Discussion Paper:

Responsible innovation, the art and craft of anticipation

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Evidently, good governance seeks to anticipate what may happen in order to be prepared, especially if and when things go wrong. And evidently, everyone is talking nowadays about emerging technologies and what will or might come about if their ambitious agenda succeeds. It would seem obvious, then, to put two and two together and formulate the demand that responsible innovation involves anticipatory governance, that is, a kind of preparedness that is based on knowledge of what may come in the future from the further development of these emerging technologies (Barben *et al.* 2008, Guston 2010, Karinen and Guston 2010).

The following 15 remarks on the art of anticipation will not question that it is always good to be prepared. They will question, however, whether responsible innovation or anticipatory governance requires knowledge – no matter how tentative or qualified – of what might be the case in the future. Technology assessment (TA) used to be post-hoc and merely reactive. In the past decades, there has been a general move towards real-time TA, including constructive TA or vision assessment (Guston and Sarewitz 2002, Schot and Rip 1996, Grin *et al.* 2000). Can we do better than this? Should we be trying to do better than this? Having caught up with the speed of technological development, is it now necessary to get ahead of ourselves, developing not just scenarios of technological alternatives but technomoral scenarios of the future (Swierstra and Rip 2007, Boenink *et al.* 2010, Swierstra 2013), engaging in prospective TA (Liebert and Schmidt 2010), and anticipating possible futures of technological development?[1]

One can be prepared for the future without seeking to know what the future will be like. In fact, trying too hard to imagine possible or plausible futures may diminish our ability to see what's happening.[2] Fracking is the most recent case in point here. The idea is not new and yet it crept up, stealthily, on policy makers and technology assessors who were fixated on the notion that the energy mix of the future will be determined by the latest scientific and technological developments and what they might bring. If it wasn't anticipated, it is because the powers of anticipation were geared to the future and missed what was right before their eyes.

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[1] I am reminded of a joke by comedian Steven Wright – that we might be able to go back in time by making instant coffee in a microwave. Are we putting real-time, constructive TA into the pressure cooker of a technovisionary discourse, conjuring the presence of the future as the only means to avert catastrophe?

[2] In the meantime, ideas and programs for the future are all on the table, published in roadmaps and reports, evoked in grant proposals and science writing – they are plainly visible and ready to be assessed for their desirability and their assumptions of breakthroughs that are yet to happen. We can form sound opinions of these ideas and programs irrespective of judgments of plausibility and probability, and without needing to imagine what they will or will not bring about.

Anticipation I: Preparing for the unexpected in the world as we know it

1. It is often said, that of course we cannot predict the future, but that we still need to learn to anticipate it and therefore to acquire a kind of knowledge that is short of prediction but still provides a sense of reasonable possibility or plausibility (Nordmann forthcoming). There is a problematic assumption in this call for a kind of knowledge that is only somewhat weaker than prediction. This is the assumption that the art of anticipation requires knowledge of the future, and that anticipation gets better the more we know about the future. But this linkage is far from obvious. Several years ago it was reported that physics students were asked to run across a basketball court carrying a ball and letting go of it so that it would bounce upon a designated spot. These students knew about inertia but many dropped the ball, literally and figuratively, just above the spot. Since the ball obeyed the law of inertia and continued forward in the direction of the runner, it would miss the mark. These students knew how to predict the motion of the ball, but they proved bad at anticipating the moment when to let go.

2. Even perfect knowledge of what will happen is not sufficient for the ability to anticipate, but is not some knowledge of what will happen necessary? In the case of the physics students, if they were only able to properly take into account what they know, they should be able to anticipate perfectly the right moment for letting go. This is because they live in an unchanging world as regards the laws of physics on our planet. What they know is the world as they know it, the world in which the law of inertia holds forever. Their knowledge is already attuned to this world, and it is only a matter of training to also attune their bodies and their knack for dropping the ball.[3] These attunements can work together, mutually inform each other, but they need not. Basketball players will deem the law of inertia hardly necessary for getting their job done, and at best a bit of a detour.

