Responsible Innovation: Bringing together Technology Assessment, Applied Ethics, and STS research

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Abstract

The ideas of 'responsible development' in the scientific-technological advance and of 'responsible innovation' in the field of new products, services and systems have been discussed for some years now with increasing intensity (Siune et al. 2009) and led to the phrase of 'Responsible Research and Innovation' (RRI).[2] The postulate of responsible innovation adds explicit ethical reflection to Technology Assessment (TA) and science, technology and society (STS) studies and includes all of them into integrative approaches to shaping technology and innovation. Responsible innovation brings together TA with its experiences on assessment procedures, actor involvement, foresight and evaluation with ethics, in particular under the framework of responsibility, and also builds on the body of knowledge about R&D and innovation processes provided by STS and STIS studies (science, technology, innovation and society). Ethical reflection and technology assessment are increasingly taken up as integrative part of R&D programmes (Siune et al. 2009). Science institutions, including research funding agencies, have started taking a pro-active role in promoting integrative research and development.[3] Thus, the governance of science and of R&D processes is changing which opens up new possibilities and opportunities for involving new actors and new types of reflection.

In this paper[4] I want to demonstrate at a more conceptual level that Responsible Innovation can build on experiences and knowledge provided by the three mentioned fields of research: ethics, technology assessment, and STS respective STIS studies. To

[2] In this paper I will usually speak of 'Responsible Innovation' but including also early stages of development and research.

[3] See the 'Responsible Innovation' programme of the Dutch science foundation NWO as an example.

[4] Because of several parallel publication projects in the field of RRI I cannot avoid some overlap with other publications. In particular, there are parallels with Grunwald 2011b in the field of responsibility; with Grunwald 2012a with respect to conceptual issues of RRI; and with Grunwald 2012b concerning Technology Assessment as major source of RRI.

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this end I will start by a brief analysis of the thematic dimensions included in the notion of responsibility and the respective disciplinary approaches to explore and investigate them (Sec. 2). The field of technology assessment is then introduced as a major origin of the Responsible Innovation movement including already some of the main ideas behind Responsible Innovation (Sec. 3). Based on the TA tradition Responsible Innovation may be characterized as a broadened extension of technology assessment complemented by ethics and STS (Sec. 4). As an illustration, the field of Synthetic Biology is introduced (Sec. 5).

Key-words: responsible innovation, Technology Assessment, ethics, governance, science & technology

JEL codes: O32, P40, Y8

The notion of Responsibility

The concept of responsibility has been used widely in connection with scientific and technological progress in the past two to three decades (Durbin/Lenk 1987). It associates ethical questions regarding the justifiability of decisions in and on science and technology with the actions and decisions of concrete persons and groups and resulting accountabilities, and it is faced with the challenges posed by uncertain knowledge of the consequences of those decisions.
The term of 'responsibility' seems to be an everyday word not needing any explanation at all. However, this might be a misleading assumption in the field of science and technology (following Grunwald 1999). Responsibility is result of *an act of attribution*, either if actors themselves take over responsibility, or if the attribution of responsibility is made by others. The attribution of responsibility is itself an act that takes place relative to *rules of attribution* (on this also see Jonas 1979, p. 173). Assignments and attributions of responsibility take place in concrete social and political spaces involving and affecting concrete actors in concrete constellations. They may change the governance of a specific field, and often the explicit reflection on and attribution of responsibility *shall* influence the governance of decision-making in that field (e.g. in synthetic biology, see Sec. 5).

The notion of responsibility often is characterized by reconstructions making the places in a sentence explicit which must be filled in to cover the intentions valid in a particular responsibility context (Lenk 1992). A four-place reconstruction seems to be suitable for discussing issues of responsibility in scientific and technical progress:

- *someone* (an actor, e.g. a scientist or an engineer) assumes responsibility for
- *something* (such as the results of actions or decisions, e.g. for avoiding safety or security problems) relative to a
- *body of rules* (laws, norms, principles, values and customs) and relative to the
- *quality of available knowledge about the consequences of the actions* (deterministic, probabilistic or possibilistic knowledge (Betz 2010).

