Report of the Expert Meeting Uncertainty Communication
- Hotel Mitland, Utrecht, The Netherlands, 10 December 2004

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1. Goal and setup of Expert Meeting

The Expert Meeting Uncertainty Communication was organized by Dr. Jeroen van der Sluijs of the Copernicus Institute for Sustainable Development and Innovation (Utrecht University). The Meeting was organized in the context of the project "Styleguide Uncertainty Communication", which contributes to the RIVM project "Uncertainties, Transparence and Communication: Guidance for Coping with Uncertainties". The Meeting originally also intended to contribute to the subproject "Risk communication and uncertainty management in participatory knowledge development for climate change prevention and adaptation" for the Bsik consortium "Climate Changes Spatial Planning". This subproject however unexpectedly received a no-go decision from the consortium board and new terms of reference for the sub-project will be written.
The goal of the Expert Meeting was to find an answer to the following questions:

- What is the state of the art in uncertainty communication?
- How can the vocabulary for the communication of uncertainty be improved in such a way that it avoids biases, framing issues, and pitfalls in the way non-scientists understand risk, probability and uncertainty?
- What are effective ways to graphically represent different sorts of uncertainty?

Two presentations and a plenary discussion were held as an introduction to the Meeting, followed by three sessions on specific subjects: uncertainty scales, graphical expression of uncertainty, and uncertainty communication to non-scientific audiences. Each session consisted of two fifteen-minute presentations followed by two ten-minute reactions (one to each presentation), and a plenary discussion. The discussions aimed to determine the most promising experiments to be done in the Utrecht Policy Laboratory, regarding the sessions' subjects.
For later ease of use, concrete proposals for experiments have been written in italic.

2. Participants

The following people participated in the Expert Meeting Uncertainty Communication:

Matthieu Craye (European Commission Joint Research Centre)
Bruna De Marchi (Institute of International Sociology of Gorizia, Italy)
Suraje Dessai (Tyndall Centre for Climate Change Research & University of East Anglia, UK)
Annick de Vries (University of Twente, The Netherlands)
Silvio Funtowicz (European Commission Joint Research Centre)
Willem Halffman (University of Twente, The Netherlands)
Matt Hare (Seecon Deutschland, Germany)
Peter Janssen (RIVM/MNP, The Netherlands)
Penny Kloprogge (Utrecht University, The Netherlands)
Martin Krayer von Krauss (Technical University of Denmark, Denmark)
Johan Melse (RIVM/MNP, The Netherlands)
Anthony Patt (Boston University, USA)
Ângela Guimarães Pereira (European Commission Joint Research Centre)
Arthur Petersen (RIVM/MNP, The Netherlands)
Jeroen van der Sluijs (Utrecht University, The Netherlands)
Hans Visser (RIVM/MNP, The Netherlands)

Arjan Wardekker (Utrecht University, The Netherlands)
Charles Weiss (Georgetown University, USA)
Robert Willows (UK Environment Agency, UK)

Suraje Dessai and Matt Hare could not attend the Meeting, but handed in a presentation and a reaction by e-mail. The Meeting was chaired by Arthur Petersen and reported by Arjan Wardekker.

3. Introduction

Van der Sluijs opened the workshop with an introduction. He argues that coping with uncertainties is essential in dealing with complex environmental problems, because decisions need to be made before conclusive scientific evidence is available, decision stakes are high, values influence assessment, and the knowledge base is a mixture of knowledge and ignorance. In these problems, unquantifiable uncertainties tend to dominate quantifiable ones. When knowledge crosses disciplinary boundaries, important caveats of that knowledge tend to be ignored, uncertainties compressed and numbers used at face value. History is full of examples that show that omitting uncertainty management in science for policy can lead to scandals, crises and loss of trust. More research does not necessarily reduce uncertainties and uncertainties are not necessarily a problem for the quality of information only. A shift of focus is needed from reducing uncertainties to explicitly coping with them. In the discussion, Melse notes that perhaps a new word for uncertainty is needed, because it currently means a lack of something.
The RIVM/MNP Uncertainty Guidance is designed to promote systematic reflection on uncertainty issues, using diagnostic checklists and an uncertainty matrix. In the reporting, uncertainties should be made explicit, robustness of results should be assessed, implications of uncertainties and relevance to the problem should be discussed, and there should be a progressive disclosure of information (traceability and backing).

