Uncertainty as a monster in the science–policy interface: four coping strategies

Jeroen van der Sluijs

Copernicus Institute for Sustainable Development and Innovation, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands (E-mail: *j.p.vandersluijs@chem.uu.nl*)

Abstract Using the metaphor of monsters, an analysis is made of the different ways in which the scientific community responds to uncertainties that are hard to tame. A monster is understood as a phenomenon that at the same moment fits into two categories that were considered to be mutually excluding, such as knowledge versus ignorance, objective versus subjective, facts versus values, prediction versus speculation, science versus policy. Four styles of coping with monsters in the science–policy interface can be distinguished with different degrees of tolerance towards the abnormal: monster-exorcism, monster-adaptation, monster-embracement, and monster-assimilation. Each of these responses can be observed in the learning process over the past decades and current practices of coping with uncertainties in the science policy interface on complex environmental problems. We might see this ongoing learning process of the scientific community of coping with complex systems as a dialectic process where one strategy tends to dominate the field until its limitations and shortcomings are recognized, followed by a rise of one of the other strategies. We now seem to find ourselves in a phase with growing focus on monster assimilation placing uncertainty at the heart of the science–policy and science–society interfaces.

Keywords Anomalies; monster theory; uncertainty

Introduction

The knowledge base available for decision-making on global environmental problems in the context of sustainable development is not of the type of well established knowledge that one can find in handbooks and textbooks of many disciplinary sciences. It has much more a preliminary and partial character and comprises bits and pieces of knowledge that differ in status, covering the entire spectrum from well established knowledge to judgments, educated guesses, and tentative assumptions (Funtowicz and Ravetz, 1993; Van der Sluijs, 1997). One could see this type of knowledge base as mixtures of knowledge and ignorance, where preliminary assumptions, scenarios, and expert judgements mask the ignorance. This is the case because the complex systems involved are imperfectly understood and imperfectly reduced into models, and yet the policy process requires the best of our knowledge to support decision-making. Typically, decisions need to be made before conclusive scientific evidence is available, while at the same time, the potential error costs of wrong decisions can be huge. The paradigm of scientific research as puzzle-solving within a well defined and unquestioned framework or paradigm meets its limits here.

Since the 1980s, computer models are increasingly being used in complex environmental assessments and foresight: they enable analysts to simulate reality and run several scenarios, thereby integrating knowledge from different disciplines. The assumption-ladenness of the models themselves, the use of models, and the transparency of models have been criticised over the years. The building of environmental assessment models inevitably involves subjective choices and value-laden assumptions. Lack of transparency with regard to these assumptions and uncertainties, and lack of reflection on how knowledge that is conditioned on these models and its assumptions differ from well established

Water Science & Technology **Vol 52 No 6 pp 87–92**

knowledge, lead to misunderstandings in the science policy interface on the nature of this type of knowledge. There is a tendency to treat this knowledge as if it is not different from well established knowledge. The history has many examples of scandals and loss of trust in the scientific basis for policies based on lack of understanding of the nature of knowledge stemming from model-based assessment and foresight. A classic example is the scandal of the IIASA energy scenarios in the eighties. In a critical review of the models used for these scenarios, Keepin and Wynne (1984) demonstrated convincing evidence of 'informal guesswork' and a lack of peer review and quality control, 'raising questions about political bias in scientific analysis', leading to a crisis within the institute. More recently the Netherlands National Institute for Public Health and the Environment (RIVM) encountered a similar scandal. Early in 1999, De Kwaadsteniet, a senior statistician, accused the institute of 'lies and deceit' in their State of the Environment Reports and Environmental Outlooks. In a quality newspaper (Trouw) he criticised RIVM for basing their studies on the 'virtual reality' of poorly validated computer models while RIVM presents these results as point values with unwarranted significant digits and without elaborating the uncertainties. It triggered a vehement public debate on the credibility and reliability of environmental numbers and models. The case got front page and prime-time coverage in the mass media over a period of several months and led to debate in the Netherlands parliament (Van der Sluijs, 2002). The case triggered a learning process within the RIVM and led to the development of a guidance for uncertainty assessment and communication for the institute (Van der Sluijs *et al.*, 2003).