While the first two places are more or less trivial in order to make sense of the word "responsible", the third and fourth places open up essential dimensions of responsibility: the normative rules comprise principles, norms and values being decisive for the judgment whether a specific action or decision is regarded responsible or not – this place constitutes the *moral dimension* of responsibility. The knowledge available and its quality including all the uncertainties form its *epistemic dimension*. Reminding the initial observation that the attribution of responsibility is a socially and politically relevant act and influences the *governance* of the respective field, it comes out as a main result that *all three dimensions* must be considered in prospective debates over responsibility in science and technology (Grunwald 2011b):

- the *governance dimension* of responsibility mirrors the fact that the attribution of responsibility is an act done by specific actors and affecting others. Attributing responsibilities must, on the one hand, take into account the possibilities of actors to influence actions and decisions in the respective field. On the other, attributing responsibilities has an impact on the *governance* of that field. Relevant questions are: How are the capabilities to act and decide distributed in the field considered? Which social groups are affected and could or should help decide about the distribution of responsibility? Do the questions under consideration concern the "polis" or can they be delegated to groups or subsystems? What consequences would a particular distribution of responsibility have for the governance of the respective field?
- the *moral dimension* of responsibility is addressed by the question whether actions and decisions should be regarded responsible relative to the *body of rules*. Insofar as normative uncertainties arise (Grunwald 2011a, Ch. 3), e.g., because of moral conflicts or indifference, ethical reflection on these rules is needed. Relevant questions are: What criteria allow distinguishing between responsible and irresponsible actions and decisions? Which traditions such as Kantian or utilitarian ethics should be involved and what

would follow? Is there consensus or controversy on these criteria among the relevant actors? Can the actions and decisions in question be justified with respect to the rules, values and ethical principles?

- the *epistemic* dimension asks for the quality of the knowledge about the subject of responsibility. This is a relevant issue in debates on scientific responsibility because frequently statements about impacts and consequences of science and new technology show a high degree of uncertainty (von Schomberg 2005). The comment that nothing else comes from "mere possibility arguments" (Hansson 2006) is an indication that in debates over responsibility it is essential that the status of the available knowledge is critically reflected from epistemological points of view. Relevant questions are: What is really known about prospective subjects of responsibility? What could be known in case of more research, and which uncertainties are pertinent? How can different uncertainties be qualified and compared to each other? And what is at stake if hypothetical worse-case scenarios would come to reality?

This brief analysis shows that issues of responsibility are inevitably interdisciplinary touching upon all of these dimensions. The issue is not one of abstract ethical judgments but entails the observance of concrete contexts and governance factors as well as of the quality of the knowledge available. Responsible Innovation must be aware of this complex semantic nature of responsibility which requires inter- and trans-disciplinary approaches. In particular, a cooperation of applied ethics addressing the moral dimension, philosophy of science taking care of the epistemic dimension and social science (STS) researching the social and political dimension as well as governance issues is needed. In the following I will give some arguments that parts of this cooperation and integration have already been achieved in the field of Technology Assessment.

Technology Assessment as origin of Responsible Innovation [5]

State of art

Technology Assessment emerged in the 1970s in the United States as a science-based and policy-advising activity (Bimber 1996) with the Office of Technology Assessment at the Congress as the first TA institution. In its first period technology was regarded to follow its own dynamics (technology determinism) with the consequence that shaping technology in the sense of RRI was not an issue. The main task of TA in that time was seen in its early-warning function in order to enable political actors to undertake measure to, for example, compensate of prevent anticipated negative impacts of technology. This changed completely during the 1980s following the social constructivist paradigm emphasising the 'shaping of technology' according to social needs and values (Bijker et al. 1987; Bijker/Law 1994). In this framework the approach of Constructive Technology Assessment (CTA) was developed (Rip et al. 1995). CTA started considering technology development and innovation processes (Smits/ten Hertog 2007). TA for orientating giving shape to new technology and possibly resulting innovations is since then part of the overall TA portfolio. New and additional motivations entered the field of TA over the past decades (Grunwald 2012a):

- *Concerns of an emerging technocracy*: repeatedly there have been concerns that the scientific and technological advance could threaten the functioning of democracy because only few experts were capable of really understanding the complex technologies (Habermas 1970). One of the many origins of TA is to counteract and to enable and empower society to take active roles in democratic deliberation on science and technology (von Schomberg 1999).

