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A forensics of wishing: technology assessment in the age of technoscience

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Abstract

If one considers the Collingridge dilemma to be a dilemma awaiting a solution, one has implicitly abandoned a genuinely historical conception of the future and adopted instead a notion of the future as an object of technical design, the realisation of technical possibility or as wish-fulfilment. The definition of technology assessment (TA) as a successful response to the Collingridge dilemma renders it a technoscience that shares with all the others the conceit of being able, supposedly, to shape the future. An alternative way of pursuing TA begins with an analysis of our age of technoscience, including its impoverished conception of the future. A critical appreciation of this conception gives rise to a forensics of wishing.

Zusammenfassung

Wer das Collingridge Dilemma für ein Dilemma hält, das lösungsbedürftig ist und vielleicht sogar gelöst werden kann, hat sich bereits von einem historisch verstandenen Zukunftsbegriff verabschiedet und sieht Zukunft stattdessen als Gegenstand technischer Gestaltung, als Realisierung eines implizit schon gegebenen grenzenlosen technischen Potenzials, als Wunscherfüllung. Wenn sie vom Collingridge Dilemma ausgeht, wird die Technikfolgenabschätzung eine Technowissenschaft wie jede andere und macht sich ihren Hochmut angeblicher Zukunftsgestaltung zu eigen. Eine Alternative besteht darin, von der Analyse unseres Zeitalters der Technowissenschaften auszugehen und aus der Kritik des verarmten Zukunftsbegriffs eine Forensik des Wünschens zu entwickeln.

Résumé

Si nous considérons que le Dilemme de Collingridge est un dilemme en attente d'une solution, nous aurons, de manière implicite, abandonné une véritable conception historique de l'avenir et, à la place, adopté une notion de l'avenir en tant qu'objet de conception technique ou de réalisation de possibilité technique ou de réalisation d'un souhait. La définition de l'évaluation de la technologie en tant que réponse réussie au Dilemme de Collingridge le rend une technoscience qui

partage avec tous les autres la vanité d'être capable, soi-disant, de former l'avenir. Une manière alternative de poursuivre l'évaluation de la technologie débute avec une analyse de notre ère de la technoscience, y compris sa conception appauvrie de l'avenir. Une appréciation critique de cette conception donne lieu à un débat sur le souhait.

These reflections advance a single, perhaps simple claim. By setting out to solve the Collingridge dilemma and to discover the right entry point for shaping the future, technology assessment (TA) becomes a technoscience like any other. It thereby undermines its critical position towards the technosciences. However, an acknowledgment of this danger may afford alternative approaches that engage technological development more closely.[1]

The argument for all this proceeds in three steps. It begins by introducing, as necessary background, the notion of technoscience and of ours as an age of technoscience. It then shows the birth of TA from the spirit of technoscience. It finally suggests a reversal: Rather than view technologies and their assessment as a consequence of technoscience, the technosciences – including technology assessment – can be fruitfully considered as a consequence of the technological milieu in which they are produced. This reversal rids technology assessment and, ideally, societies at large of their fixation upon the future as the harbinger of novelty and object of shaping.

1. The age of technoscience

To make sense of ours as an age of technoscience, one must assume that it supersedes a previous age, call it the age of science, the age of big science, or the age of mode-1 laboratory research. Either way, the age of technoscience is just as mythical as was the one that preceded it (Bensaude-Vincent 2009). The claim that we live in an age of technoscience, then, does not imply that the technosciences themselves are new or that research practices are fundamentally different now from how they have been before. The age of technoscience is characterised, instead, as a way of valorising the technosciences. The organising myth of technoscientific innovation orients the expectations and priorities of scientists and other social actors just as much or as little as did the powerful myth of scientific Enlightenment (Nordmann forthcoming).

Here is a concise, though admittedly somewhat abstract definition of "technoscience": As opposed to the "sciences" (as conceived, especially, by scientists and philosophers of the 19th and 20th centuries), the "technosciences" do not even attempt to distinguish between theoretical representation of the world and technical intervention into the world. It is nowadays a commonplace that representing and intervening are part of every attempt to arrive at knowledge of empirical matters (Hacking 1983).

