalism; we are living through a movement from an organic, industrial society to a polymorphous, information system - from all work to all play, a deadly game. (Haraway 1991/1985: 161)

2 Technoscience: epochal break and high-tech culture

While Latour focuses mainly on epistemological questions, Haraway's perspective is also affected by societal questions and the intermingling of technoscience and everyday life. In the tradition of the cultural studies of science and technology, she interprets technoscience as culture (Haraway 1997: 149) and an integral part of contemporary western societies (Reinel 1999: 166). This means that nowadays, science, technology, society, the industrial-military complex, as well as everyday culture, are intermingled in a new and more intimate way. Partly leaning on Winner (1986), she interprets not only technologies but also technoscience (culture) as a life form, as a comprehensive practice, a product of the increasing permeation of society by technology, as a conglomerate of posthuman high-tech and postmodern pop culture. The thorough technoscientific proliferation and the pervasion of technoscience into everyday life, the increased production of hybrids and the fusion of nature and culture are specific to our contemporary high-tech culture. The latter is closely intertwined with new and emerging techno-subjectivities, a new world order governed by the "informatics of domination" (Haraway 1991/1985: 161) and a new 'politics of life itself' (Haraway 1997).[2] Technoscience is a "*mutation in historical narrative*, *similar to the mutations that mark the difference between the sense of time in European medieval chronicles and the secular*, *cumulative salvation histories of modernity*" (Haraway 1997: 3, emphasis added).

Haraway is not the only one to claim a profound change in the epistemological, ontological and socio-material order of science and technology. In the 1990s, concepts such as 'mode-2 research' (Gibbons et al. 1994), 'post-normal science' (Funtowiecz and Ravetz 1993), or 'entrepreneurial science' (Etzkowitz and Leydesdorff 1997) drew on the profound changes in the contemporary organization of science, technology, industry and society, the (changing) epistemological and

[2] I am thinking of new technologies of the self, e.g. for optimizing one's life, such as neuro-linguistic programming or yoga, as well as genetic counselling or sex change; see also Haraway's concept of 'technobiopower', Rabinow's 'concept of biosociality or Rose's concept of 'somatic individuality'.

ontological fundamentals and socio-material practices of science and technology and the reconfigurations of concepts such as ‘nature’, ‘body’ and ‘subjectivity’. Some of the theoreticians share Haraway’s diagnosis of an epochal break. For example, the historian of technology Paul Forman recently also made the claim of a historical break—not with regard to socio-technical restructuring, but mainly with regard to the radical change of values of science and technoscience, respectively. He argues that since the late 1980s, science has not been valued primarily as a project of knowledge acquisition, inherent to progress, with technology applying its insights for practical solutions. Technoscience is seen primarily as an entrepreneurial and pragmatic project in which technology assumes the leading role in developing innovative solutions for specific societal problems, as well as new markets.

Today the role and dimension of technoscience or, respectively, mode-2 research, entrepreneurial science, etc., are quite contested. Nevertheless, no one doubts that science and technology or technoscience(s), respectively, comprehend a wide variety of disciplines, methodologies, epistemic values, theoretical foundations, experimental cultures, representational practices, and so on. As Nordmann opines,

> It is wrong even to posit a monolithic and idealized notion of ‘science’ in the first place. Instead, there was and is a multiplicity of sciences. Some of them are strongly oriented towards the demands of practice… Others have fashioned themselves after an unattainable ideal of “pure” or “basic” science… Indeed, no epochal break thesis should deny this multiplicity of the sciences and, happily, none does. (Nordmann 2010)

At stake is the question of the epochal break. With regard to the multiplicity of the discourses and practices of (techno)sciences, philosopher Alfred Nordmann argues that it is not possible to ‘*prove*’ either that technoscience is modern business as usual or that there has been a congruent shift from science to technoscience. Nevertheless, he makes the point that the *epistemic values* have changed radically from science to technoscience. While modern sciences in one way or another were bound to the enlightenment project, recent technosciences are devoted to the (techno)scientific (entrepreneurial) enterprise. Insofar, one could speak of an epochal break between science and technoscience as the a priori of the shift in knowledge from the representation of truth in the name of human progress towards the pragmatic solution of everyday problems.

Given the highly contested idea of technoscience as the signifier not only of profound changes in science and technology, but also of an epochal break, I would like to reframe the discussion. For this purpose, I will draw on the Foucauldian concepts of episteme and apparatus (*dispositif*). Foucault’s concept of episteme stands for the historical conditions of the possibility and validity of (scientific) knowledge, the formation of a specific rationality in a historical epoch: “by episteme we mean … the total sets of relations that unite, at a given period, the discursive practices that give rise to epistemological figures, sciences, and possibly formalized systems” (Foucault 1972: 191).