[5] This Section summarizes the description of TA given in Grunwald 2012a and 2012b. For a general and more detailed introduction into TA see Grunwald 2009.

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- *Experiences of technology conflicts*: little acceptance of some decisions on technology (such as on nuclear power in some countries), doubts about their legitimacy and resulting conflicts motivated TA to think about procedures of conflict prevention and resolution, in particular involving participatory approaches (Joss/Belucci 2002).
- *Shaping technology according to social values*: If technology could be designed according to social values, so the hope, problems of rejection or conflict would no longer occur at all. This line of thought seems to be one of the main sources of Responsible Innovation.
- *Innovation issues*: in the past decade TA is increasingly considered part of regional and national innovation systems (Smits/ten Hertog 2007).
- *Shift in the societal communication on new and emerging science and technology (NEST)*: techno-visionary sciences such as nanotechnology, converging technologies, enhancement technologies and synthetic biology entered the arena. The widespread use of visions and metaphors became an important factor in societal debates (Grunwald 2007; Selin 2007).

Technology Assessment today constitutes an interdisciplinary research field aiming at, generally speaking, providing knowledge for better-informed and well-reflected decisions concerning new technologies (Grunwald 2009a). Its initial and still valid motivation is to provide answers to the emergence of unintended and often undesirable side effects of science and technology (Bechmann et al. 2007). TA shall add reflexivity to technology governance (Aichholzer et al. 2010) by integrating any available knowledge on possible side effects, by supporting the evaluation of technologies according to societal values and ethical principles, by elaborating strategies to deal with inevitable uncertainties, and by contributing to constructive solutions of societal conflicts around science and technology. There are four partially overlapping branches of TA addressing different targets in the overall technology governance: TA as policy advice, TA as medium of participation, TA for shaping technology directly, and TA in innovation processes (following Grunwald 2012a/b):

(1) TA has initially been conceptualised as *policy advice* (Bimber 1996, Grunwald 2009a). The objective is to support policymakers in addressing the above-mentioned challenges by exploring political measures such as adequate regulation (e.g. the Precautionary Principle), by reflecting priority-setting in research funding, and by developing strategies towards sustainable development. In this mode of operation TA does not *directly* address technology development but considers the *boundary conditions* of technology development and use.

(2) Participatory TA developed approaches to involve citizens, consumers and users, actors of civil society, stakeholders, the media and the public in different roles at different stages in technology governance. The participation of citizens and of those affected is believed to improve the knowledge basis as well as the values fundament on which judgements are based and decisions are made. Several approaches and methods have been developed and applied in the recent years, such as consensus conferences, citizens' juries, and focus groups (Joss/Belucci 2002).

(3) Building on research on the genesis of technology made in the framework of social constructivism (Bijker et al. 1987) the idea of *shaping technology* due to social expectations and values came up and motivated the development of several approaches such as Constructive TA (CTA) or Social Shaping of Technology (Yoshinaka et al. 2003). They all aim at increasing reflexivity in technology development and engineering by addressing the level of concrete products, systems and services, going for a "better technology in a better society" (Rip et al. 1995).

(4) As is well known the 'supply side' of science and technology and the societal 'demand' do not always correspond, and scientific-technical inventions do not automatically lead to successful and economically profitable innovations. TA regarding the entire innovation process is expected to improve this situation (Smits/den Hertog 2007).

