Nanoethics (2015) 9:255–260
DOI 10.1007/s11569-015-0244-z

INTRODUCTION

Crossing the Line – "Science" and "Decisions" Facing Emerging Technologies

Christian Büscher · Jutta Jahnel

Received: 13 October 2015 / Accepted: 16 October 2015 / Published online: 9 November 2015

Keywords Scientific knowledge production · Interdisciplinarity · Risk analysis · Nanomaterials · Responsible research and innovation

Introduction to the Special Section

Drawing a Distinction – Indicating one Side – and Then Crossing the Line

The discussion in this special section has been stimulated by the National Research Council report: "Science and Decisions. Advancing Risk Assessment" [1]. In this title, two different domains are simultaneously linked and held apart by the word "and". This word reveals the problem addressed in this special section. Science is comfortable in its own self-referential domain of theory-driven observation, methodical data generation, and hypothetical, i.e. provisional, knowledge production. Science's world cannot be sustained without proper alimentation; hence, there is a lot of pressure to deliver "useful knowledge," which is defined as the kind of knowledge that stimulates economic growth. Natural sciences and engineering sciences claim their advantage by providing results with practical functions, or at least results that may lead to functioning technological realities in the near future. Nowadays, even philosophical research is expected to prove its societal impact and usefulness by contributing to more customer-oriented, sustainable, and ethically defendable technological systems [2].

The crossing from "science" to "decisions" is unavoidable and mandatory, so it appears, but the interaction between science and decision-making is not straightforward. The regulator faces a "dilemma" [3]: On the one hand, decision-makers seem to be asking questions that science cannot give clear answers to (e.g., what are the environmental implications of nanotechnology?) under increasing public pressure. On the other hand, scientists provide answers, in ever greater detail, to questions that decision-makers did not ask or are not interested in (e.g., by what mechanisms do carbon nanotubes cause asbestos-like pathogenicity). Science does not deliver certainty, as the discussions about ignorance or non-knowledge illustrate: "Sometimes, to learn more is to discover hidden complexities that make us realize that the mastery we thought we had over phenomena was in part illusory" [4].

The realization of indeterminacies as a universal fact is like an unmovable object which collides with the irresistible force, i.e. the postulate to make decisions: "Only those questions that are in principle undecidable, we can decide" [5]. While we must decide on matters

This special section originated from discussions at the 6th S.Net Annual Meeting: "Better Technologies with no Regret?" (Karlsruhe, Germany, 21-24 September 2014). Title of the session: "Science and Decision Facing Emerging Technologies: Uncertainty, Non-Knowledge and (Self-) Commitment."

C. Büscher (✉) · J. Jahnel
Institute for Technology Assessment and Systems Analysis (ITAS), Karlsruhe Institute of Technnology, Karlstrasse 11, DE-76133 Karlsruhe, Germany
e-mail: christian.buescher@kit.edu

which are complicated and complex, scientific knowledge can be used to lay out the options which are available, but it cannot determine the specific course of socially acceptable action(s). And if we must decide, then we must take the responsibility for the consequences. To carry the burden of responsibility, we call for justification. Humans have invented many technical and organizational means to cope with this uncertainty, such as bureaucratic programs and legal rules to decide in accordance with the "state of science and knowledge." As a consequence, the re-crossing of the distinction between science and decisions is inevitable.

New and Emerging Science and Technologies (NEST)

In particular, the challenges evolve in cases of possible yet unknown future impacts of technical innovations. There is a pressing demand for scientific expertise to answer questions about environmental, health, and safety (EHS) issues, as well as about ethical, legal, and societal implications (ELSI). Simultaneously, knowledge production has to struggle with uncertainties, non-knowledge, and the selectivity of scientific observation. *Nanotechnology* is a prime example of this struggle which political decision-makers are facing.

The term "facing," in the sense of the title for this special section, means "confronting", as well as "being confronted." On the side of scientific knowledge production, science itself promulgates the development of emerging technologies – and risk assessment has to cope with the consequences, i.e. develop new methods of assessing risks and hazards. Knowledge about possible threats is necessary. On the side of politics, concerns about risks and hazards stimulate regulatory decision-making. In consequence, there a generally high pressure to act. Therefore, regulators must show their "actionability" – even if this turns out to be "some" action at all cost.

Values, Transparency, Inclusion

In the face of uncertainty, the scientific risk assessment of NEST, or of nanomaterials as a special case, cannot deliver actionable information which provides a clear orientation, or practical alternatives, for decision-makers. Thus it seems that scientific knowledge production and political decision-making are become increasingly separated domains with a significantly hampered relationship [6]. Jasanoff realizes this disappointing situation for scientists and policymakers. She helplessly demands "meaningful interaction" ([7], p. 238), however, without offering concrete suggestions.