Petersen adds to this, in his presentation on the need for guidance, that experts should be reflexive, that methods for dealing with uncertainty are merely tools, and that communication with a wider audience is crucial. Fear for paralysis in policy making is not necessary in his view, although this seemed to be one of the reasons why the Bsik subproject on uncertainty communication in the assessment of the risks of climate change received a no-go.
Weiss comments on this in the discussion, that the idea that an open debate on uncertainty can paralyze the policy process seems more a normative statement than an empirical one. *The question of whether or not communication on uncertainty causes paralysis in policy making could be tested in the Policy Lab.*
Funtowicz notes that uncertainty has sense in context. If the paradigm is complex systems where things are in permanent flow, uncertainty means something and it will not cause paralysis. If there the paradigm is that science provides certainty, uncertainty will have no meaning and may well cause paralysis. Communication of uncertainty depends on the overall goal.
Further support for uncertainty communication comes from Van der Vlist, the Director-General for Environmental Protection. He notes that politicians must decide under uncertainty and that the RIVM/MNP should bring all relevant scientific arguments into the political debate. The RIVM/MNP should inspire the Ministry in openness and dealing with uncertainties. The

RIVM/MNP Guidance was created to offer assistance to analysts in assessing and communicating uncertainty.
The IPCC Third Assessment Report on Climate Change offered two forms of communication: the use of words to reflect different levels of certainty (or "confidence", as the other IPCC working group interpreted the scale) and the use of graphics. The advantage of the use of words is that people are better at hearing, using, and remembering risk information in words, rather than in numbers. The disadvantage of this method is that people in their brain do not separate probability and magnitude of an effect and thus tend to take the magnitude of effects into account when translating probability language into numbers and vice versa. Furthermore, words have different meanings for different people and result in broad ranges of estimated chances. The word "possible" is the most problematic, resulting in an estimated range between 0 and 100% chance. The advantage of using graphics is that they can conveniently summarize significant amounts of uncertainty information. The disadvantage is that most graphical expressions are not straightforward to understand.
In the context of the existing guidance, the following questions were posed:

- What standardized phrasing can help to convey probability estimates and qualitative uncertainty characterizations?
- What standardized graphics can facilitate the uncertainty communication?

In response to this, Halffman asks what to standardize and why. Patt notes that it is difficult to standardize in a multi-language context. Van der Sluijs suggests that it might be better to use the word "harmonize". Petersen replies that the RIVM should use similar categories and vocabulary across the various reports RIVM publishes in order to facilitate communication and avoid confusion or misunderstanding. This vocabulary is often used to give readers an idea on uncertainties and is a useful device in debate on where uncertainties lie. There is a perceived need for such a vocabulary among researchers. Its use will not be policed or enforced. Halffman notes that the standardization would be for the specific context of the RIVM only, which limits its usefulness (no universality). A styleguide uncertainty communication could give a list of "words not to use" and of "good words", and what people understand by them, or offer various ways to express different sorts and levels of uncertainty.

Krayer von Krauss suggests to phrase conclusions together with a disclaimer, for instance in the format "To the best of our knowledge *it is likely that we will meet the Kyoto target without additional policies*, however, our knowledge is limited by.... and that implies that..." packing it in such a way that it forces critical reflection on the conclusion. However, the use of these words would deny the first statement, according to De Marchi. One should pay good attention to specific language and the linguistic and psychological aspects of its use.