In order to make TA work in specific projects, a set of methods has been developed in the form of a "method toolbox" (see Decker/Ladikas 2004). The methods applied in TA are research methods, interactive methods and communication methods*. Research methods* are applied to TA problems in order to collect data, to facilitate predictions, to do quantitative risk assessment, to allow for the identification of economic consequences, to investigate social values or acceptance problems and to do eco-balancing. *Interactive, participatory or dialogue methods* are needed to organise social interaction in such a way as to facilitate conflict management, allow for conflict resolution, bring scientific expertise and citizens together, involve stakeholders in decision-making processes and mobilise citizens to shape society's future. *Communication* should be seen as a two-way process. On the one hand communication methods are used to communicate the corporate image of a TA institute, the TA approach, the TA process and the TA product to the outside world so as to increase the impact of TA. On the other hand communication is important for enabling the TA institute to keep in touch with the outside world and thus with reality.

Responsible innovation draws on the body of knowledge and experience provided by TA's history over decades and on the methodological toolbox – but also extends the scope of consideration to ethical issues of responsibility and to broader governance and STS issues.

Responsible Innovation

The emergence of Responsible Innovation (Siune et al. 2009) reflects the diagnosis that available approaches to shape science and technology still do not meet all of the far-ranging expectations towards technology governance and achieving a "better technology in a better society" (Rip et al. 1995). The hope behind the Responsible Innovation movement is that new – or further-developed – approaches could add considerably to existing approaches such as TA and engineering ethics. Indeed, compared to earlier approaches such as SST or CTA there are shifts of accentuation and new focuses of emphasis (Grunwald 2012a):

- "Shaping innovation" complements or even replaces the former slogan "shaping technology" which characterised the social constructivist approach to technology. This shift reflects the insight that it is not technology *as such* which influences society and therefore should be shaped according to society's needs, expectation and values, but it is *innovation* by which technology and society interact as has been pointed out by many STIS studies.

- There is a closer look on societal contexts of new technology and science. Responsible Innovation can be regarded as a further step towards taking the demand pull perspective and social values in shaping technology and innovation more serious.[6]

- Instead of distant *observation* following classical paradigms of science there is now a clear indication for *intervention* into the development and innovation process: Responsible Innovation projects shall "make a

[6] An expression of this shift was the strong role of the Societal Panel in the application phase of the NWO programme 'Responsible Innovation' mentioned above.

difference" not only in terms of research but also as interventions into the "real world".[7]

- The spectrum of stakeholders to be involved in participatory processes and dialogue is to be broadened further because of new forms of science and technology governance (Siune et al. Chap. 3 and 4).

- Following the above-mentioned issues, Responsible Innovation can be regarded as a radicalisation of the well-known post-normal science (Funtowicz/Ravetz 1993) being even closer to social practice, being prepared for intervention and for taking responsibility for this intervention.

However, what „responsible" in a specific context means and what distinguishes "responsible" from "irresponsible" or less responsible innovation is difficult to identify. The distinction will strongly depend on values, rules, customs but also on the knowledge available and its validity, and will vary according to different context and actor conditions. Taking the three dimensions of responsibility (Sec. 2) seriously leads to the conclusion that Responsible Innovation unavoidably requires a more intense inter- and trans-disciplinary cooperation between engineering, social sciences, and applied ethics. The major novelty in this interdisciplinary cooperation might be the integration of ethics (normative reflection on responsibilities) and social sciences such as STS and governance research (empirically dealing with social processes around the attribution of responsibility and their consequences for governance). This integration is at the heart of Responsible Innovation – and a major obstacle might be that applied ethics and social sciences have to deal with deep-ranging controversies and mutual antipathy (Grunwald 1999). It will be one of the most exciting challenges in which way these obstacles might be overcome.

Responsible innovation – the moral dimension

The great majority of technology-relevant decisions can be classified as "business as usual" or "standard situation in moral respect" in the following sense (Grunwald 2000; Grunwald 2011a): the normative aspects of the basis for the decision including

[7] This is reflected by the strong role of the Valorisation Panels in the projects of the NWO programme 'Responsible Innovation'.

assumptions about responsibility are not made the object of special reflection, but accepted *as given* in the respective situation, thereby also accepting the elements of the normative framework this entails. The demands on the normative framework which define a business-as-usual situation are formulated more precisely by the criteria (expanding on Grunwald 2000; Grunwald 2011a) of *Pragmatic Completeness; Local Consistency; Sufficient Lack of Ambiguity; Acceptance and Compliance.* If these conditions are satisfied in a specific context, then neither moral conflicts nor ambiguities exist. There is, consequently, no need for explicit ethical reflection and thinking about responsibilities.