3. It is hard to maneuver even the world as we know. It is too complex and full of surprises. Accidents can happen. Accordingly, people in many professions study the solid principles of their trade and at the same train themselves to anticipate unexpected events. Firefighters train for the event of an airplane crashing into a nuclear power plant, pilots simulate engine failure in the midst of a thunderstorm, student drivers with learning permits are taught to anticipate balls rolling into the street and kids running behind them. Banks and stock markets might crash, the best of science might fail to produce industrial innovations, a new product can take the market by storm, someone somewhere will clone a sheep or a human being. These things can happen and we prove better or worse at responding to them and in this sense, to anticipate them. We tend to be better at this when we don't take anything for granted and aren't easily surprised, when we have adaptive institutions, and are resourceful and quick at social learning.

[3] On certain conceptions of "working knowledge" (Baird 2004, *cf.* also Polanyi 1958 and 1966, Collins 2010 and Nordmann 2013), the attunement of the body is also a kind of, albeit unarticulated knowledge. In contrast, anticipatory governance and its critique in this paper refer on the one hand to explicit or propositional knowledge of regularities in the presently given world and on the other hand to the demand for explicit of propositional knowledge of what might be in the future.

4. When we consider the firefighters, the pilots, the student drivers, the policy makers who train themselves to anticipate unexpected events, are they in any way engaged in anticipating the future? They do so only in the most trivial sense and no more so than the student of physics. They are seeking to be prepared for a moment in time that has not occurred as yet – the plane hasn't crashed, the engine hasn't failed, no kid has run out into the street in front of the car. All these events might yet happen and in this sense are in the future – just like that moment in time when the ball released by the physics student hits the ground.[4] However, we know that these events might happen because versions of these events have happened before. What we are preparing for and learning to anticipate are the accidents that can happen in the world as we know it, and thus features of the currently given, present world. In this trivial sense, physicists with their accurate and lawful predictions are also anticipating the future.

5. The physicists know the future trivially and without needing to concern themselves with the future *qua* future. Their future is only incidentally in the future. Indeed, and as a matter of course it could also be a past future, that is, an effect that was a future event in relation to a cause that happened even earlier. This is because the present world as the physicists know it and the world that we inhabit now is extended not only in space but also in time. This holds regardless of any special era or future world that might be coming and regardless of the many predictable and unpredictable ways in which life on earth is changing all the time. It is with respect to this given and known world and its extension in space and time that one can speak of the future in a trivial sense. In this sense, the future is any point in time t+1 or t+n or some "next moment" in the world as we know it. Take the question, of whether I will I bebe going to work tomorrow. Well, yes. Even though I cannot know this for sure – an accident might happen between now and then – my answer to the question is not a statement about the future but about the daily grind. And can an airplane crash into a nuclear reactor? Yes, likewise, and we better be prepared for this.

Anticipation II: Getting ahead of ourselves

6. In order to be prepared for the unexpected, it is difficult but necessary to make judgments of what can plausibly happen in the world as we know it (Nordmann forthcoming). These judgments are informed by experience, by precedent, by history. Accordingly, historians of science, technology, and science policy have a lot to contribute to questions of responsible innovation and the assessment of emerging technologies. What can we learn about the feasibility of "targeted drug delivery" from the history of "rational drug design"? And what can we learn about unsuspected technological developments from the history of the laser or giant magnetoresistance? And what is the track-record of the Delphi method, of roadmapping exercises, and other forms of seemingly controlled speculation? Historians can tell us that things never turn out the way they were meant to be. More so than any consideration of possible futures, their simple and sobering reminders of historical contingency might just be the best grounding for anticipatory governance, that is, for the

[4] Here the art of anticipation corresponds to the Greek notion of *kairos*, that is, the implicit knowledge of or feeling for the right moment when it is proper to act. This knowledge is acquired through attunement to or participation in ongoing dynamic processes and behavioral patterns.

development of institutions and mind-sets that can handle contingency, that can expect the unexpected and do not fall for false promises or the illusion of intellectual and technical control.

7. Apparently, however, this generalized sense of preparedness is not enough and more is demanded from the assessment of emerging technologies. Publics and policy makers would like to know what these technologies will bring. At the present time, particular technological applications are not clearly in sight. But since emerging technologies come with the promise of transforming how things have been done thus far, we would like to know about their transformative impacts. Clearly, responsible innovation would benefit if innovation processes could be steered to either bring about or prevent what is suggested by the various socio-technical, technomoral, or governance scenarios of the future.