Methods

In the following, I will use a 'monster metaphor,' borrowed from the work of Dutch philosopher of technology Martijntje Smits (2002, 2004) on the cultural domestication of technologies. I use her monster-concept to explore the way in which the scientific community responds to the monstrous uncertainties that they face in the production of the knowledge base of complex environmental problems. Building on work of Mary Douglas (1966) on purity and danger in traditional cultures, Smits has developed a theory in which she explains the co-existence of public discomfort and fascination with certain new technologies such as GMOs by using the metaphor of a monster. The idea is that we are accustomed to order the world in terms of binary categories such as humans versus animals, and organisms versus machines. Douglas has shown that such categories differ from culture to culture. They are the result of a social learning process. For the most part they are shared collectively, therefore they could be called cultural categories. They shape a symbolical reconstruction of worldly phenomena. A special case of confusion appears, when at the same moment, a phenomenon fits into two categories that were considered to be mutually excluding. Smits calls this ambiguous phenomenon, this unnatural being, a monster. For instance, in xeno-transplantation, the human–animal categories get mixed up. The ambivalent nature of such a monster induces discomfort and fear. As Smits argues, fear is one of our reactions to things or situations we cannot understand or control. Fear is connected to the presentiment of radical unknown dangers. Fascination or reverence is another reaction to the unknown which makes some see, for instance, GMOs as a miracle giving humanity unprecedented opportunities by crossing the species barrier.

When we apply Smits' monster concept to the production of a knowledge base for policy making on complex environmental problems, we can make a number of interesting observations. The categories that we thought to be mutually exclusive and that now tend to get increasingly mixed up to create monsters in the science policy interface include: knowledge versus ignorance, objective versus subjective, facts versus values, prediction versus speculation, and science versus policy.

Smits distinguishes four styles of 'monster-treatment' with different degrees of tolerance towards the abnormal. These styles are: monster-exorcism, monster-adaptation, monster-embracement, and finally monster-assimilation. These strategies have some resemblance with strategies distinguished by Lakatos (1976) for preserving mathematical models against apparent refutations, which he also called monsters. Lakatos distinguished four styles of coping with monsters in models: Surrender (throw the model away and start all again), Monster barring, Monster adjustment, and Lemma incorporation. Another instance of monster theory can be found in Boon (1983). In the following, I explore each of the four strategies distinguished by Smits for coping with the monster of uncertainty.

Results and discussion

Monster-exorcism

Monster-exorcists want to expel the monster. Uncertainty simply does not fit within symbolical order where science is seen as the producer of authoritative objective knowledge. They call for more objective research that should aim at reducing uncertainties. The borders between facts and values, knowledge and ignorance, science and policy are seen as real and inflexible and often the categories are also seen as norms (as in the notion that it is a good thing to keep science and policy, facts and values, objective and subjective separated). Yet monster-theory predicts these attempts will prove to be vain in the long run: for each head of the uncertainty monster that science chops off, several new monster heads tend to pop up due to unforeseen complexities.

This failure of the monster exorcism strategy to cope with uncertainty is indeed evident in the history of climate research and earth system research. Initially, climate research programmes aimed primarily and explicitly at the reduction of the uncertainties in climate forecasting (WCRP, 1979; IGBP, 1992). The belief in the feasibility of this objective was so strong that the Intergovernmental Panel on Climate Change (IPCC) stated in their 1990 report that they "*are confident that the uncertainties can be reduced by further research* (Houghton *et al.*, 1990)." They were referring to the uncertainties about sources and sinks of greenhouse gases, cloud formation, oceans, and ice sheets. IPCC's 1995 Second Assessment Report was still dominated by the belief in the reducibility of uncertainties and the ultimate 'do-ability' of long-term climate prediction, in spite of a growing awareness among the research communities involved that further research will not necessarily reduce the overall uncertainties regarding future climate. There are some uncertainties about particular aspects of the climate system and its dynamics which have been reduced by research. However, ongoing research is also revealing unforeseen complexities in the climate system and novel uncertainties, which increase the uncertainty of which we are already aware. For each head climate science chops off the uncertainty monster, several new monster heads tend to pop up.