Indeed, science (and politics in any case) is increasingly confronted with requests for more transparency and inclusiveness. This has consequences for how science and knowledge is used to justify risk management and political decisions. A "meaningful interaction" between science and policy, in the sense of more transparency and inclusion, could lessen the confidence in "sound science" and impede consensus among different actors. The concept of "risk," as it is used in conventional risk assessment, remains an enduring heuristic to capture the possibility of future events. However, recent publications stress the fact that expert-based risk assessment is no longer sufficient for the governance of NEST and propose an increased value-based procedure.[1]

Crossing Needs Communication

The frontier between "science" and "decisions" reminds us that we are dealing with a social relation. We cannot refer to both sides simultaneously. And yet some scholars diagnose forms of amalgamation: "scientification of politics" and the "politicisation of science" [9] with unwanted consequences for the authority of science and the legitimization of decision-making. The propositions for improving the relation are manifold. They are all sequential and procedural in nature: iterative interaction throughout different stages. At the beginning, during, and at the end of processes, actors come together, go back home to the laboratory or office, and then later meet again; each actor continues carrying out his or her goals, interests, and claims.

In contrast, our approach is founded on the belief that we need to understand scientific statements as *communication* offered in specific forms to an actor who is required to understand them. The model of this relation contains a threefold selection of information (the selection of facts), of the message (the selection of how it is communicated), and of how the message is understood (the selection determined by the expectations of addressees). This model highlights the problem that neither science nor decision-making determines how these selections are conducted. This special section of *NanoEthics* addresses the increased disconnection between scientific knowledge

[1] Recently, and representative for many [8].

production in conventional risk assessment and the information needs of decision-makers in risk management. Procedures of "science" and "decisions" can be enhanced by attaining a deeper understanding about the (social) interaction and integration of the two separated domains.

"Science and Decisions" as a Commonly Shared Referential Problem

The special section's topic "Science and Decisions" is highly complex and needs multiple approaches and perspectives. The authors come from different disciplines, including natural science, chemical engineering, social science, and philosophy. They try to elucidate specific aspects of this interdisciplinary and shared referential problem by using concrete examples relating to scientific risk assessment and political decision-making around emerging technologies and nanomaterials. The most important challenge is to appraise the problem of adequately addressing and expressing disciplinary insights for an enriched and comprehensive interdisciplinary discussion. Therefore, the single contributions should not only be read separately. The added value of this treatment predominantly lies in the overarching picture which arises when the different pieces of the "fuzzy puzzle" are put together. With this in mind, the goal of this special section is neither to give the latest and detailed disciplinary results regarding the governance of nanomaterials, nor to give an in-depth and complete technical or actor analysis. This special section tries to link very different sources of information and research to establish a common ground for a rich and broad discussion on NEST and to point out strategies for overcoming the difficulties facing decision-making about the regulation of emerging technologies.

"Conceptual Questions and Challenges Associated with the Traditional Risk Assessment Paradigm for Nanomaterials"

The contribution from Jutta Jahnel begins with the scientific part of "Science and Decisions." She addresses the inner world of scientific risk assessment and sheds light on the inherent epistemological problems and the pressure to deliver support for decisions dealing with nanomaterials. Using natural-scientific language, she describes conventional procedures for assessing the risk of chemicals. This detailed explanation is needed to understand that chemical risk assessment is an expert-based chemical-by-chemical approach, which provides a range of data with inherent variability and uncertainty relating to the prediction of possible harmful effects. Uncertainty is even more pertinent to assessing nanomaterials, which present an overall problem since we lack an agreed concept for their identification, characterization and measurement. Jahnel shows how the considered risk assessment approaches rely on confidence in the relevant knowledge and on the possibility of managing uncertainty despite serious methodological challenges. It becomes apparent that the term "uncertainty" is often used in a very narrow meaning of word, in terms of measurement and statistical uncertainty.