8. Significantly, the technologies with their transformative impacts here appear as markers of the future in a non-trivial sense. As in science fiction literature, they are introduced as a "novum," "game changer," or even a "black swan event" that separates an era of new technological possibility from the world as we know it (Gammel 2009, Suvin 1979, Taleb 2007). This imagined future is a different world, inhabited not only by different technologies but inhabited by different people, too: By the time the envisioned new technologies have insinuated themselves into the fabric of society, this will be a society of new people in that they will have integrated these new technologies with their system of values. If we now wanted to anticipate the presumed impacts of the new technologies, we would need to take into account the various ways in which this non-trivial future constitutes a world that is profoundly different from the only one we know.
   To be sure, this special demand for knowledge vanishes once we change the wording in this paragraph ever so slightly, and once instead of "this imagined future is a different world" we would simply say "a different world is imagined here." When a different world is imagined as a possible alternative to our presently given world, it can be assessed for its desirability without being an object of anticipation. The power of anticipation is trained to things that might happen, and thus the idea of anticipating future impacts of emerging technologies arises only when one supposes that current research programs and technological visions contain within themselves what might happen. And if programs and visions are an omen of what is to come, they are taken to be much more than proposals for other ways of doing things and are treated instead as half-formed futures waiting to be realized. It is these postulated, half-formed, non-trivial futures that are the object of anticipation and that can easily be excluded from TA of emerging technologies. Moreover, when we imagine a world that is different from ours without being also an imagined future world, we avoid the encumbrance of imagining the outcome of a historical process that would have changed people, too. Like the utopias and dystopias of old, sketches of alternatives world present themselves in travel narratives. They are made to be beheld and judged not by future generations but by people like us who, akin to tourists, encounter another way of living, consider its pro and cons, and might end up trying to integrate it with their world at home – fully anticipating(!) that any negotiated process of integration will introduce many distortions to the original plan. Far from being "future scenarios" or "scenarios of possible futures," envisioned alternative worlds prove useful and credible as proposals that can indicate a general direction of change.

9. The aspiration to anticipate the future proves difficult to comprehend as soon as it involves a non-trival sense of "future" – which it does just as soon as one talks about a different era that will be ushered in by new technological capabilities.[5] In more ways than one, any non-trivial future is inaccessible to socio-technological shaping, predictive control or anticipatory evaluation. One reason for this has been hinted at. The inhabitants of this non-trivially future world will be different from us in the relevant respect of having integrated the presumed novel technologies into their fabric of life. Obviously, they will judge them differently from within the context of use than we do out of concern for the preservation of values that are dear to us. Since we cannot deny that people change in the course of history and through the uptake of new technologies, we are adopting in effect a paternalistic attitude towards the inhabitants of the future world when we judge their technologies from our point of view. This is hardly defensible, and we need to acknowledge our inability to imagine ourselves as having become different people with different experiences and different values. If this line of reasoning suggests that it is incoherent to take a non-trivial future as an object of anticipation, other arguments against doing so are more normative. For example, to take the future as an object of anticipation fosters the problematic, perhaps dangerous illusion that a historical or evolutionary process – the somewhat haphazard product of intentions, contingencies, and politics – might be subject to intellectual or even technical control.[6]

10. If the aspiration to anticipate the future proves incoherent and deeply problematic in more ways than one, it does not imply that we have to limit our thinking, planning, and hoping to the present and to acquiesce in the one and only given and known world.[7] It was already pointed out that we can and should conceive of alternative worlds (*e.g.*, utopias or socio-technical scenarios or a variety of R&D trajectories). Moreover, "the future" can remain a powerful political referent and engine of change if the future is not considered an object of anticipation, management, or design.

    As for the first of these points, nothing in what has been said so far should discourage us from engaging in more or less elaborate thought-experiments.[8] Imagined alternative worlds

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[5] I have shown this for judgments regarding the plausibility of possible scenarios in Nordmann (forthcoming). There I distinguish the pretty difficult ordinary case of knowing what can plausibly happen in any given known or imagined world from the impossibly difficult case of plausibility^2, or plausibility squared, which involves judging what might plausibly be the case in a future world which in itself is only more or less plausible.

[6] I have shown how TA for the sake of responsible research and innovation fosters this illusion when it considers the so-called Collingridge Dilemma a problem in need of solution. By suggesting that TA can determine the right moment for effective and consequential intervention in a technological development – neither too early and before impacts are discernible, nor too late when the process is already irreversible – reveals technoscientific hubris, namely the attitude of seeking to control historical processes (Nordmann 2010, see note 4 above). Arguably, TA thereby surrenders critical distance towards other technoscientific pursuits. In particular, it loses credibility when it comes to assessing the characteristic mind-set of taking the future as an object of design.