[1] This claim and its associated recommendations cannot be fully substantiated in a single paper. Here, it serves mostly to stimulate discussion, and its presentation therefore retains the semi-formal format of a lecture.

However, the “pure” sciences are pure precisely because they invest a lot of analytical effort into the conceptual and technical separation of these two activities: The Large Hadron Collider is necessary to detect the Higgs boson, and a great amount of effort will go into showing that what is detected is no artefact. The sole purpose of the gigantic experimental intervention is to allow the representation of something that is part of the furniture of the world. In contrast, the technosciences have been considered impure precisely because they are not concerned about maintaining this distinction: A pharmacological laboratory is necessary to produce a chemical substance that will dilate arteries and increase the flow of blood. Though this chemical represents some general features of the world, it does so like any chair, table or other artefact. It would appear to be a moot exercise to take this pharmacological agent or to take the effected dilation of the arteries and carefully tease apart what is due to human intervention and what to features of nature. It is in this rather obvious sense that the technosciences do not distinguish between theoretical representation of the world and technical intervention into the world – because it is neither necessary nor possible to achieve this kind of purity.[2] This is true not only for today’s paradigmatic technosciences such as nano and biotechnological research, but has been true for alchemy, pharmacy, the agricultural sciences, forestry, nursing science, materials research, information and communication technologies, synthetic chemistry and the like.

In the age of science, all the sciences, but also these technosciences are beholden to the ideal of separating representation and intervention and its associated ideals of distinguishing between science and technology, nature and culture, between what is given and what is made, between organic growth and thinglike construction. For the technosciences, orientation to this ideal meant that they were considered less pure than theoretical physics and evolutionary biology, but that they nevertheless made a contribution to the overarching aim of the scientific enterprise, namely to advance what Max Weber has called the disenchantment of the world through increasing rationalisation and intellectualisation (Weber 1946).

In the age of technoscience, the ideal of pure science appears to be obsolete.[3] Basic technoscientific research is dedicated to the acquisition of basic capabilities of visualisation, manipulation, modelling and control and is not dedicated to the advance of Enlightenment by way of truth-seeking or the criticism of prejudice and superstition. Even basic research is now application-oriented – where the applications are research techniques, proofs of concept, stepping-stones and tool-kits.

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[2] Some theorists of technoscience, most notably Bruno Latour, argue that there is no difference between science and technoscience because upon close analysis all sciences turn out to be technosciences – their work of purification never succeeds (Latour 1987, 1993). In the age of science, at any rate, it is a hallmark of science to engage in this work of purification, whereas in the age of technoscience even much of physics and biology is abandoning it.

[3] Many drivers conspired to render the ideal obsolete and they all belong to the age of technoscience. They include science policy-makers and many scientists themselves – preferring the likes of a Louis Pasteur to a Nils Bohr on the one hand, and a Thomas Edison on the other (Stokes 1997). They also include Science and Technology Studies – against the vigorous resistance by many philosophers and some historians of science.

The notion of an all-out epochal break may be too grandiose even to those who appreciate the different characterisations of the ages of science and of technoscience. It would appear, after all, that representing and intervening have always been inextricably interwoven throughout the history of science and that the dream of teasing them apart was the hopeless conceit of only a negligibly small group of empiricists, logical positivists, and other scientists and philosophers of science in a mostly Kantian tradition – how can one even envision seeking an understanding of the world without changing it, too?

Though it downplays the powerful influence of the scientific dream of reason, this is a perfectly plausible view of the history of science, and it is the only plausible view from the vantage point of the age of technoscience. From its point of view, there has never been anything but technoscience without an epochal break anywhere in sight. Looking back into history from our current age it would appear that there has been nothing but tinkering all along: fitting data to theory, constructing models as mediators between theory and reality, specifying explanatory mechanisms, establishing the resilience or robustness of accounts and the like.