However, science and technology can challenge and possibly "disturb" business as usual situations in moral respect, transform them into non-standard situations and make ethical and responsibility reflection necessary (Grunwald 2011a). Then, moral ambiguities, conflicts on responsibility and indifferences, as well as new challenges for which moral customs have yet to be established or where there are doubts as to whether established moral traditions apply. In the following, I will refer to such situations as situations of *normative uncertainty* – then it will be a matter of debate, inquiry or controversy what should be regarded as responsible and what as irresponsible. In this modified situation, there are simply three options to choose from:

- *The techno-sceptic and more conservative approach*: reject the innovation causing moral trouble – renounce its possible benefits and maintain the initial normative framework. As a rule, this option is chosen if there are strong, i.e., categorical, ethical arguments against the new technology. An example is reproductive cloning. Such cloning or research on cloning is prohibited in many countries for ethical reasons. Although Habermas' (2001) argument against interventions in the germ line also claims to be such a strong argument, in discussions it is an object of controversy.

- *The constructive approach*: Try to modify the properties of the innovation responsible for causing moral trouble (maybe circumstances of its production involving animal experiments or the location of a nuclear waste disposal site in a sacred region of indigenous people) in order to be able to harvest the expected benefits without causing moral trouble. The option of shaping technology specifically according to ethical values or principles is behind the approaches of constructive technology assessment (CTA; see Rip et al. 1995), of the social shaping of technology (Yoshinaka et al. 2003), and of value sensitive design (van de Poel 2009, pp. 1001ff.). The focus is on directing the shaping of technical products or systems along the relevant factors of the normative framework so that the products or

systems fit the framework. This would so to speak in itself prevent normative uncertainty from arising.

- *The techno-optimistic approach*: Modify the normative framework, so that the new technology could be accepted (and the benefits harvested) in a way that would not lead to normative uncertainty and moral conflict. Frequently there are even more complex necessities to balance factors, such as when the (highly promising) use of a new technology or even research on it is not possible except by producing normative uncertainty. Examples are animal experiments undertaken for non-medical purposes (Ferrari et al. 2010) or research in which the moral status of embryos plays a role. The issue is then to examine if and to what extent the affected normative framework can be modified without coming into conflict with the essential ethical principles. Even the handling of technical risks that have to be tolerated in order to utilize an innovation often takes place by means of modifying the normative framework, such as in the implementation of precautionary measures.

Responsibility reflection plays a different role, however, in each of these options. The results of the reflection have to be introduced to the different fields of action (e.g., politics, economics and law) which relates the moral dimension of responsibility to the governance dimension.

Responsible innovation – the epistemic dimension

The subjects in responsibility debates in the field of new and emerging science and technology (NEST) often consist of assumptions about future developments. Expectations, fears, concerns and hopes play a role while reliable knowledge about those future developments usually is hard or even impossible to achieve. Therefore, the subject of responsibility is only known to a limited degree of knowledge. A fundamental problem of responsibility debates about far-ranging future developments in science and technology such as visions is the inevitably high degree to which material other than knowledge is involved.

An interesting epistemological controversy concerning ethical reflection on nanotechnology was recently subject to the debate about "speculative nano-ethics" (Nordmann 2007, Grunwald 2010). The critics of speculative nanoethics pointed out that no legitimate conclusions could be drawn if the ethical reflection addresses merely speculative and arbitrary futures ("mere possibility arguments," cf. Hansson 2006). In order to circumvent this criticism, explorative philosophy (Grunwald 2011a, Ch. 10) must not be epistemologically blind but has to develop and apply methods and procedures for assessing the degree of rationality behind images of uncertain futures. It must clarify the cognitive and normative content of the partially speculative future conditions and consequences of nanotechnology:

> Instead of welcoming without scrutiny anyone who cares to add to the stock of promises and concerns about nanotechnology, we need to encourage discussions about quality of promises. (Nordmann/Rip 2009, 274)