Later on Foucault broadened the concept, adding the element of apparatus (*dispositif*). While ‘episteme’ signifies more or less (the conditions of) the rationality of a specific time, the term ‘apparatus’ signifies not merely discourses of scientific knowledge, but a "thoroughly heterogeneous ensemble consisting of discourses, institutions, architectural forms, regulatory decisions, laws, administrative measures, scientific statements, philosophical, moral and philanthropic propositions" (Foucault 1980: 144–145).

In my view, the concepts of episteme and apparatus are helpful because they express a specific new 'rationality', which is not, however, conceptualized as closed and totalitarian discourses, but as multiple and competing ones. They govern their realm while elements from other rationalities coexist. Moreover, it makes it possible to think of technoscience not only as diverse relations between elements, but also to theorize material practices.

Reframing the question of an epochal break in terms of episteme and apparatus, I will outline some of the new epistemological and ontological assumptions of contemporary technoscience—elements of a new and technoscientific rationality. At the same time, the apparatus is not only one of a new techno-rationality, but also of a 'New World Order Inc.' (Haraway 1997), of technoscientific culture with its new 'politics of life' (Franklin 1995; Rose 2001), the reconfiguration of race, class and gender in technoscience, the amalgamation of everyday life, technoscience and (pop) culture, as well as the prevalence of the enlightenment project (Nordmann 2010).

Last but not least I will reflect on the epistemological vantage point from which this interpretation of technoscience as a new episteme with diverse apparatuses becomes plausible—confronting traditional approaches of philosophy and history of science and technology assessment (TA) with interventional approaches, such as postcolonial and feminist cultural studies of technoscience. While the traditional approaches more or less cling to a tradition of 'objective' and 'scientific' descriptions of the problems of a given technological society and their probable solutions, the latter works in a tradition of a self-reflective, situated critique of our "technopolitan *culture*" (Winner 1989/1986: ix, emphasis added). From the latter perspective, technoscience is not only a specific empirical-historical regime (Rheinberger 2007: 12) *but a situated and self-reflexive perspective*, a contested life form, a culture co-constructed by humans and nonhumans, deeply impregnated with values and governed by diverse hegemonic economies of knowledge/power. These critical approaches doubt the possibility of a neutral, empirical, historical 'objective' description of the regime and put the logic of mainstream policy advice into question. They strive to make heterogeneous, nondominant forms of knowledge visible beyond the dominant episteme (of technoscience). As Donna Haraway claims, critical technoscience studies do not only ask *how* but *for whom* the hybrids of the 'New World Order Inc.', as well as one's own research, work. Self-reflective research wants to be accountable for its own cognitive and socio-political interests, its own perspective and semantic strategies—rejecting the ideology of a God's eye view.

3 Tinkering with black boxes: epistemological and ontological reconfigurations in technoscience

From my point of view, research fields such as cybernetics, artificial life (ALife) and (new) robotics are good examples of the new technosciences in question—and of the amalgamation of science and technology. They are radically interdisciplinary,[3] and they are neither (pure) science nor (pure) engineering. Investing in the construction of *artificial autonomous systems* and leaning on search heuristics and probabilistic strategies, such as genetic programming or postprocessing (see below), it becomes obvious that it is not possible to distinguish—not even theoretically (Nordmann 2004)—between the scientific and technological aspects of these new technosciences. Cybernetics, artificial life and new robotics—and also many other new research fields, such as biotechnology, nanotechnology and neuroscience, the so-called convergent technologies—work with new epistemological and ontological assumptions (Pickering 2002; Weber 2010) leaving the information paradigm behind (Kogge 2008).

While new robotics, like its predecessors, cybernetics and artificial life, does not aim at the representation and application of the laws of nature, mainstream artificial intelligence can be seen as a more traditional (Newtonian) science. One could interpret the history of the development of intelligent machines as parallel tracks: The 'scientific' track is the one with artificial intelligence as a more traditional science with its orientation towards mathematics and physics, resting on a rational–cognitive and top–down approach, using machine-oriented concepts, algorithms as well as automats, and focusing on symbol processing and formal logic for problem solving. It relies on the paradigm of information processing where intelligence, brain and the calculation of symbols is equated. Mental processes—which are more or less identified as cognition or even intelligence—are interpreted as the processing of calculations equated with algorithms. 'Good old-fashioned Artificial Intelligence' (GOFAI) rests heavily on abstraction, disembodiment and decontextualization. For example, the central hypothesis of the 'physical-symbol-system' (Newell and Simon 1976) claims that the processing of symbols is sufficient to model and produce intelligence. While it is necessarily based upon a physical system, the latter is not important as long as the *rules* for processing symbols and for the physical machine are powerful enough. The representation of knowledge, i.e., *the adequate modelling of the world via symbols and logical inference* is the core of the research paradigm of traditional artificial intelligence.[4] This kind of modelling abstracts from all physical and material aspects. The internal processing of symbols, the representation of knowledge and plan-based action on the basis of preprogrammed knowledge are regarded as the distinctive features of intelligence.[5] In working with representational, detached models 'about the world', artificial intelligence behaves more like a traditional science. It wants to track the 'real' mechanisms of intelligence and foster understanding, and at the same time rebuild the 'natural' model.