However, this characterisation of the history of science as a history of multiple activities, all of them involving representations and interventions, misses out on "science" as a cipher for human intellectual progress and the Enlightenment. The fact that the association of science, modernity and the Enlightenment is mythical does not make it less relevant for questions of self-image, cultural prestige and epistemic orientation of the many sciences and technosciences. Even if the myth of science casts only a handful of Galileos, Darwins and Einsteins as great thinkers who upset prejudice and advanced theoretical knowledge, and even if it therefore makes for a highly selective and deeply flawed history of scientific practice, the abandonment of this myth is culturally significant for societies at large and for scientific self-understanding – especially when it comes to defending pure science and basic research, and especially when it comes to assessing the limits of knowledge or the relation between the regimes of truth and power. From the point of view of the age of science, accordingly, hardly anything could be more significant than the demotion of this mythical idea of "science" as a principle that orients the scientific enterprise as a whole (Forman 2007). Looking from the age of science, nothing less than an epochal break is required to settle into the age of technoscience.

It is at this point that technology assessment comes in. If the sciences were pure, TA would not be interested in scientific research at all. In this way, but also as a knowledge producer in its own right, TA is implicated in the age of technoscience. Does this mean, however, that TA is somehow beholden to the technosciences that are at the same time subject to its assessments? One example shall suffice to indicate, at least, what kinds of problems arise for TA from this possibly dangerous proximity: The age of technoscience is emphatically disinterested in disciplinary divisions, limits of theoretical understanding or technical control, or epochal breaks. Instead, it valorises a transdisciplinary convergence, that aims everywhere at a kind of intensification or enhancement of material nature. Alongside speculative schemes for human enhancement there are, therefore, many more or less

ambitious attempts to turn dead and dumb matter into smart material. This makes it difficult to isolate plausible technological trajectories, and this difficulty is aggravated by a general reticence to distinguish between theoretical possibility and technical feasibility – implicitly, at least, everything that does not contradict outright the known laws of nature is taken to be a technical possibility. This opens up an immeasurable vista of candidates for TA where no one quite knows what to believe and what not to believe, and where TA might easily be seduced to validate far-fetched technological schemes.[4]

2. TA in the spirit of technoscience

The very fact that the Collingridge dilemma is considered a dilemma that is in need of a solution shows that TA is not just implicated in the age of technoscience, but actually participates in its spirit of technoscience. The supposed dilemma states that it is always either too early or too late to engage effectively in TA:

> "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 economics 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 1980:11)[5]

As Wolfgang Liebert and Jan Schmidt have shown in their careful analysis of the Collingridge dilemma, the "main criterion for TA would, therefore, be to maintain controllability. TA is successful if, and only if, the dilemma does not emerge" (Liebert/Schmidt 2010a in this volume). Current debates about upstream, midstream or downstream technology assessment and public engagement with technology reflect this need to find the right moment at which technological development might still be subject to social shaping or political control (Wynne 2001, Fisher/Roop/Mitcham 2006).

It is worth noting how strange a thing is being sought here. "The right moment for influencing the development of technology" is a moment in the present, where there is sufficient knowledge of sufficiently remote outcomes such that these can be modulated in a manner that transforms them from mere side effects that occur in the future into intended consequences that are agreed upon today. One might say that this is a dilemma in a rather trivial sense, namely in that it merely reflects, as an inescapable given, how we are limited by the always precarious position from which we experience

[4] For all we know at this point, the technology assessment of nanomedicine serves primarily to add weight to its promises.

[5] The worry behind this dilemma is not new. In a 1963 essay on Husserl's philosophy of technology, Hans Blumenberg noted that in respect to the technological condition, the time when it is not yet possible to raise questions becomes fused with the time in which it is no longer possible to ask questions (Blumenberg 1963).

and pursue technological developments.[6] However, by seeking this strange thing of a right moment and by taking the Collingridge dilemma as an obstacle to be overcome, the attitude is not one of resigned acknowledgment of human contingency, but rather one of seeking an expansion of boundaries. In particular, the project is one of exceeding or outflanking the limited temporal horizon of our sphere of influence. This is an ambition quite in the spirit of the age of technoscience.