The epistemological task is to examine both the cognitive and evaluative content of the prospective knowledge which to be used in responsibility debates to describe the subject of responsibility. An epistemological "deconstruction" of prospective statements is necessary. Epistemological analysis of future knowledge and of expectations would initially have to uncover the cognitive content of the futures under considerations, i.e., the portions of knowledge and lack of knowledge that are involved, their respective premises, and the way they are combined to form coherent images of the future, such as scenarios. An important aspect would then be to examine the conditions needed for such futures to become reality and the periods of times that are involved. Furthermore, the *normative content* of the prospective knowledge would have to be reconstructed analytically: the images of a future society or of the development of man, and the possible diagnoses of current problems, the solutions to which are supposed to be facilitated by the more visionary developments. In this context the vision assessment approach has been proposed in order to uncover the epistemological and ethical grounding of visionary futures (Grin/Grunwald 2000; Grunwald 2009b). It aims at uncovering the epistemological and normative ingredients of future statements in order to permit better informed and more rational formation of opinion, assessment and decision making on the attribution of responsibilities. In this way, vision assessment can contribute to ethical and responsibility reasoning by helping to avoid running into the problem of dealing with "mere possible arguments" (Hansson 2006).

Responsible innovation – the governance dimension

Responsibility reflections take the perspective of a *participant* in ongoing debates over science, technology and innovation rather than merely being a distant *observer*. Thus responsibility reflection on technology and innovation are part of the overall technology governance. Responsibility inquiry into technology aims to influence the further course of development or, in short, *to make an impact* rather than being a mere ornament. Therefore, it has to be clarified how responsibility deliberations could take place and upon what grounds they could be founded but also how their results could enter decision-making processes.

Entry points for responsibility reflections of technology and innovation are those situations in social praxis in which there is normative uncertainty on the basis of technological issues (see above). This determines who the partners are in an interdisciplinary and trans-disciplinary dialogue which formulate the respective problem, provide information about the relevant contexts and are the addressees of advice concerning RRI. In the following I will briefly describe the most important of those entry points of the responsibility ethics of technology.

Political Decisions: Since governmental technology policy creates obligations for everyone, the influence it exerts on technology in a morally pluralistic society is always a stage on which normative uncertainties will probably manifest themselves. Policy consultation by responsibility ethics can, for example, take place in the preparatory phase of legislation relevant to technology. Ethical advice that helps to overcome normative uncertainties in these areas can on the one hand be handled in the context of professional consultation on policy, such as in technology assessment (Grunwald 2009a). On the other, they can also be dealt with in ethically enlightened public debates and participatory processes.

Entrepreneurial Decisions: The development of technology takes place primarily in the economy at market conditions. The shaping of technology and innovation by and in enterprises is operationalised by means of requirement specifications, project plans, and strategic entrepreneurial decisions. These in turn take place on the prescriptive basis of an enterprise's headline goals, general principles, plan goals, and self-understanding but also including assumptions about later consumers of the technology and future market conditions.

Engineering: Engineers and engineering scientists are confronted in a special way with attributions of having responsibility because of their close links with the processes of the development, production, utilization, and disposal of technology (Durbin/Lenk 1987; van Gorp 2005). Reflection on the moral foundations of

engineering activity also are a pragmatic location of the ethics of technology inasmuch as normative uncertainty arises during this activity, such as in cases of conflicts over the evaluation of safety and environmental issues between an engineer as an employee and the enterprise as the employer.

Consumer Behaviour: The individual preferences of users and consumers of technical systems and products help determine the success of technology developments and innovation in two ways: first, by means of their purchasing and consumer behaviour, and second (and less noted), by means of their comments in market research. Their preferences contain moral backgrounds and values. In the purchase of an automobile, for example, criteria such as sportiness, cost, status, and environmental compatibility play a large role that varies from person to person. The influence on technological development and innovation resulting from consumer behaviour arises however almost naturally from the concurrence of the actual purchasing behaviour of many individual persons.