[7] Guston suggests as much when he fears that the "ethical ostrich that hides from the future to focus on the present may well contribute to the perpetuation of present injustices" (2013, 115).

[8] In her critique of the critique of speculative ethics, Rebecca Roache takes thought experiments to be a form of speculative ethics. However, although they are inventive and, in a sense, stimulate the speculative mind,

that do not carry the burden of having to serve as possible futures can be judged without incurring the charge of paternalism (see the second paragraph of remark 8 above). In a thought experiment we are only judging, after all, whether we deem some imagined socio-technical scenario good and proper for the likes of us. We thereby maintain a greater degree of attitudinal freedom towards scenarios of societies that we can now judge to be better or worse off than we are in our present condition. After all, to attach the epithet "(possible) future" to a scenario narrows the space of alternatives and amounts to privileging it. We can only adopt the reactive attitude of expecting it, perhaps trying to prevent its coming or preparing for its arrival. Arguably, then, scenario thinking is less encumbered and becomes more versatile, creative, and powerful if the scenarios are considered proposals for alternative socio-technical arrangements rather than possible or likely images of the future.

As for the second point, it benefits the deliberation of research and development if "the future" is not restricted merely to what can or might be. In much political thought but also in technological visions of progress, the future does not influence the present in virtue of being half-formed or only needing to be manifested by emerging technologies. Instead, the future influences the present by providing a standard or measure of progress. We act now for the sake of the future and do so not because the future is already given as an object of design but because the future represents regulative ideas of a better world in which welfare and justice might be achieved. In the present, we do not so much expect the future but are obligated toward it (*cf.* Hölscher 1999, Groves 2013).

It would appear, superficially, that to refrain from anticipating the future restricts our thinking and planning conservatively to the present. As it turns out, it is quite the other way round: Normative conceptions of a better world can orient evaluative discourse in a direction of change only if the future is not treated as an object of anticipation and not conceived as what will or might come to be. Only then scenario thinking becomes liberated and can serve a thought experimental heuristic, allowing it to break the mold of preparing us for what is presumably already in the making and half-destined to be, and allowing us instead to envision a better world and thus to judge scenarios for their desirability, unencumbered by insinuations of inevitability.[9]

Anticipation III: The politics of the future

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thought experiments are cognizant of the counter-factual, merely "what if" and subjunctive character of their premises. The critique of speculative ethics concerns those forms of reason that blur boundaries by engaging futuristic "what if" considerations so as to prepare ourselves for their possible impacts (Nordmann 2007, Roache 2008).

[9] Indeed, the charge might be reversed and an accusation of complicity with prevailing ideology launched against those who transform TA or Science and Technology Studies (STS) into a technological project of engineering a robust fit between emerging technologies and societal benefit. Here it is not the intention to ensure societal benefit that is problematic (indeed, this intention may well produce important corrections to established assumptions and arrangements). Problematic instead is fostering the illusion that this kind of engineering can be done in the first place. This illusion solidifies the prevailing notion that technological and social change will originate in advances in technoscientific research and that a specific STS or TA expertise is required to prepare societies for the changes to come.

11. The recommendation so far is to distinguish between anticipating what can happen in the world as we know it and anticipating the future. This distinction revolves around a trivial conception of the future as a next moment in the temporally extended known world and two non-trivial conceptions of the future: If we consider the future non-trivially as a markedly different world from ours, this alternative world might be confusedly conceived as an object of anticipation and design, that is, as the world that will or might come to be, depending on whether we do the right or wrong things now. By rejecting this confused conception, we restore in its proper place the future as a markedly different world that serves as the measure or *telos* of the currently known world, embodying a conception of the good life that orients our actions today without any hint at a distinct or indistinct causal pathway that can lead from here to there, from now to then.

    For the purposes of their critique of consequentialism and of a prudential approach to the ethics of nanotechnology, Jean-Pierre Dupuy and Alexei Grinbaum offered a related distinction between occurring and projected time (Dupuy and Grinbaum 2004). Since occurring time consists of a seemingly continuous succession of temporal states it seductively invites us to extrapolate even beyond the trends and tendencies of the currently known world. This notion of occurring time leads us to confusedly equate a future marked by genuine technological novelty with one that arises seamlessly from current tendencies and trends. However, once the notion of occurring time is restricted to the temporally extended, currently known world, we can behold the projected image of an absolutely desired or absolutely detestable future – a projected world that enjoins us to realize or to avoid it but that is not an object of extrapolation or prediction, anticipation or design, intellectual or technical control.