She demonstrates that, beyond the nanospecific problems and the general challenges regarding chemical risk assessment procedure, there are also overarching governance hurdles. Jahnel focuses in particular on the institutionalized conceptual distinction between risk assessment and risk management, which leads to an increasing separation between scientific knowledge production and the information needs of decision-makers. The division of labor between scientists and policymakers leads to technical risk definitions which cannot be translated into assessments of value-relevant impacts on humans and ecosystems. Further questions emerge about the legitimacy of scientific procedures and about strategies for improving the procedures' relevance and usefulness for decisions. Complementary tools, such as grouping and ranking of nanomaterials, will improve conventional risk assessment, but stakeholders are increasingly concerned and also demand the development of a changed role of risk assessment in the entire governance process. Jahnel introduces examples for improved risk governance frameworks with additional inclusive assessment steps and an enhanced interaction between risk assessors and risk managers. In these models, the dividing line between "science" and "decisions" is still respected and a new dimension of interaction and mutual influence between risk assessment and risk management is preferred. However, it remains a difficult challenge to put these models into practice. The problem persists that regulators possess neither the power nor the expertise to include societal issues when undertaking risk assessment.

"Risk Calculation as Experience and Action – Assessing and Managing the Risks and Benefits of Nanomaterials"

Jahnel's findings resonate with the call for *absorption of uncertainty* in an interactive social mechanism between "science" and "decisions" proposed by Christian Büscher. He analyses the relation of risk assessment and risk management and comes to the conclusion that uncertainty is not absorbed solely by scientific knowledge, but rather by the interaction of the parties. In this sense, Büscher focuses on the underlying functional problem of the relationship between science and decision-making. While most theories on risk management concentrate on "intelligent" decisions, they often neglect the problem of *motivation* to accept *hypothetical*, i.e. provisorily, knowledge. In this contribution, the role and function of risk assessment, as a special field in natural science, is elucidated from a sociological perspective and the process of scientific knowledge production is described in detail. Scientific experience in risk assessment is directly linked to action and decision-making for risk management purposes. Hence risk assessment is often understood and applied as an instrument or tool for decision-making.

This instrumentalist perspective is critized, since although science and decisions are intrinsically interwoven, it does not follow that scientific knowledge imposes specific courses of action – there is no deterministic relation between them. Individual behavior and decision-making cannot be determined by statistical statements about the likelihood of potential future hazards.

Moreover, factual and normative aspects cannot easily be separated. Hence risk calculations and risk assessments are always a result of observer-related selections and reflect experience and action, mingling factual and normative aspects in the scientific production of knowledge. The promise, indeed the very definition, of a risk-assessment concept is based on a belief in objectivity, independence, and value-free experience. However, risk assessment exceeds a mere description of events, matters, and causalities. This tension is highlighted by the relations between uncertainty, action, and mobilization in risk issues. Managing and reducing uncertainty needs motivation to act. Because of epistemic uncertainty, decision uncertainty arises. The author takes the view that social mechanisms shape the interaction between science and decisions in order to absorb uncertainty. Thus, decision-making can be conducted as a temporarily stable process of self-binding, in an inclusive and iterative process.

"DPSIR- and Stakeholder Analysis of the Use of Nanosilver"

In his contribution, Steffen Foss Hansen and Anders Baun show that the different interests of actors are highly relevant for decision-making. They empirically assess the importance and influence of different actors in a concrete negotiation process about the use of nanosilver. The case is particularly intriguing in the light of the governance principles of inclusiveness and responsible innovation. In order to understand and map the known risks and issues associated with the use of nanosilver, the authors introduce the methodology of a DPSIR-analysis, which focuses on the Drivers, Pressures, State, Impacts and potential policy Responses. This tool was chosen as an alternative to classical risk analysis like risk assessment and risk management. According to this practical approach, Europe needs a new chemical, biocide, and medical legislation for nanomaterials in general, and nanosilver in particular. To determine potential policy responses, a stakeholder analysis was performed.

In addition, Hansen and Baun explore the possibilities for reaching consensus among the identified stakeholders with different interests, influence, and power. The authors conclude that industry players and NGOs have fundamentally conflicting views and interests which can be "boiled down" to different ethical perspectives on nature and the environment. Their work supports the conclusion by Renn et al. [10] that if issues become more complex and if the participants' stake in the outcome are raised, then the infusion of values and non-scientific knowledge in the debate will increase, and the relative weight of science will decrease.

"Logic of Choice or Logic of Care? Uncertainty, Technological Mediation, and Responsible Innovation"

Finally, Christopher Groves shows a way out of the infinite circle of (non) knowledge and action: he proposes to leave the evidence-based thinking in favor of an "ethics of care." This could provide an orientation for both science and decisions. He argues that regulation represents a specific, historically-emergent way of constructing the relationship between the present and the future. A politics of the future was evolved over decades

and even centuries through practices of standardization and expertise in prediction and foresight, resulting in the prominence of "risk thinking" as a way of dealing with uncertainty. Yet because the characteristics of new technologies "in the wild" cannot be predicted on the basis of knowledge of the past, regulation of emerging technologies has difficulties dealing with this politics of the future and the forms of governance associated with it. This situation requires new kinds of instruments and principles for responsible modes of action in the face of uncertainty.