It is interesting to see that for that reason, the IGBP (International Geosphere Biosphere Programme), one of the largest international research programmes on global change, concluded during their third Scientific Advisory Council Meeting in January 1993 that it might not be feasible to reduce uncertainties (Williamson, 1994). Williamson also notes that the increasing complexity of global models inevitably decreases the precision of their products and "*full predictability of the earth system is almost certainly unattainable.*" He makes a case for the replacement of the research objective to reduce uncertainties by a pragmatic research goal to "*provide reliable estimates of probability within defined limits, so that risks can be assessed and appropriate actions taken, rather than single value 'predictions' with spurious exactitude.*" On the subject of the research objective of reducing uncertainties, Bert Bolin, former chairman of the IPCC, says: "*We cannot be certain that this can be achieved easily and we do know it will take time. Since a fundamentally chaotic climate* *system is predictable only to a certain degree, our research achievements will always remain uncertain. Exploring the significance and characteristics of this uncertainty is a fundamental challenge to the scientific community.*" (Bolin, 1994).

Another strategy to cope with unwelcome uncertainty that may fit in the monster exorcism style and that needs mention here for the sake of completeness is the strategic hiding of uncertainty. One can think here of keeping the uncertainties in knowledge claims deliberately under the table because they do not fit a political agenda, to avoid that one's knowledge claims are disputed, or because one is afraid that prevalence of uncertainty will be judged as poor science by the outside world.

Monster-adaptation

The second style, monster-adaptation, aims at transforming the monster into a phenomenon that will better fit in existing categories. In terms of taming the uncertainty monster, this can be seen as attempts to quantify uncertainties. Monster adapters feel uncomfortable with anything that does not fit in a spreadsheet. They need numbers, for otherwise they cannot do their calculations that they deem to be the basis of rational decision support. Where there is no objective ground for quantification, monster adapters tend to use subjective probability and Bayesian approaches to quantify uncertainties in terms of the degrees of belief that experts assign to their knowledge claims. By normalizing the post normal along these lines, the classic paradigms of Decision Support striving for optimisation of expected utility as rational risk management strategy can be maintained.

In the field of Integrated Assessment Modelling another tendency can be observed to push back the monster in the categories of knowledge and ignorance, objective and subjective. This attempt to purification is evident in the tendency to build system models based on 'objective science' and then to externalise the subjective parts and uncertainties into ranges of scenarios, grouped into story-lines representing different value orientations, that are used to feed these objective models. The model is then seen as grounded in science and belongs to the domain of the scientists. Policymakers and stakeholders are welcome to contribute their insights, but in the scenarios that feed into the models, not in the science of the models itself.

This process in the science policy interface, by which parts of a debate are depoliticized by defining them as belonging to the scientific domain, is what the sociologist Thomas Gieryn (1983) calls boundary work. In her study on the role of scientific advisers in American regulatory politics, Jasanoff (1990) has further explored how scientists use a variety of boundary-defining strategies to establish who is in and who is out of relevant peer groups and networks of prestige or authority. By drawing boundaries between science and policy, scientists post 'keep out' signs to prevent non-scientists from challenging or reinterpreting claims labelled as 'science.' The creation of such boundaries seems crucial to the political acceptability of expert advice. However, Jasanoff also found that the experts themselves seem at times painfully aware that what they are doing is not 'science' in an ordinary sense, but a hybrid activity that combines elements of scientific evidence and reasoning with large doses of social and political judgement.