In contrast, cybernetics, artificial life and new robotics can be seen as technosciences. They move away from the rational–cognitive approach (with its computational theory of mind) towards biologically, neuro- and emotional-inspired approaches. Cybernetics and new robotics interpret human as well as machine

[3] They bring together experts from mathematics, physics, as well as biology, cognitive science, engineering, computer science, psychology, philosophy, pedagogy and other fields.

[4] Pfeifer and Scheier (1999) and Christaller et al. (2001: 66).

[5] Becker and Weber (2005).

behaviour as a (negative) feedback of errors, as relying on processes of tinkering and of trial and error. The basis for this new epistemological approach is the idea of an intimate coupling of system (organism/machine/artefact) and environment, as well as a new interest in materiality, embodiment and situatedness. New robotics works with the assumption that there is a certain autonomy and unpredictability in the behaviour of systems (Heylighen and Joslyn 2001: 3; Weber 2003) which must be exploited by means of probabilistic strategies, search heuristics and postprocessing, by implementing processes of adaptation or imitation and by using emotion, to make artificial intelligent behaviour possible. These technosciences shift their focus from mathematics and physics towards biology, neuroscience, psychology and engineering as new resources of inspiration and innovation. Unlike traditional science, they do not strive for an analysis of the intrinsic features of systems, but rather try to develop new ways to predict their teleological or nonteleological behaviour. While artificial intelligence (AI) regards the representation of the world as the central precondition for intelligent systems, new robotics does not invest in the relationship between the model and the real world. *Neither representing nor intervening* (Hacking 1983) *is the main issue in today's technosciences, but rather building flexible, robust, situated and embodied systems.*

In the mid-1980s, Rodney Brooks—current head of the AI lab of the Massachusetts Institute of Technology, roboticist, entrepreneur and one of the founders of new robotics—developed a new architecture for robots called subsumption architecture. This architecture rests on the "idea of a large number of parallel, loosely coupled processes connecting sensors to actuators with relatively little internal processing" (Pfeifer and Scheier 1999: 656). It consists of several layers of behaviours. Instead of following a one-way-street from perception to world modelling to action, here there are many layers working in parallel, trying to find a better solution for a given task by means of tinkering and trial and error. As the interaction between the many layers cannot be predicted, trial and error, probabilistic strategies, observation,[6] evolutionary algorithms and genetic programming are means of fostering emergent, unpredictable behaviour. The latter is analysed via postprocessing to develop new behaviours, as well as effective new patterns of interaction between the layers. Thereby, genetic programming—inspired by biology and genetics—became a central tool for ALife and new robotics. The idea is quite simple: A program is varied many times and its variations are tested against a pregiven fitness criterion. The most successful variations ('genetic parents') are further used to produce next 'generations', which are tested in turn, and so on—until the 'programmer' decides that the program is successful enough (Hayles 2003; Weber 2003). Building on probabilistic strategies, the underlying thought is that there is a population of potential solutions which can be converged, and that a high diversity of populations helps to find successful solutions.

The technoscientific approach in new artificial intelligence draws on concepts such as emergence (the interaction between layers triggers unpredictable behaviours/solutions), self-organization, decentralization, distributed systems, bottom–up

[6] One could also talk of an 'ethnography' of machines.

processing, performativity and the exploitation of unpredictable behaviour. It more or less abandons the concepts of abstraction, top–down processing, reference, distancing of the researcher from the object, objectivity and universality. In new robotics, many researchers argue that according to evolutionary theory, organisms are ‘designed’ for a particular niche. Therefore, the robot needs to be nonuniversal. As a robot is supposed to act in many different environments, in the real manifold shaped environments, a universal robot does not make sense from a technoscientific perspective. This is quite contrary to the universal claim of computation. Focusing on internal processes and abstracting from material processes and (most of) the external world, computation took place in a virtual, idealized world where universality can be (easily) claimed (cf. Pfeifer and Scheier 1999: 94 et sqq.).