4. Uncertainty Scales

Patt presents a number of issues with the IPCC 7 point scale. In addition to the issues mentioned earlier by Petersen in using words to represent uncertainty, he notes that the use of words also results in loss of precision. The use of a fixed scale, such as the IPCC scale, has some additional good and bad points. A fixed scale's consistent use of language makes it easier to remember and consistent messages are considered to be more credible. However, a fixed scale doesn't match people's intuitive use of probability language. People translate the language taking the event magnitude into account as well, which results in an overestimation of the chance of low

magnitude events and an underestimation of high magnitude events. Options for improvement include drawing attention to problem areas and using similar language in multiple scales across issue areas. This use of similar language in multiple scales, in addition to describing sources of uncertainty and reasons for disagreement, increases credibility of the message.
An unsolved problem is empirical research on the links between expert disagreement, stochastic uncertainty, and information credibility, storage, and use. Other unsolved issues are whether use of language preserves credibility when there is disagreement, and workable theories linking how people remember and use uncertainty and magnitude, and how people's heuristics and biases adapt.
In response to Patt, Craye notes that the use of such scales privileges attention to quantifiable and probabilistic uncertainty. It is much harder to address radical uncertainty in for instance problem framings. There is a risk of limiting uncertainty communication to uncertainty that can be captured in probabilistic expressions. The knowledge production on climate change is complex, as is the knowledge itself. Using only probability scales imposes a framework on users. However, there is no clearly preferred or fixed approach to study phenomena and environmental health risks. Scales don't deal wilt more fundamental issues, such as choices. The use of scales may mask the debate on framing. An alternative to the probabilistic view of uncertainty is to see uncertainty as non-conclusive evidence. Probability makes sense only within a robust and undisputed problem framing. If no robust framing exists, probabilistic expressions of uncertainty make little sense. Furthermore, Craye notes that there is a need to transfer probability information Scientists tend to underestimate the uncertainty in their own predictions, therefore it is best to use broad ranges and wordings that better reflect the limited state of knowledge. Communicating overly precise risk characterizations can decrease trust.

In the discussion it was noted that uncertainty communication is not a neutral exercise, it has impacts on society and opens black boxes. There are significant trade-offs between epistemological, functional, and (strategic) normative aspects in uncertainty communication. There now is the phenomenon of deliberate manufacturing of uncertainty in order to destabilize knowledge claims that conflict with one's interests. (See e.g. http://apha.confex.com/apha/132am/techprogram/paper_96367.htm)

Weiss presents an uncertainty scale based on standards of legal proof, as a complement to other scales. In legal situations, a certain level of uncertainty is tolerated, based on the relative value society places on a false positive or false negative judgment. In the climate change issue there is also a need to create a judgment, considering all the evidence and views. The Weiss Scale uses 12 points to express the probability of something being true: "beyond any doubt" (100%), "beyond a reasonable doubt" (99%), "clear and convincing evidence" (90-99%), "clear showing" (80-90%), "substantial and credible evidence" (67-80%), "preponderance of the evidence" (50-67%), "clear indication" (33-50%), "probable cause / reasonable belief" (20-33%), "reasonable indication" (10-20%), "reasonable, articulable grounds for suspicion" (1-10%), "no reasonable grounds for suspicion / inchoate hunch" (<1%), and "impossible" (0%). These points correspond to cases that people can understand, being legal situations where this standard of proof applies. They have well defined meanings and are based on case history. Weiss notes that the scale can be used for science, but that it may also be useful to distinguish between opinions.
Halffman comments on the details and context of the scale. On the details, he notes that the scales is linear and questions whether or not all types of uncertainties can be expressed on one scale. For

instance uncertainty in problem framing cannot be expressed on this scale. (Making the parallel to the court: the view "this is not a crime" would render the whole issue of evaluation of how convincing the evidence is - irrelevant.) He notes that statistical terms are used on an ordinal scale (that is a scale where higher numbers represent higher values but where the intervals between the numbers are not necessarily equal), and that the accuracy of the numbers is a guess. Furthermore, there is a problem at the extremes of the scale, where the examples are not always correct for the scale. With regard to the context, he notes that the terms often run into problems where scientific evidence comes in. Furthermore, the terms are aimed at a US audience, while other audiences are not programmed for them, and framing is under appreciated in this type of approach.
In the discussion, Weiss replies that the categories can handle science, although the legal system doesn't want to. Halffman notes that in US courts, scientists are affiliated with parties and are played out. A systematic approach is preferred.
Funtowicz comments that the American legal context (adversarial approach) is significantly different from the European and facts and interpretations are looked at differently in different contexts. The US context more strongly reflects a positivist image of science than the European context does. What type of image you have of science carries through to the legal system. In science we more and more see a shift from "discovery" towards "invention". Patents have commercialized science and have changed epistemology. To tackle the issue of uncertainty and improve its articulation, we have at the same time to change the epistemology, that is, we have to change the game, the type of relation between science and policy, the role of science.
Later, Willows notes that there is confusion of the expression of probability. The Weiss Scale is more transparent, clearly showing a balancing of interests.