In addition, innovation processes require a more open-ended and adaptive regulation in order to shape it towards particular ends. Groves shows that the central aspect of the innovation process is uncertainty which derives from novelty. According to this new innovation perspective, human action and knowledge are woven together and no longer separated into science and decisions. Future-oriented soft regulations are needed, based on principles that have to be specified in individual cases through processes of reasoning and debate. This kind of innovation governance has to reckon not just with new epistemological problems of limited information or knowledge as described by the Collingridge dilemma [11], but with an older problem: the existential uncertainties that derive from human finitude.

The open-ended narrative of action includes influencing by design and shaping risk identification with a wide range of stakeholders and a process of social learning, by creating a solidaristic form of cooperation and thus a re-embedding of techno-science within society. This value-based transformation of technology governance reflects a logic of "care" (as discussed by Anne-Marie Mol [12]), and thus future-oriented concepts of responsibility, as promoted by advocates of responsible research and innovation (RRI). Groves suggests that governance needs to become immanent to innovation with the aid of normative frameworks provided by a particular ethico-political approach – an "ethics of care" – that focuses not primarily on outcomes, but on dispositions through which certain outcomes are more likely to be reached. This represents a call for a thoroughgoing change, both in how those involved as innovators are educated to see themselves as *citizens*, and in how the institutions of innovation are organized so that citizens can participate in innovation. Thus a transformed relationship between knowledge and decision-making is envisaged.

Further elaboration is needed to conceptualize this kind of "ethics of care" and the question remains how to implement it in a manner which moves beyond an idealistic rhetoric that postpones necessary decisions. It is, moreover, exciting to reflect on this idea in the context of the empirical results obtained by Hansen. The author questions a mutual or collectively agreed ethics, due to the plurality of actors and their specific contested interests.

Conclusion: Confirmation or Crossing the Line?

Beyond the aforementioned concrete open questions, these four papers give a general impression of traditional and new thinking about "science" and "decisions." Coming from a strongly institutionalized separation between risk assessment and risk management with its questionable use for NEST, introducing ideas and experiments for further interaction between the actors of those two domains, we might arrive with Groves at a new concept of constant crossing without unraveling the distinction. In this sense the mark "and" still indicates a dividing line; however, we are reaching a state of thinking where crossing becomes routine. It will take quite some time and more discussions to fully understand this change. This special section wishes to give an initial impulse.

References

1. NRC (2009) Science and decisions advancing risk assessment. National Academies Press, Washington
2. Ribeiro PF, Polinder H, Verkerk MJ (2012) Planning and designing smart grids: philosophical considerations. IEEE Technol Soc Mag 31:34–43. doi:10.1109/MTS.2012.2211771
3. Weinberg AM (1985) Science and its limits - the regulators dilemma. Issues Sci Technol 2:59–72
4. Dupuy J-P (2007) Rational choice before the apocalypse. Anthropoetics 13:1–18
5. Foerster H von (1994) Ethics and Second-order Cybernetics. SEHR 4(2). URL: http://www.stanford.edu/group/SHR/4-2/text/foerster.html
6. SCHER, SCENIHR, SCCS (2013) Making Risk Assessment More Relevant for Risk Management. Scientific Committee on Consumer Safety; Scientific Committee on Health and Environmental Risks; Scientific Committee on Emerging and Newly Identified Health Risks; European Commission, Brussels
7. Jasanoff S (2003) Technologies of humility: citizen participation in governing science. Minerva 41:223–244

8. Miller G, Wickson F (2015) Risk analysis of nanomaterials: exposing Nanotechnology's naked emperor. Rev Policy Res 32:485–512. doi:10.1111/ropr.12129
9. Weingart P (1999) Scientific expertise and political accountability: paradoxes of science in politics. Sci Public Policy 26: 151–161. doi:10.3152/147154399781782437
10. Renn O, Webler T, Johnson BB (1991) Public participation in hazard management: the Use of citizen panels in the U.S. RISK: Issues in Health and Safety 2:197–226
11. Collingridge D, Reeve C (1986) Science speaks to power the role of experts in policy making. St Martin's Press, New York
12. Mol A (2008) The logic of care: health and the problem of patient choice. Routledge, London, New York