The needlessness of the classical scientific value of objectivity is linked to a voluntary involvement of the researcher with his or her artefact. Relying on close observation and/or ethnographic studies of the *behaviour* of the artefact, the researcher is intimately interwoven with the artefact. This development is accompanied by a shift in human–machine relations from the traditional master/slave relationship to one of partnership or of caregiver and infant—not only between the user and the machine, but also—at least partially—between the engineer and the artefact (Weber 2005). Imitation, adaptation, learning, gesture, mimicking, and the expression of emotions become important features of so-called socio-emotional machines. The dream of an autonomous machine relies now on the idea of the engineer and the machine co-producing the artefact, and on the empathy of the engineer, who is supposed to anticipate the ‘standpoint’ of the machine, and understand it and its problems. Empathy and mimesis become proper epistemological strategies as part of a new ‘search heuristics’ that rests on testing/changing the boundary conditions of a system rather than optimizing a top–down working control. This approach rests on tinkering and trial and error, to work with the idea of evolution, incoherence and partial solutions. This is more than a new culture of computing, and radically different from the epistemological stance of traditional artificial intelligence.

Recent approaches such as “behaviour based robotics” (Brooks 1986; Christaller 2001), “evolutionary robotics” (Husbands and Meyer 1998; Nolfi and Floreano 2000) or “embodied artificial intelligence” (Pfeifer and Scheier 1999) demonstrate very well the ongoing fusion of the natural and the artificial, similarly, the prevalence of the differentiation between the natural and the artificial. They also foster the blurring of the boundaries between the researcher (subject) and the artefact (object; Haraway 1991/1985; Latour 1993; Rheinberger 2007; Weber 2003), aiming for the development of autonomous unpredictable machines and socio-emotional and self-learning artefacts. At the same time, an ontology is developing that interprets organisms as biotic components in a (biocybernetic) network with systemic properties such as self-organization, information processing, transformation and (information) transportation. With the rise of system theory, the life sciences and especially molecular biology, the organism is understood as a communication system and the borders between the physical and nonphysical are getting increasingly blurred. These profound ontological changes enable an intimate coupling of human and machine, to theorize change (evolution), dynamic behaviour and complexity. Cybernetics, artificial life and new robotics primarily focus on the function, classification and control of the dynamic behaviour of systems—organisms as well as technological systems. To achieve this goal, organisms and machines are blackboxed, the understanding of their intrinsic features becomes irrelevant and traditional values of modern science are abandoned.

These changes in the epistemological and ontological assumptions, tools and methods of recent technosciences are only part of a bigger picture that cannot be elaborated on any further here. However, I regard these changes as important and prominent. Other crucial changes concern the molecularization of life, the introduction of new visualization techniques, a shift of values from the quest of knowledge (Forman 2007)—which was at the core of the modern enlightenment project (Nordmann 2010)—towards problem solving, innovation, efficiency, application orientation and the exploration of new markets.

4 Technopolis, New World Order Inc. and an emergent form of life

In 1986, the philosopher of technology Langdon Winner wrote:

> The map of the world shows no country called Technopolis, yet in many ways we are already its citizens. If one observes how thoroughly our lives are shaped by interconnected systems of modern technology, how strongly we feel their influence, respect their authority and participate in their workings, one begins to understand that, like it or not, we have become members of a *new order in human history*. (Winner 1986: ix, emphasis added)

Donna Haraway, Langdon Winner and others argue that the systemic character of technoscience(s), the amalgamation of technologies with everyday life, has radically changed our societies.

What also adds to the threshold is not only the systemic character of technology, but also the close intertwinement of technology development, industrial research, multinational corporations and public funding policies, which results in new organizational, economic, methodological, political and management dimensions of technology or technoscience, respectively. These developments are closely related to the shift from knowledge towards problem solving, from analysing and representing the laws of nature towards the technological production of new artificial entities and the engineering of nature. A new 'hyper-capitalism' (Haraway) which leads to "the increasing capital concentration and monopolization of the means of life, reproduction and labour; appropriation of the commons of biological inheritance as the private preserve of corporations; the global deepening of inequality by region, nation, race, gender, and class" (Haraway 1997: 60). The rapidly growing markets of information and communication technologies and the knowledge economy and other phenomena are taken as indicators for radical change.

The background of these developments is not only the molecularization of life as a new frame of thought in biology, but also the optimization and subjectivation of life. In the nineteenth century and the first half of the twentieth century, the reproduction of the European population was modelled top–down through discourses and practices of a nation-centred biopolitics. An individual life in one of today's neo-liberal societies is supposed to be self-motivated and seems to afford self-modelling in a constructive way—through psycho-techniques, beauty surgery, sex change, the design of emotions and thoughts, designer babies, genetic and tissue engineering, brain enhancement via microchips, or through educating one's personal robot. The relationship between technoscience and the individual is changing radically, insofar as the individual subject is governed not only by duties, rights and expectations, but in addition the entrepreneurial self is supposed to self-optimize him- or herself as best as possible with the help of technoscientific strategies of enhancement.