There is a school of thought of radical monster adapters for whom the scenario approach is still too monstrous. They are discomforted by the idea that science is not able to say which scenario is the most probable in a range of conceivable future scenarios and argue for Bayesian approaches giving a quantified probability to each scenario.

The limitations of the purification, or monster adaptation, approaches are obvious in the many critiques on the models. The IPCC Special Report on Emission Scenarios clearly shows that different models fed with the same scenarios produce very different results. This reflects the significance of model structure uncertainties. Further, several authors have shown that current models are not so objective as they claim to be: they contain many value-laden assumptions and stem from value laden problem framings (see for overviews for instance Van der Sluijs, 1997; Schneider, 1998; Van der Sluijs, 2002; Kloprogge *et al.,* 2005).

Monster-embracement

The third response, monster-embracement, can perhaps be associated with fascination about the unfathomable complexity of our living planet Gaia. It creates the possibility to be filled with wonder and respect, something that was taken away by the engineering worldview in which science is able to understand and control nature, reflected in notions seeing the biosphere as something that can be managed. The schools of thought of Holism and attempts to integrate science and spirituality in Inclusive Science (Ken Wilber) can also be considered as embracing uncertainty, because they emphasize the limits of the positivist reductionist schools of thought for which they provide alternatives.

Another type of response to monstrous uncertainty that can be seen as monster embracement is denial of the reality of environmental risks by pointing to all those uncertainties. Sometimes this is done strategically. For instance, regarding the risks of anthropogenic climate change, in (Van der Sluijs, 1997) I argued that greenhouse sceptics with an incentive (e.g., through their funding or because they value economic growth higher than environmental protection and see discourses on environmental risks as an unwelcome break on innovation and progress) to discredit the IPCC, also have a strong drive to find weak spots in the science. A variety of techniques is used to deliberately raise doubts about the realness of environmental risks, such as distortion and magnification of uncertainties (making mountains out of molehills), and even acts "at variance with good scientific practice" (as more recently the Danish Committee on Scientific Dishonesty qualified some of the things Lomborg did in his book *The Sceptical Environmentalist*). I argued that the IPCC process should be open to such sceptics, even to the strategic ones, and that the unpleasant way in which the game is played and the mixture of valid and ungrounded criticisms that it produces is the price that has to be paid for the key advantage for quality control of the identification of weak spots in the knowledge base. This brings me to the fourth category: monster-assimilation.

Monster-assimilation

Monster-assimilation refers to a strategy of adapting the monster, but also the cultural categories by which it is judged. As Smits (2002, 2004) argues, in contrast to the other styles of monster dismantling, the style of monster-assimilation makes use of the insight that cultural categories are flexible and constructible. In other styles, the uncertainty monster is somehow judged in terms of existing cultural categories and these cultural categories are in turn considered more or less as facts.

Rethinking the categories that got mixed up in the monsters is at the core of the monster assimilation strategy. Post-normal science (Funtowicz and Ravetz, 1993) and other forms of reflexive science are clear instances of attempts to assimilate the uncertainty monster and give it a central and explicit place in a deliberative management of environmental risks. Because scientific consensus about the truth of complex environmental risks is unlikely to be achieved given the post-normal situation (facts uncertain, values in dispute, high decision stakes), we will have to drop our demand for a single certain truth and strive instead for transparency of the various positions and learn to live with ambiguity and pluralism in risk assessment.

A pitfall of this assimilation strategy is that changing the categories by which we judge the monster is likely to create new monsters, as every categorization is an imperfect reduction of complexity.