    When we contemplate our present and past, we will deny radical discontinuity and invoke occurring time to declare, confidently, that the future will be the result of our present actions just like the present is a product of our past. And , indeed, the future will be the result of prior actions and events . But when we contemplate the ways in which the present was produced by the past, we are quickly reminded that what is of our own making is not therefore of our on design or even a possible object of anticipation or design.[10]

12. So, for example, information about continually rising sea-levels is information about occurring time and an extrapolated sequence of temporal states in the world as we know it.[11] Rising sea-levels are a feature of our world and our difficulties in sustaining it. There is

[10] From arguments about the haphazard ways of evolution and our desire, perhaps, to finally take human evolution in our own hands, we are familiar with related claims: In the past we made the future in haphazard and inadvertent ways but we should aspire to transform our *de facto* ways of making a new world into a systematic and deliberate pursuit and this pursuit must take the future as an object of design. This is *par excellence* technological hubris and – just like taking evolution into our own hands – one of the things that are much more easily said than done.

[11] That ocean levels will have risen by so many meters in the year 2025 is a statement about the future only in the trivial sense of future. In this statement what we say about the year 2025 is merely a temporal extension of the world as we know it now (and it therefore requires no knowledge other than what we already have about current tendencies and trends). If we say, however, that climate change will have become catastrophic by 2025, we are talking about the future in a non-trivial way, namely about a new era of human history and, by the same token, about a future that cannot be known, anticipated, or designed. The same would hold if we

nothing trivial about the need to address this problem, even if it involves a trivial conception of the future as what will be should present trends continue. And because rising sea-levels are a feature of our world, it requires no anticipation of the future to make this determination and to take action that is motivated by care and concern for the preservation and of the given world. Moreover, we do not seek to anticipate the governance challenges of the profoundly different world that might lie beyond the climate crisis in a non-trivial future. This profoundly different world would be defined by presently inaccessible features only of the future and not of the current world, for example, some geoengineering measure that saved human civilization at the last minute, or some institutional arrangements that emerged from the surrender of coastal areas and a move into the mountains. In other words, we address global warming in order to sustain the world that supports our present conditions of life, and without trying to second-guess, anticipate, shape, design, influence, grant or withhold some future world.[12]

13. Following upon an example of how we anticipate extrapolated events in the world as we know it, here is a contrasting example that appeals to the transformative powers of emerging technologies. Since we seem to be making progress in the neurosciences, becoming better able at localizing, visualizing, and tracking thought processes, we might have to anticipate the challenges to privacy protection that arise from the technological capability of reading minds. However, even if contemporary research programs and visionary talk invoke this possibility, this capability is decidedly not a feature of our world. Since it is premised on a whole range of scientific and technological breakthroughs, it is not in-the-making or already emerging either. The demand to anticipate its implications for privacy thus confronts us with an incoherent task since the anticipation of impacts requires the acquisition of knowledge that is not available, in principle, and especially knowledge about the development of society and humanity between now and the establishment of this new and different world.[13]

14. Though the difference between the two examples should be clear enough in light of the foregoing discussion, it is obscured by the metaphor of "emerging technologies" which suggests that the emergence even of radically new technological capabilities can be likened to a rising tide – it will just go on and on, and at some point the dams to a new world with new capabilities, opportunities, and risks will simply break. And yet, if only for the distinction

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were talking about 2025 as a time in which people's lives will have been altered by climate engineering technologies.

[12] This point can be developed further by considering the discussion of climate engineering options. The one that extrapolates the best (solar radiation management through the introduction of aerosols in the atmosphere) is the one that is most familiar in terms of precedents from volcanic eruptions and the like. Even for this option, however, we consider it primarily in terms of sustainability (*e.g.*, "if we ever start relying on this measure, we will have to maintain it forever") and not by developing socio-technical scenarios or by reflecting societal implications in a future society that needs to constantly maintain proper concentrations of aerosol.