On the one hand, this development only became possible with the new option of disassembling life into discrete objects that can be stored, collected, changed and substituted and the convergence between bio- and information technologies. On the other hand, it goes together with the intimate coupling of human and machine, with the blurring of the boundaries between the human and the artificial and between body and mind. In modernity, science interpreted nature in a static way, and was occupied with the laws of a dead matter, while the living was regarded as nondisposable.

In the age of technoscience, the dimensions of becoming, the possible and the unpredictable are of central concern and at the heart of a new techno-rationality[7] that does not represent the living as dead material. The new flexibility of the living, with options for optimization and enhancement, are at the same time the basis for a new biopolitics of risk management, individual health engineering and the intimate coupling of technoscience and techno-economy. Central features of this new biopolitics are "marketization, autonomization, and responsibilization" (Rose 2007: 4). These changes are, according to Rose, accompanied by,

> more general shifts in rationalities and technologies of government, notably the *transformations in the provision of security*, *welfare*, *and health* associated with challenges to the social state in Europe and Australasia, and the rise of new 'advanced liberal' governmental technologies (Rose 2007: 3).

With regard to biomedicine and health politics, Nicholas Rose identifies five 'pathways of significant mutations' in the present: 'molecularization', 'optimization', 'subjectification', 'somatic expertise' and 'economies of vitality' (Rose 2007: 5). Reasoning about the scale of these changes, he writes:

> I am wary of epochal claims, and it is necessary to recognize *that none of these mutations marks a fundamental break with the past*: *each exhibits continuity alongside change*. *Yet*, *I suggest*, *from the point of view of the present*, *a threshold has been crossed*. Something is emerging in the configuration formed by the intertwining of these five lines of mutation, and this 'something' is of importance for those, like myself, who try to write the history of possible futures. (Rose 2007: 7)

[7] Weber (2010).

French philosopher Gilles Deleuze elaborated on the new rationalities and technologies of government, diagnosing a shift from disciplinary societies towards societies of control. He writes:

> These are the societies of control, which are in the process of replacing disciplinary societies. 'Control' is the name Burroughs proposes as a term for the new monster, one that Foucault recognizes as our immediate future. Paul Virilio also is continually analyzing the ultrarapid forms of free-floating control that replaced the old disciplines operating in the time frame of a closed system. There is no need to invoke the extraordinary pharmaceutical productions, the molecular engineering, the genetic manipulations, although these are slated to enter the new process. There is no need to ask which is the toughest regime, for it's within each of them that liberating and enslaving forces confront one another. For example, in the crisis of the hospital as environment of enclosure, neighbourhood clinics, hospices, and day care could at first express new freedom, but they could participate as well in mechanisms of control that are equal to the harshest of confinements. (Deleuze 1992/1990, no pagination given)

Today's surveillance studies stress the ubiquity of dataveillance and surveillance in the twenty-first century, the new focus on risk management in security and crime prevention, while a 'new penology' (Feeley and Simon 1992) is preoccupied not with the societal reintegration of the delinquent, but with an actuarial perspective of 'risk profiling', 'risk management' and 'damage minimization'. This perspective does not rest on values such as truth or justice, but instead seeks pragmatic solutions for 'given' problems. This new approach puts its prime emphasis on securitization rather than civil liberties and human rights. In the course of this, the new penology invented preventive detention, which is oriented towards probability, risk minimization and avoidance of costs.

The systemic character of technology, the interest in the living and unpredictable in technoscientific discourse and practice, 'molecularization', 'optimization', 'subjectification', securitization, demands of autonomization and responsibilization on the individual are some of the 'mutations' of a new episteme. Others are the apparatuses of the military-industrial-university complex or the military-multimedia entertainment complex, of "the apparatuses of hypercapitalist market traffic and flexible accumulation strategies" (Haraway 1997: 15), as well as the new axes of in- und exclusion on the basis of race, gender and class. It is not one of these mutations; there is a simultaneity of change and continuity, but the ensemble of these frequent and ubiquitous mutations makes the decisive difference that marks a new episteme.

5 Business as usual, the openness of the future and the politics of (non)intervention

Though these descriptions of new epistemological foundations in technoscience of sociotechnical, economic and cultural changes make a profound change in our episteme highly plausible, I would agree with Alfred Nordmann (2009) that this does not and cannot prove a new age of technoscience.

Therefore, I want to change perspective and come back to the discussion of technoscience in philosophy/sociology/history of science and technology, techno-science studies and technology assessment.