Public Debate: The course of technical development is also decided by public debates, above all by those in the mass media. Public discussion in Germany influenced, for example, political opinion on nuclear energy, thus providing much of the basis for the recent decision to phase out atomic energy in that country. Similarly, the public discussion about genetically modified organisms has influenced the regulatory attitude of the European Union and the official acceptance of the precautionary principle. Most of the public debates conducted in the media have also influenced the shaping of the policy framework, with its indirect influence on technology.

Technology governance is a complex interplay of interventions at all of these different levels. The governance dimension of RRI is thus confronted with the necessity to establish a complex view on the sharing of responsibilities and accountabilities among a large variety of actors.

The RRI Case of Synthetic Biology

The goal of Synthetic Biology is to employ technology to influence and shape living systems, allowing in some future also the creation of artificial life 'from the scratch'. The question whether such developments are or could be made responsible has been raised in intensified form in view of the ever increasing extent of man's interventions

in nature. The moral issues posed by synthetic biology resulting in challenges to responsibility can be classified according to the different normative frameworks and sets of rules that are affected: the question regarding how to deal with risks, normative uncertainties about the moral status of artificial living things, and questions of regarding the human hubris or "playing god" (Boldt et al. 2009; Grunwald 2011a, Ch. 7). Because of the (very) early stage of development the responsibility of *research* is still the main questions rather than responsible innovation issues. The research process including its organisation, the agenda-setting process and the possibility of external involvement (e.g. by CSOs) are the main items of discussion.[8]

The responsibility of scientists at the lab will form a major issue in the run-up to genuine regulation and responsible research. In particular, issues of bio-safety and bio-security are frequently discussed (de Vriend 2006). The moral dimension which causes the necessity of ethical reflection in case of conflict touches questions such as: how safe is safe enough, what risk is acceptable according to which criteria, and is it legitimate to weigh up expected benefits with risks, or are there knock-out arguments morally forbidding cost/benefit comparisons? All these questions are well-known from many other fields of risk ethics but must be answered anew in the particular context of synthetic biology.

The production of new living things or technically strongly modified ones by synthetic biology will raise the question of their moral status. Insofar as with respect to their moral status a difference in principle is made between the living and nonliving objects of ethical reflection, the question will be whether synthetically produced living things are also accorded moral status. Dependent on assigning different moral statuses to such forms of "life" could lead to different answers on the questions for responsibility.

In synthetic biology, man moves from being a modifier of what is present to a creator of something new: "In fact, if synthetic biology as an activity of creation differs from genetic engineering as a manipulative approach, the Baconian *homo faber* will turn into a creator" (Boldt/Müller 2008, p. 387). In 2005 a high-level expert group on behalf of the European Commission called it likely that work to create new life forms will give rise to fears, especially that of synthetic biologists "playing God." Concerning responsibility issues the question could be (and is!) raised whether humans would run out of being able to act responsibly at all if they would start "Playing God".

[8] This Section summarizes diagnoses and findings published in Grunwald 2011a and 2011b.

However, most of the issues mentioned are highly uncertain as being parts of ongoing techno-visionary communication (Grunwald 2007). In the context of responsibility the question arises whether there is a clear issue at all for which responsibility can be taken or not. The following quote supports serious doubt about this:

> Fifty years from now, synthetic biology will be as pervasive and transformative as is electronics today. And as with that technology, the applications and impacts are impossible to predict in the field's nascent stages. Nevertheless, the decisions we make now will have enormous impact on the shape of this future (Ilulissat Statement 2007, S. 2).

The authors expect Synthetic Biology leading to deep-ranging and revolutionary changes with our today' decisions having high impact on future development. If, however, their assumption that we do not know at all how those future impacts will look like would be true there wouldn't be any chance to assign responsibilities, even to speak about responsibility wouldn't be without any purpose because there wouldn't be any valid subject to talk about. Any ethics of responsibility would be obsolete because of a missing subject (Bechmann 1993). The solution to this problem can be taken from the debate on speculative nano-ethics and its results so far (see Sec. 4) by differentiating responsibility issues with respect to the time-span of the involved concerns and by careful looking at the epistemic issues touched upon.