[13] Again, to be sure, we can address and evaluate the contemporary research programs and visionary talk that invoke this possibility, *e.g.*, by treating them as more or less desirable depictions of an imagined alternative world.

between trivial and non-trivial future and for the different knowledge requirements in respect to both, the two examples cannot be assimilated to each other. Accordingly, the idea has to be rejected that a non-trivial future is part of a rising tide, that its profound novelty will emerge from ongoing technological trends, and that it is therefore simultaneously part of our world and of a substantially different future world. Intellectual honesty demands an acknowledgment of an incoherent task, especially where the task can be transformed into quite a manageable one that does without anticipations of the future.[14]

History – and the history of technology, in particular – offers another reason for rejecting the idea that a non-trivial future is already in the present, like a seed perhaps that only needs to germinate. History firstly requires us to refrain from the technological determinism that is inherent in the image of the rising tide or of the seed and what it harbors. Such imagery renders the inhabitants of the present world mere recipients of what is to come, allowing them only to prepare for the future, at best to modulate the course of events. Historical sensitivity also allows us to engage in a hermeneutics of envisioned futures, that is, an interpretation and critique of envisioned alternative worlds as they appear in the writing of promoters and critics of current technological research. Such a hermeneutics of envisioned futures is recommended by Armin Grunwald for what it tells us about our currently given world, without assuming that it can tell us anything about a future world (Grunwald 2013).

This sensitivity to the contingencies of history and to human dreams of technological mastery prepares the ground for a third reason to reject the idea that the future world is already in-the-making and emerges along with emerging technologies. This third reason is political or ethical and concerns the achievement of a "free" relation to the future and to technologies now and of the future. If we think of the future as something to be anticipated, expected, prepared or braced for, and, at best, modulated as it comes upon us, we postulate ourselves as fundamentally unfree in respect to the future. If, in contrast, we engage in utopian thinking and freely envision a future world that accords to our values and needs, this projected future would not be an object of anticipation – in spite of everything we might do to bring it about, it is nowhere to be seen in occurring time with its sequence of temporal states that begins in the world as we know it.[15]

15. It is a sign of our times (and probably not just of ours) that in the popular imagination – in radio and television features, in white papers and ethics committees, in science museums and research proposals – there is a sense of imminence. Brain-machine interfaces, targeted drug delivery, emission-free power plants, solar-powered airplanes, quantum computers, and artificial photosynthesis are thought to be on the horizon, well within the realm of

[14] Intellectual honesty also demands that STS and TA maintain a critical stance and not adopt the credulous attitude of equating what is *said* about the long-term transformative implications of emerging technologies research with what the future *may or will be*. To accept this equation is to valorize the technoscientific economy of promises (Felt *et al.* 2007).

[15] Here, then, is an occasion for a debate worth having. Informed by the same political values, Guston (2013) argued against the prohibition of speculative thinking. In attempts to anticipate the future, do we exercise our freedom (Guston) or do we ratify that we are beholden to technology and to what will or might be (Nordmann)?

technological possibility, only waiting to be realized. However, all these things are part of our world only in the form of hopes, dreams, prophecies, programs, and promises. For the reasons suggested above, we would be ill-advised to anticipate the future in which these dreams are finally realized technologically, including the devices to show for and the socio-technical life-world in which they will be integrated. We thus have all the more reason, then, to engage these futures as they are present in our world, namely, in the form of hopes and wishes for technological deliverances, in the form of anxiety and expectations of what technologies might bring, in the form of ideas of the good life, and of the problems we face and the solutions that would satisfy us. When the promoters of a technological vision conjure what they consider a highly desirable future, we can ask whether we do, indeed, find it desirable – independently of whether we believe in its possibility or plausibility.[16] For the sake of responsible research and innovation, we can also ask about "responsible representation," how we should talk and think about emerging technologies in the first place, and whether it is responsible to assume that fundamental scientific breakthroughs will happen soon enough to assure sustainable development.

Conclusion: Real-time responsible innovation and anticipatory governance

The critique of speculative ethics is said to defy common sense, as are injunctions against technomoral or socio-technical scenarios of the future, management solutions to the Collingridge dilemma, or proactionary principles (Fuller 2013). Doesn't everyone have to be concerned about the future? Yes, of course, that's why we create an image of a better world that obligates us towards taking care of the world as we know it. This obligation does not require that we know or assume anything about what kind of breakthroughs or novelties the future will or might hold and what their impacts would be (though we do need to understand the perhaps unsustainable trends and trajectories that are already part of our temporally extended world). And whatever we do, don't we need to "consider the consequences" of our actions or of the technological trajectories that we have embarked upon (Pitt 2011, 37)?