One frequent objection to the argument of a new epoch is that there are some changes going on, but that the extent of change is overestimated and does not lead to a new epoch or a new episteme.

Many theoreticians agree that there is an ongoing amalgamation of nature and culture in the discourses and practices of science and technology. Philosopher of science Martin Carrier argues that this phenomenon is not new but its ubiquitous character:

> The two traditional types of relationship between science and technology are, first, that science is instrumental in producing technology, and, second, that technology is used in experiments for gaining new knowledge about nature. The rise of technoscience means that a third mode has gained ascendance. *Technologically produced entities or processes have become the objects of scientific scrutiny. We have made them but we fail to understand their causal or nomological properties. …*
>
> I hasten to admit that this technoscientific mode of research is not new. It started perhaps with Sadi Carnot's analysis of the steam engine in the framework of caloric theory. What is novel, instead, is that the technoscientific mode has become dominant in the past decades. (Carrier 2010: 46 et seq.)

Philosopher of technology Gregor Schiemann also admits a intensification of the blurring of boundaries between nature and culture in technoscientific practices; however, unlike Winner and Haraway, he does not interpret technoscience as a life form and cultural practice, but insists there still exists a gap between the realm of technoscience and the *Lebenswelt* insofar as most people still are not trained in science or engineering, and do not have an understanding of the inner logic of science and technology:

> In everyday life, we are usually confronted only with the surfaces of modern technological objects. Although ever more aspects of life are directly dependent on the use of scientific technology, and this dependency is increasingly changing our understanding of ourselves, the black-box character of this technology constrains its influence within certain boundaries. There is as little need to take an interest in the scientific knowledge at the basis of a technical device as there is to understand the technical workings of the device. (Schiemann 2010: 36 et seq.)

To the extent that nonscientific beliefs and values are still important in everyday life, Schiemann sees no evidence of an epochal break.

Others stress that science and technology have always been intertwined, but that philosophy of science was so preoccupied with (theoretical) physics that the intertwinement of science and technology was overlooked until the 1990s. Even when theoreticians such as Heidegger or Derrida addressed the issue of techno-science, their statements were either overlooked or interpreted differently. Only with the growing interest in technosciences such as computer science, artificial intelligence and bio- and nanotechnologies, the intertwinement of science and technology becomes increasingly visible. Nevertheless, this does not explain why the—at least conceptual—differentiation between science and technology has been plausible in modernity, while it seems to become impossible in recent techno-sciences. Paul Forman argues that it is not the *practices* that changed in the last decades but the *values* of science:

> … prior to *ca* 1980, the primacy of science in cultural value *to* technology, and in practical culture *for* technology, was very nearly universally presupposed, notwithstanding that the primacy of science itself was continually challenged in modernity by a powerful romantic tradition among artists and intellectuals, and intermittently by populist upsurges. The rapid reversal about 1980 in the more than merely modern—the millennial—primacy relations between science and technology is unquestionably epoch-making. If identified with the transition from modernity to postmodernity, that reversal in the science-technology relations gives to this historical-cultural transition a greater specificity and a still greater significance. (Forman 2007: 70)

The dispute over the epochal significance of a new postmodernity—starting in the 1980s—was never settled. And the same might happen with the question about a new epoch called technoscience, as long as we frame it in a similar way. We can give indicators for the change, discuss significant ‘mutations’ and argue that a ‘threshold has been crossed’ (Rose 2007: 7). This stance cannot be proved, but it can be made plausible.

Therefore, I also want to reconsider the debate from a different angle and ask myself: Who took up the concept of technoscience in the last two decades and how—and for what reasons? Which connotations were conveyed about the concept of technoscience?

Looking more closely at the debate, one can see that ‘technoscience’ became a central concept in cultural studies of science and technology, especially in feminist and postcolonial approaches (Andersen 2002; Braidotti 2002; Bryld and Lykke 2000; Haraway 1991/1985, 1997; Lykke 2008; McNeil and Franklin 1991; Reinel 1999; Star 1991; Suchman 2003; Verran 2002; Weber 2006), while it was not used or discussed in the mainstream of philosophy,[8] sociology[9] and history of science and technology, as well as technology assessment, until recently.

6 The seamless web of technoscience, self-reflexivity and the politics of intervention

It makes a decisive difference for a theory of technology to assume that we live in a technopolis and to interpret technology as a socio-political system and immanent

[8] Naturally, there are always exceptions, as found in the work of Don Ihde and Alfred Nordmann.