Another name for our sphere of influence is simply "the present". And it is fairly obvious that we dispose of occurrences in the present, at best, and that we have no control over events that have occurred already in the past or that will occur in the future. To consider this as a dilemma is tantamount to viewing the present as an obstacle that can and needs to be overcome.

This may sound like a self-evident truth but it countenances a serious objection. According to this objection, it is not really the case that we are locked into a vanishingly small window of time and that there is very little to effect between a past that we cannot influence any longer and a future that we do not have at our disposal yet. The future is not simply what is given to us only at some future time, but is produced by us and, in a sense, grows out of the present. And since it is us who produce the future, we should be permitted to ask when and how we can best get a hold on it – not too late, but just in time, before it is too late and the future becomes transformed into the past.

As before, with the objection to the notion of an epochal break, this objection becomes part of the claim that is being advanced here. It is the very idea of taking hold of the future that characterises the transgressive hubris of the technosciences. The debates about human enhancement and cultural evolution show this with particular clarity. Looking at the history of technology and humanity, it is fair to say that humans alter not only the world, but also themselves. As John Dupre has pointed out, by using technology to alter their physical and cognitive environments, humans create conditions for their further evolutionary development. By having to adapt and constantly re-adapt to a world of their own making and re-making, humans change along with their technologies. But all this is a far cry from the claim that humans can become masters of their own evolutionary history. There remains a categorical difference between creating the conditions in which the future will take place and steering, shaping or controlling what the future will be like. The fact that I will become a different person in a different technological environment does not mean that I can design myself by designing new technologies (cp. Dupre 2008, Nordmann 2007). All this applies straightforwardly to the case at hand: Though we do, in fact, produce the future, the future remains utterly contingent and is not, therefore, something that is made according to our wish or will, and is not a target of socio-technical design.

If this sounds like a provocative statement, this is only because it runs counter to the current spirit of the age of technoscience. Citizens in the age of technoscience are likely to insist that technology and politics have always been engaged in shaping the future. Indeed, they might ask, if one does not

[6] To be sure, as Liebert and Schmidt (2010a) point out, Collingridge himself does not suggest that the dilemma can be avoided by getting hold of the future through knowledge. He envisions a kind of ongoing control that keeps the problem from arising.

believe that it is possible to shape the future, why engage in politics and the development of technologies at all?[7] However, this is by no means evident. One can deliberate political and technological choices without referring to the future at all. *Technological research is dedicated to problem-solving, creates alternatives, develops tools for shaping another, perhaps better world. It improves upon and refines existing technologies, it establishes control of novel phenomena and highly complex situations. Societies successfully learn to deal with problems by trying out something new, observing resulting effects, making adjustments, observing again, and so forth.* These statements express the conviction that politics and technology can change the world – except that they do not appeal at all to what the future might or will hold, and they certainly do not posit it as an object, to be shaped by technology, politics or technology assessment.

The conceit of not just changing but shaping the world and of taking the future as an object of design is implicit in the very decision to consider the Collingridge dilemma a problem awaiting a solution. To the extent that it adopts this perspective, TA, along with various theories of social shaping of technology and society, reveals a technoscientific attitude.[8]

3. TA and other technosciences in their technological milieu

The argument so far can be summarised, paradoxically, as follows: Given that our sphere of influence is limited to the present, it is an impossible dream to control the future development of technology; wanting to do so anyhow is a technoscientific conceit. Obviously, there is something deeply confusing and confused about this picture – how can the technosciences routinely claim to do something that, on the other hand, defies temporal logic? This confusion may rest upon an equivocal use of the word "future". When nanotechnologists or social constructivists speak of shaping the future, perhaps they are not referring to something that lies outside the sphere of human influence, as do the past and the future referred to above. By focusing on this equivocation in the use of "future," we might discover an alternative and more productive way of conceiving the proximity of TA and the technosciences.