Today responsibility considerations should relate, because of the epistemological problems of far-ranging expectation and concerns, mainly to research itself rather than to products and other innovations (IRCG 2009, p. 7). This diagnosis focuses the need for governance of synthetic biology on the necessity to debate the *responsibility* of scientists as individual professionals and of science as a system. Thus the focus here is on questions of the responsibility of the scientists and the disciplines involved, of the accountability of certain areas of research, and of the relationship between the self-regulation and self-obligation of science and state regulation.

Self-obligations in science have come in for criticism in the field in Synthetic Biology. On the occasion of a conference on synthetic biology in 2006, 35 nongovernmental organizations (including the ETC Group, Greenpeace, and the Third World Network) wrote a joint letter critically reacting on a memorandum on the responsibility of Synthetic Biology (Maurer et al. 2006) which was approved at that conference. This letter is characterized overall by:

- Mistrust of scientific self-regulation and self-obligations. Such self-governance is undemocratic as scientists should not be allowed to decide such far-reaching questions affecting their own activities.
- Demands for a broad investigation of the social consequences of synthetic biology instead of restricting any investigation to abuse scenarios, e.g., by terrorists.
- Emphasis on the necessity for including social groups in dialogs about the agenda of research and the handling of possible social consequences.

The normative uncertainty and conflict that are symbolized by this letter and the activities at the second conference on synthetic biology concern the *distribution of responsibilities* for the further research process. What influence do scientists, the public, the state, or other social actors or areas have on the further course of events in synthetic biology in particular? Should there be a "policy of knowledge" (Stehr 2004) that decides where the acquisition of knowledge is desirable and where it should be prevented? What role might this policy play? And how should responsibility and accountability consequently be distributed? All of the questions are highly relevant for the responsibility debate and are belonging to its socio-political dimension.

Thus, both *inter- and trans-disciplinary efforts* are needed to be able to respond to the RRI challenge in this field. Neither individual scientists nor disciplines such as synthetic biology or even philosophy can address these questions alone with any prospect of success. When it comes to attributing responsibility, a broader approach is thus necessary, one that does justice to the realities of an extensive division of labour, citizens' claims for democratic participation, and the specific circumstances in the sciences. One of the demands for a transparent relationship between science, politics, and the public is for there to be deliberation about the agenda of science, in this case of synthetic biology, which is conducted in a democratic manner (Habermas 1970).

To take demands seriously for participation by a democratic public as well as for decision-making processes that are politically legitimized, however, does not lead to synthetic biology being freed of all responsibility. These fields are justifiably expected to provide transparent information to the public. The specific responsibility of scientists to provide information at an early stage lies in the fact that they possess particular cognitive competence in their own area and are the first to have certain

information. This responsibility also extends to participation in interdisciplinary and social dialogues and in political advice.

Summarizing these thoughts briefly shows that it is essential to consider the moral, the epistemic, and the political dimension of responsibility altogether rather than restricting the debate to one or two of them. Taking this result seriously implies that responsibility issues should not be dealt with by ethicist only but by interdisciplinary teams involving also philosophers of science, political and social scientists, governance researchers and the affected natural scientists.

Summary

The terms of responsible development, responsible research and responsible innovation have been used over the last years to an increasing extent. These terms are highly integrative because they cover issues of engineering ethics, participation, technology assessment, anticipatory governance and science ethics. They include what has been stated in this paper: adding reflexivity to technology development and design (see also Voss et al. 2006). In this sense responsible development and innovation might be a new umbrella term (von Schomberg 2011) with new accentuations which may be characterized by:

- involving ethical and social issues more directly in the innovation process by integrative approaches to development and innovation
- bridging the gap between innovation practice, engineering ethics, technology assessment, governance research and social sciences (STS)
- giving new shape to innovation processes and to technology governance according to responsibility reflections in all of its three dimensions mentioned above
- in particular, making the distribution of responsibility among the involved actors as transparent as possible

- supporting "constructive paths" of the co-evolution of technology and the regulative frameworks of society

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