[9] With the exception of some scholars working in actor-network theory and other post-constructionist approaches in STS, such as John Law or John Urry.

part of everyday life. If technoscience is interpreted as a central part of everyday culture, intimately intertwined with society, the economy, policy and the military, it is no longer convincing to 'assess' technology and question its effects *on* society, but rather to regard it as "practical culture and cultural practice" (Haraway 1997: 66). This is the logical result in a culture where the boundaries of science, technology, industry and society are blurred, a new 'seamless web' of technoscience culture is emerging, and radical changes in the epistemological and ontological assumptions of the technosciences are taking place.

One could roughly distinguish two different reactions to the new situation:

With regard to more traditional approaches, one could talk of a pragmatic turn of science and technology studies—turning from (social) theory, epistemology, philosophy/history/sociology of science, and so on, towards policy advice, applied philosophy/ethics, science communication. And while there are strong pragmatic trends in philosophy, sociology and history of science and technology as well as STS, one could interpret the younger field of technology assessment as a product of technoscience (Nordmann 2009).

Nordmann argues that TA does not assess or reflect technology from a social theory perspective, which also looks at questions of in- and exclusion and the best possible future of the technopolis in terms of pursuing a common goal, but which is mainly preoccupied with optimizing or enhancing the future—understanding the latter as an object and product of social and socio-technical engineering. Thereby, TA situates itself within the very limited framework of the Collingridge dilemma, according to which social effects and risks of technology can only be understood empirically and only after its implementation—exactly at the moment when changes become very difficult or even impossible:

> …the social consequences of a technology cannot be predicted early in the life of the technology. By the time undesirable consequences are discovered, however, the technology is often so much part of the whole economic and social fabric that its control is extremely difficult. This is the *dilemma of control*. When change is easy, the need for it cannot be foreseen; when the need for change is apparent, change has become expensive, difficult and time consuming." (Collingridge 1981: 11)

Therefore, technology assessment engages with the effects and risks of new technologies or technosciences but does not analyse the politics of technology. It does not consider the conditions for a just and a more liveable technopolis and outlines possible options. It is not a *political* theory of technology. It does not contemplate appropriate forms of technology and the active and democratic shaping of the future, or the participatory design of technology, speculative ethics or a critical social theory of technology. It concentrates on the issues of efficiency and risk—terminology that became popular in the last decades. The political philosopher of technology Langdon Winner already criticized in the 1980s,

> [the] very introduction of risk as a common way of defining policy issues … [as] far from a neutral issue. At a time in which modern societies are beginning to respond to a wide range of complaints about possible damage

> various industrial practices have on the environment and public health, the introduction of self-conscious risk assessment adds a distinctly conservative influence. By the term 'conservative' here I mean simply *a point of view that tends to favor the status quo*. (Winner 1989/1986: 138 et seq., emphasis added)

Even participatory technology assessment, which has—at least in principle—its focus on democratization and inclusion of the public, often fails to facilitate this goal because it favours a deficit model according to which lay experts and the public need to be informed and educated. It (mis)understands its goal in bringing 'rationality' into the public discussion and supporting a (positive, noncritical) 'scientific' perspective. Often participatory technology assessment does not primarily facilitate the critique of dominant (expert) discourses and practices, of the distribution of economic and social power and helps to include counter-expertise, local and situated knowledge and civic responsibilities into the processes of decision-making and public debate. In decision-making processes such as consensus conferences, it often shapes the questions and procedures in such a way that lay experts tend to obey the predominant technoscientific and economic 'rationalities' (Goven 2002; Schaper-Rinkel 2010).

The second reaction to the new situation can be seen in the field of cultural studies of technoscience and of science and technology, respectively, with their feminist and postcolonial approaches strongly driven by social theory and social movements. These approaches cling to the modern idea of the future as a common, democratic project, while at the same time trying to use the radical changes of the age of technoscience as a possible starting point for rewriting the traditional symbolic, political and material orders.

Cultural studies of science and technology interpret our technoscientific culture as a social practice, a situated, complex and heterogeneous process in which many agents, both human and other beings, as well as concepts, institutions or machines produce meanings and, thereby, maintain or refigure cultural boundaries. Unlike the mainstream of technology assessment with its preoccupation on risk and efficiency, and unlike actor-network theory which focuses primarily on how and why new technologies succeed or fail, the field of cultural studies of science and technology wants to know not only how, but also for whom, technologies work: How do technologies shape our identity and bodily experiences? How do they contribute to the shift in traditional dualisms, such as body/mind, nature/culture, human/machine? At the same time, it is interested in the interplay of 'standardization and local experience (on) that which is between the categories, yet in relationship to them' (Star 1991: 39).