Put briefly, the sciences in the age of science had a future in a historical sense of the term, but technology does not – and when the technosciences speak of shaping the future, they are not referring to the future of humanity and society, but rather to the realisation of a potential or the fulfilment of a

[7] This claim is at the heart of a disagreement about appeals to the future in TA of nanotechnology between Dupuy and Grinbaum (2004), Grunwald (2008) and Nordmann (2008). Certainly, such disagreements deserve more attention than the somewhat curt and provocative treatment they receive here.

[8] The analysis so far agrees with Liebert and Schmidt (2010a) in its analysis of the Collingridge dilemma as a problem of control. They argue, however, that Collingridge does not sufficiently appreciate the opportunities afforded under the conditions of technoscientific knowledge production. Their own proposal for avoiding the dilemma takes these conditions into consideration (Liebert/Schmidt 2010a, 2010b). As such, their proposal appears to confirm the present analysis. However, Liebert and Schmidt rely on a distinction between the ambition to control technological development and soft, participative, reflective, and characteristically technoscientific modes of shaping it. Again, a more sustained discussion is required to explore the viability and potential significance of this distinction.

wish, that is, they are talking about a future that is fully contained in the present. And if to posit a potential or to formulate a wish is the same as shaping the future, TA needs to be a forensics of wishing and can thus engage the future without going beyond the present.

Obviously, all this needs to be unpacked, and one way of doing so is to go back to the original meaning of the term "technoscience". The Belgian philosopher Gilbert Hottois coined this term in order to refer to research that is performed in a technological milieu – somewhat along the lines of Peter Galison, when he spoke of an "engineering way of being in science" (Hottois 1984, Galison 2006). The technosciences thus work not only under the expectation of creating technology, but, even more importantly, they arise under technological conditions and proceed in the manner of engineering. Ann Johnson refers to this as "research in a design mode" (in conversation). As such, the technosciences are the producers, but also the products, of the development of science and technology. Since a milieu is a sort of spatial surroundings and environment, what kind of future does one encounter in these technological surroundings?

It may not be obvious, at first, that there are different kinds of futures and that "shaping the future" can therefore involve equivocation.[9] For present purposes, this can be illustrated simply by contrasting the different "futures" of the ages of science and technoscience. The former expresses once again the mythical alliance of science and enlightenment: The search for knowledge is oriented towards a future state of truth, justice and beauty which may well be unattainable but that nevertheless sets the goals for our present efforts to gradually improve ourselves. Accordingly, when a scientific hypothesis is advanced, it is not immediately known to be true or false, but has to be subjected to an indefinitely long process of criticism – though its falsity may become apparent along the way, the final determination of its truth is beyond reach as inquiry continues on into the future. Accordingly, a hypothesis is a claim and a question all at once – it is unsure of what it says in that it needs to be confirmed through a process of inquiry. In contrast, the attainment of physical control or the working of a device is self-vindicating. Whether a current flows from here to there is hardly a question of truth – with the help of a measurement or two, it is immediately evident that this set-up allows a current to flow from here to there. One might come up with better, safer, more efficient machines, but the physical achievement remains self-sufficient.[10]

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[9] However, see Hölscher (1999) for a history of the future, including a concluding chapter that notes the abandonment of the future as a historical category in our current age.

[10] This is leaving aside the fascinating question as to whether there are technical systems so complex that it would require a sustained, perhaps indefinite process of inquiry to determine what some machine does or does not do. Also, materials research might formulate and deliberate hypotheses about specific properties of a device. To be distinguished here are the temporal horizons for the scientific hypothesis "such and such stresses induce material fatigue (and a device of this kind will break after 15 years)" and for the technoscientific claim "the controlled growth of carbon nanotubes can be achieved with this kind of seeding on this kind of substrate." The first of these claims requires past and future history of science to be validated, the second is validated at the moment of its realisation.