Clearly, responsible research and innovation is mindful of the fact that actions and events have consequences for which we are responsible. And clearly, anticipatory governance can be responsible only by way of its cognizance, modulation, mitigation or management of these consequences as they become discernible.Ethical considerations of the nature and scope of human responsibility should and, indeed, do not burden "responsible innovation" and "anticipatory governance" with requirements that cannot be met, *i.e.*, the requirement of being able to anticipate the future or to make discernible what cannot be seen.

In the case of Kantian or so-called deontological ethics, to consider the consequences amounts to a consideration of duties or obligations – accordingly, its scope is restricted to intended consequences and is emphatically indifferent to the actual consequences, more or less remote: One cannot assign credit or blame for positive or negative consequences that just came about and for which one cannot

[16] The hermeneutics of possible futures (see the previous section) can prepare the ground for such assessments or debates.

be held accountable.[17] So-called consequentialist or utilitarian ethics goes beyond intended to anticipated consequences in order to weigh the likely costs and benefits of some action, but only those consequences that are familiar in our known world can be anticipated and assessed for their likelihood. While including an appropriately broad range of consequences requires experience and imagination, such imagination is informed primarily by historical knowledge of how things have not been turning out as planned. Most significant, finally, for anticipatory governance and responsible innovation, is the Aristotelian or virtue ethical approach that refers "consider the consequence" to a precautionary attitude and approach that proceeds in real-time, mindful of the need to hope for the best, brace for the worst, and in the meantime to monitor and track the consequences of our decisions or actions. Such a virtue-ethical approach begins with responsible representation, that is, the demand to reflect honestly and appropriately about who we are, what we want, and what we can do – especially when we create images of the future and make claims of shaping or controlling it.

In other words, the three major interpretations of "consider the consequences" agree that it is not necessary or even desirable to try the impossible, namely to anticipate a non-trivial future.[18] It is unnecessary for assessing the programs of emerging technologies, or for acting in a responsible, reflective, future-oriented way. If the desire to anticipate the future turns out to be a confused wish and if responsible innovation is nevertheless thought to require it, then "responsible innovation and anticipatory governance" is also confused in what it wants to achieve. This critique of a popular notion is not surprising. To the extent that "responsible research and innovation" is primarily an actors' term and to the extent that there is constant public demand for "societal implications research," their implicit preconceptions require conceptual and historical analysis.

The critique of anticipations of the future need not be fatal at all, however, to "responsible research" and "anticipatory governance" as normative concepts or categories of analysis and interpretation. On the contrary, the foregoing critique is quite in line with various forms of real-time TA, such as the

[17] This consideration reflects a rather deep general point about human action and how it relates to the future, one that accords well with the notions suggested above: Even for a single, isolated, short-term, ordinary human action it holds that it intends to bring about some future state, that is, to transform a present to a specific future state. As such, simple actions like throwing a switch are oriented towards an image of the future. Epistemically, however, we do not and cannot claim that we can actually control, let alone contain the pathway from the present to the future. Likewise, we cannot claim for our actions that we can anticipate their consequences and know whether the actual consequences of our action are in rather close or rather tenuous agreement with the intended consequences. This lack of knowledge is due not only to the ways in which the realization of intentions can be disrupted but also to the whole range of unintended side-effects and long-term consequences that can undermine our intentions.

[18] To be sure, this judgment blatantly disregards a future-oriented version of consequentialism that misguidedly sets out to include possible or plausible societal impacts of future technologies that, if realized, would profoundly set apart the world of future impacts from our currently known world. Arguably, this conception of consequentialism is a symptom or artifact, itself a consequence of the conceptual confusion that was exposed in these pages. The production of this illusion and its fostering by way of STS, ELSA, or TA deserves a historical or ideological critique of its own. The impossible desire to anticipate the future and to make non-existent technologies subject to consequentialist considerations of their impact can be viewed as a telling symptom of a larger ill, namely the exaggerated last hope of Western civilization as it desperately wagers on emerging technologies to offer a way out of an unsustainable condition.

hermeneutics of possible futures or social learning from real-world experiments (Krohn and Weyer 1994, Schwarz forthcoming, van den Poel 2009). And as we have seen, one can make sense of anticipatory governance and the art of anticipation as a precautionary approach that promotes a regime of vigilance, that is informed by historical experience, and that requires imagination for what might happen in the world as we know it – without anticipating impacts or requiring knowledge of what the future might hold.

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