Given the intimate bonding between technoscience, society, economy, politics and the military, as well as the vanishing of classical values and norms such as objectivity,[10] neutrality and universality in recent technoscience(s),[11] the distinction between objective science and politically motivated or so-called 'ideologically'

[10] For example, the roboticist Thomas Christaller states that it is not possible and productive to model "the world in an objective, complete and non-contradictory way" (Christaller et al. 2001: 72).

[11] With regard to its practices—not to its rhetorics; see above.

motivated research and activism fades away—at least in principle. Therefore, it also becomes easier to grant oneself the right to intervene; as feminist cultural theorist Anne Balsamo writes, 'we have a right, and in fact a duty, to debate, contest, modify and perhaps even to transform' (Balsamo 1998: 294). This includes those who are not trained and socialized in technosciences, as well as those who are not part of the community of knowledge producers. All are requested to reflect on the development of technoscientific practices and artefacts shaping our world, our identity and everyday life in an increasingly intensive and profound way.

Given the new awareness of the socio-political embeddedness and economic dependence of research and development, claims of objective expertise from former 'neutral' scientists and engineers, as well as from 'detached' philosophers, TA experts or sociologists of technology, are not convincing. With the growing visibility of the socio-economic and political dependences of technoscience and the situatedness of its commentators, it becomes more difficult to label interventionist-oriented approaches as biased in comparison with so-called 'objective' experts.

The problematization of objectivity or neutrality as epistemological givens also leaves room for a closer and more critical look at rhetorical practices. For example, feminist STS and cultural studies of science and technology question the mirroring of traditional (techno)scientific narratives in STS, philosophy of science and TA, and demand more attention be paid to self-reflexivity and the situatedness of knowledge. For example, Haraway criticizes Latour's heroic actor-network theory narrative of entrepreneurial technoscientists competing for resources and allies:

> Perversely, however, the structure of heroic action is only intensified in this project—both in the narrative of science and in the discourse of the science studies scholar. For the Latour of *Science in Action*, technoscience itself is war, the demiurge that makes and unmakes the worlds. … Trials of strength decide whether a representation holds or not. Period. To compete, one must either have a counterlaboratory capable of winning in these high-stakes trials of force or gives up dreams of making worlds. … [The story] works by relentless, recursive mimesis. (Haraway 1997: 34)

Cultural studies of technoscience can be seen for one thing as a very close and somewhat 'pragmatic' encounter with our (everyday) technoscientific culture. It takes a close look at everyday discourses, practices and narratives, the reinvention of epistemological and ontological fundamentals in recent technosciences, as well as the symbolic order. It analyses the efficiency of new technosciences (for example, the life sciences with their capacity to dis- and re-assemble life), analyses the narratives, while at the same time trying to rewrite these narratives. Grounded in social theory and social movements, it resists the common narratives of technoscientific and economic rationalities, optimization, enhancement as well as the biopolitics of risk management and social engineering. It aims at reinventing new 'rationalities' of our technopolis, to explore possibilities of intervention, to write not only the 'history of possible futures' (Rose 2007: 7), but also to outline 'more liveable worlds' (Haraway 1994, 63)—not least for "*the dispossessed*, *the abused*, *the excluded*, *the* '*other*' *of the high tech clean and efficient bodies that contemporary culture sponsors*" (Braidotti 2002: 139).

Postcolonial, feminist and other critical cultural studies of technoscience analyse the reconfiguration of our technopolis to open up possibilities for intervention. The crisis of (post)modernity and the new epoch of technoscience is interpreted as a chance for participation in the making of worlds, insofar as theory is also about power relations and patterns of exclusion.

Twenty years on, the hope of rewriting our technopolis and reordering technoscience might have diminished in the face of the reification of power relations, but it revolves nevertheless around the question of how to construct less hierarchical discourses and practices, and narratives of more liveable worlds:

> How might inhabitable narratives about science and nature be told without denying the ravages of the dedication of techno-science to militarized and systematically unjust relations of knowledge and power, while refusing to replicate the apocalyptic stories of Good and Evil played out on the stages of Nature and Science? (Haraway 2004/1994: 134)

Given this perspective, one could ask: When and why does technoscience (not) count as an epoch? The consideration of relations between power and knowledge, of patterns of ex-/inclusion, focusing on everyday culture and technoscience, challenging the status quo and exploring possibilities of intervention, seem to make way for the interpretation of technoscience as something new and different, to seeing its qualitative difference and assuming that 'a threshold has been crossed' (Rose 2007: 7). This is not to claim that cultural studies of technoscience represent the only critical approach in the field of STS. To claim the existence of an untouched *Lebenswelt* or an untouchable realm—be it the lived body, nature or art—beyond technoscientific discourses, practices and narratives is another strategy to limit the territory and power of technoscientific rationalities. But it is not a strategy of intervention.

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