Scientific inquiry requires the future as a historical and epistemological category – it is obligated towards the future, it reaches fulfilment in the future, the very generality of its hypotheses anticipates the idea of timeless truth, it seeks to cleanse its findings from the historical contingencies of the present and to universalise them for future use. The future of technology is in the immediacy of its realisation – a working device is a proof of concept and requires for its validation no special knowledge or effort of the imagination. Its potential is stored up in its functionality and is manifested in its operation, just like a wish carries within itself the image of its fulfilment. To the extent that the technosciences, including TA, arise in a technological milieu, they refer to the future as the realisation of given technological potential – and this is usually the extent of what they say about human destiny.[11] This is exemplified with particular clarity in public, but also ethical, discourse about nanotechnologies. The so-called "future" of nanotechnology is nothing more than a nanocosm full of technological possibilities waiting to be realised. Most of these possibilities are seen as ciphers of what is to come and, as such, as a technological destiny. Some of these possibilities are correlated with current problems to which they might offer a green solution, for example. Hardly any of these possibilities are associated with ideas of a better kind of technology or as tools for human betterment.[12] For the technosciences, therefore, but also for TA, the future is not something that comes towards us or that emanates from us, but is rather an intensification or amplification of the present, in the sense that wishes are conjured up and their fulfilment promised. Moreover, even though in most cases it takes time for a wish to be fulfilled, the fulfilment does not lie in the future as much as it lies in the wish. The wishes themselves are not just the products of technological development, but also its drivers. To the extent that they inform technological development, they are suitable subjects for TA – they hold the image of a technologically conceived future that is fully contained in the present. Without wondering what will be in 5, 10 or 15 years, a forensics of wishing moves TA upstream to the cultural imaginaries and stereotypes that define research agendas and shape ideas of technical solutions to societal problems. This is a kind of "vision assessment" (Grin/Grunwald 2000) that focuses not only on the roadmaps that lead from the wish to its fulfilment, but at least as much on the idea of fulfilment that is contained in the wish. This vision assessment can be limited to something that is amenable to assessment now without estimates of probability and credibility.[13]

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[11] This is a strong claim, to be sure, that requires a cultural history of the present. For an extremely modest beginning, see Nordmann/Schwarz (2010).

[12] Again, here is a distinction that demands closer attention – while everyone talks about acceptance or rejection of human enhancement technologies, there is no teleological or regulative discourse about the role of technology in the process of enlightenment, including intellectual and moral improvement (with the exception, perhaps, of Khushf 2007). Indeed, such a discourse would appear rather quaint in a technological milieu or the age of technoscience.

[13] Though the following focuses on the forensics of wishing, quite literally, this is not the only approach that avoids reference to the future. Any assessment that evaluates technological alternatives can do this.

Forensics is a technoscience that usually presupposes the scene of a crime, if not a corpse lying ready for dissection. This gives rise not so much to a dilemma, but rather to a new set of questions. Instead of asking, along with Collingridge, "when can we get hold of the future such that it is neither too early nor too late for meaningful TA?" the new question becomes "what are the best sites for a forensics of wishing?" This is not the place to consider the various sites that recommend themselves – which range from imaginaries in popular culture to the multi-stakeholder technology platforms at the European Commission. Here, just one prominent site will be mentioned, namely technoscientific research practice as studied by philosophers, historians and sociologists of science.

What will a forensic science find by way of technological wish-fulfilment when it turns to technoscientific research laboratories? To be sure, it will sift through the texts that are produced by technoscientists and find in them an abundance of promises and expectations, and a good deal of confidence about what one will be able to do given sufficient money and time. These promises may be the researchers' own, or they may be the way in which societal expectations are mirrored in the laboratory. Aside from finding texts, this forensics will come upon a group of so-called advanced users of technology. Technoscientists use simulation modelling, for example, to learn the control of complex phenomena in a substitute system. They rehearse patterns of interaction with new technologies by trying out, for example, how much or how little one needs to know to attain secure grasp of a physical process.

This kind of TA, as a forensic technoscience, is no longer in danger of becoming absorbed into the spirit of technoscience by assimilating the technoscientific hubris of "shaping the future". Instead, it takes as its starting point the age of technoscience with its impoverished conception of the future as the mere realisation of technical possibilities. By assessing this conception with its logic of wish-fulfilment it becomes a critical observer rather than implicit promoter of technoscientific hubris.