Conclusions

In this paper, I used a monster metaphor to explore the different ways in which the scientific community responds to uncertainties that are hard to tame. A monster is understood as a phenomenon that at the same moment fits into two categories that were considered to be mutually excluding, such as knowledge versus ignorance, objective versus subjective, facts versus values, prediction versus speculation, science versus policy. Four styles of coping with monsters can be distinguished: monster-exorcism, monster-adaptation, monster-embracement, and monster-assimilation. Each of these responses can be observed in the historic learning process and current practice of coping with uncertainties in the science–policy interface on complex environmental problems. We might see the ongoing learning process of the scientific community of coping with complex systems as a dialectic process where one strategy tends to dominate the field until it fails followed by a rise of one of the other strategies. We now seem to find ourselves in a phase with a growing focus on monster assimilation. Several efforts have been made in the field to rethink the categories knowledge and ignorance that we used to think of as mutually exclusive. Assessment and communication of uncertainty and ignorance and a post normal science approach of extended peer review are essential in this new approach.

References

Bolin, B. (1994). Science and Policy Making. *Ambio*, **23**(1), 25–29.

Boon, L. (1983). *De list der wetenschap. Variatie en selectie: vooruitgang zonder rationaliteit*. Ambo, Baarn.

Douglas, M. (1966). *Purity and danger: An analysis of the concepts of pollution and taboo*. Routledge, London & New York.

Funtowicz, S. and Ravetz, J. (1993). Science for the Post-Normal age. *Futures*, **25**(7), 735–755.

Gieryn, T. (1983). Boundary-work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists. *American Sociological Review*, **48**, 781–795.

Houghton, J., Jenkins, G. and Ephraums, J. (eds) (1990). *Climate Change, The IPCC Scientific Assessment.* Cambridge University Press, Cambridge.

International Geosphere Biosphere Programme (IGBP) (1992). *Reducing Uncertainties*. Royal Swedish Academy of Sciences, Stockholm, Sweden.

Jasanoff, S. (1990). *The Fifth Branch, Science Advisers as Policy Makers*. Harvard University Press, Harvard.

Keepin, B. and Wynne, B. (1984). Technical analysis of IIASA energy scenarios. *Nature*, **312**, 691–695.

Kloprogge, P., Van der Sluijs, J. and Petersen, A. (2005). *A method for the analysis of assumptions in assessments applied to two indicators in the fifth Dutch Environmental Outlook*, Research Report. Department of Science Technology and Society, Utrecht University, Utrecht, The Netherlands.

Lakatos, I. (1976). *Proofs and Refutations: The Logic of Mathematical Discovery*, John Worrall and Elie Zahar (eds), Cambridge University Press, Cambridge.

Schneider, S. (1998). Integrated assessment modeling of global climate change: transparent rational tool for policy making or opaque screen hiding value-laden assumptions? *Environmental Modeling and Assessment*, **2**, 229–249.

Smits, M. (2002). *Monsterbezwering, De culturele domesticatie van nieuwe technologie*, Boom, Amsterdam.

Smits, M. (2004). *Taming Monsters. The cultural domestication of new technology*, University of Eindhoven, Eindhoven, The Netherlands.

Van der Sluijs, J. (1997). *Anchoring Amid Uncertainty: On the Management of Uncertainties in Risk Assessment of Anthropogenic Climate Change*, PhD thesis, Utrecht University, Utrecht, The Netherlands.

Van der Sluijs, J. (2002). A way out of the credibility crisis of models used in integrated environmental assessment. *Futures*, **34**, 133–146.

Van der Sluijs, J., Risbey, J., Kloprogge, P., Ravetz, J., Funtowicz, S., Corral Quintana, S., Guimaraes Pereira, A., De Marchi, B., Petersen, A., Janssen, P., Hoppe, R. and Huijs, S. (2003). *RIVM/MNP Guidance for Uncertainty Assessment and Communication: Detailed Guidance*, Copernicus Institute for Sustainable Development, Utrecht University, and RIVM-MNP, Utrecht, The Netherlands, Available at www.nusap.net.

World Climate Research Programme (WCPR) (1979). Geneva, Switzerland.

Williamson, P. (1994). Integrating Earth System Science. *Ambio*, **23**(1), 3.