References

Bensaude-Vincent B (2009) Les Vestiges de la Technoscience. Éditions la Découverte, Paris

Blumenberg H (1963) Lebenswelt und Technisierung unter Aspekten der Phänomenologie. In: Blumenberg H, Wirklichkeiten in denen wir leben. Reclam, Stuttgart, pp 7–54

Collingridge D (1980) The Social Control of Technology. St. Martin, New York

Dupre J (2008) What is a Human Being. In: Ganten D, Gerhardt V, Ingersoll J-CH, Nida-Rümelin J (eds) Was ist der Mensch. De Gruyter: Berlin

Dupuy J-P, Grinbaum A (2004) Living with Uncertainty: Toward the ongoing Normative Assessment of Nanotechnology. Techné 8:4–25

Fisher E, Mahajan Roop L, Mitcham C (2006) Midstream Modulation of Technology: Governance From Within. Bulletin of Science, Technology & Society 26(6):485–496

Forman P (2007) The primacy of science in modernity, of technology in postmodernity, and of ideology in the history of technology. History and Technology 23:1–152

Galison P (2006) The Pyramid and the Ring. Presentation at the conference of the Gesellschaft für Analytische Philosophie (GAP), Berlin

Grin J, Grunwald A (eds) (2000) Vision Assessment: Shaping Technology in 21st Century Society. Springer, Heidelberg

Grunwald A (2006) Nanotechnologie als Chiffre der Zukunft. In: Nordmann A, Schummer J, Schwarz A (eds) Nanotechnologien im Kontext: Philosophische,ethische, gesellschaftliche Perspektiven, Akademische Verlagsgesellschaft, Berlin, pp 49–80

Hacking I (1983) Representing and Intervening.Cambridge University Press, Cambridge/UK

Hölscher L (1999) Die Entdeckung der Zukunft. Fischer, Frankfurt/M

Hottois G (1984) Le Signe et la Technique: La Philosopie à l'épreuve de la technique. Aubier, Paris

Khushf G (2004) Systems Theory and the Ethics of Human Enhancement: A Framework for NBIC Convergence. Annals of the New York Academy of Sciences 1013:124–149

Latour B (1987) Science in Action. Harvard University Press, Cambridge/MA

Latour B (1993) We Have Never Been Modern. Harvard University Press, Cambridge/MA

Liebert W, Schmidt J (2010a) Collingridge's Dilemma and Technoscience: An Attempt to Provide a Clarification from the Perspective of Philosophy of Science. Poiesis & Praxis 7, this issue

Liebert W, Schmidt J (2010b) Towards a Prospective Technology Assessment: Challenges and Requirements for TA in the Age of Technoscience. Poiesis & Praxis 7, this issue

Nordmann A (2007) If and Then: A Critique of Speculative NanoEthics. NanoEthics 1(1):31–46

Nordmann A (2008) No Future for Nanotechnology? Historical Development vs. Global Expansion. In: Jotterand F (ed) Emerging Conceptual, Ethical and Policy Issues in Bionanotechnology. Springer, Dordrecht, pp 43–63

Nordmann A (forthcoming) Science in the Context of Technology. In: Carrier M, Nordmann A (eds) Science in the Context of Application. Springer, Berlin

Nordmann A, Schwarz A (2010) Lure of the 'Yes': The Seductive Power of Technoscience. In: Kaiser M, Kurath M, Maasen S, Rehmann-Sutter C (eds) Governing Future Technologies: Nanotechnology and the Rise of an Assessment Regime. Springer, Dordrecht, pp 255–277

Stokes D (1997) Pasteur's Quadrant - Basic Science and Technological Innovation. Brookings Institution Press, Washington

Weber M (1946) Science as a Vocation. In: Gerth HH, Wright Mills C (eds) From Max Weber: Essays in Sociology. Oxford University Press, New York, pp 129–156

Wynne B (2001) Creating public alienation: expert cultures of risk and ethics on GMOs. Science as Culture 10(4):445–481