The question is posed on whether climate change and sustainable development deal with discovery or invention. Petersen poses that post-normal science is getting normal. Funtowicz says that when talking about uncertainty, we should go beyond scientific uncertainty, because of the science-policy context. The tools also transform the scientists themselves.
De Marchi notes that one should stay open to the possibility that you identify more problems and to show the contradiction and paradox of applying a narrow scale.
Melse mentions that communication of uncertainty is often kept as minimal as possible. He also notes that numbers and language are not perceived as different languages. Furthermore, in a multi-language context, it is impossible to be precise: words are hard to translate across languages because they are embedded in different contexts. Halffman points out that we are talking about a specific way of uncertainty communication in the context of the RIVM and its situation and relationships. However, Funtowicz poses that the RIVM has higher aspirations that The Netherlands alone.
Communication is a process of producing meaning together. Even if only one side conveys information, one usually asks if the other side understands, and if the message is paraphrased in other words by the receiver this indicates that the communication was successful. Two things are at stake in uncertainty communication: decision on action based on knowledge and uncertainty information and producing a rationale for action. *Melse suggests studying the process of forming meaning and rationale for action. He suggests giving a group people information and letting them discuss about it. We could follow this discussion, and draw our conclusions from the discussion and its results and conclusion.*
Halffman notes that uncertainty and consequences are already entangled, because more research is done if the consequences are high, which has an effect on the uncertainty. A multidimensional

scale of different types of uncertainty, and different scales that can be used at the same time seems more useful.

Van der Sluijs suggests to *test how various audiences cope with uncertainty information expressed using multi-dimensional / multi criteria scales versus expressed with a single, aggregated scale.*

Willows comments that the ranking of the Weiss scale is linked to consequences, not to probability. Weiss nuances this and states that the standard of proof comes from the balance of interests and rights of the persons affected. Funtowicz hypothesizes that frequency is associated with probability. He also notes that if people know something is based on expert opinion, they may be less confident in it. *Furthermore, he suggests doing two experiments. One to explore what is understood by probability. He expects that most people will associate it with frequency rather than with subjective belief or opinion. A second experiment could deal with how different stakeholders judge uncertainty. Different audiences have different ways of thinking on uncertainty and. using uncertainty strategically. One could think of four audiences, parliament/government, stakeholders, NGOs, and the public.* The theory is in the Post Normal Science diagram: there is a relation between uncertainties and consequences or decision stakes. If stakes are low, applied science works, if high, uncertainty becomes crucial.

Weiss notes that NGOs need to be educated into dealing with uncertainty. Not to be able to deal with it is a vulnerability, as it leaves options for enemies to attack. Melse adds that scientists need to be educated in policy games.

Krayer von Krauss suggests seeing how different descriptions of the same source of uncertainty, expressed using different scales, affect people's willingness to pay or act on that information. Visser notes that many variables influence perception, e.g. the magnitude of the problem. One could vary those variables and see what promotes effective communication.

5. Graphical Expression of Uncertainty

Van der Sluijs presents Dessai's presentation on graphic representation of uncertainty. Dessai notes not to be an expert on graphical representation of uncertainty, but he did some literature research to prepare the presentation. Surprisingly little research has been done on this subject, with the exception of Ibrekk and Morgan (1987). This study presented nine different methods to respondents, both with and without explanation, and asked respondents to estimate the best estimate, the chance of crossing a threshold (more than 2 inches of snow), the chance of being between two thresholds (between 2 and 12 inches of snow), how sure they felt about their answer, and if they have ever seen this method before. These methods were:

point estimate with error bar, bar chart, pie chart, conventional probability density function (PDF), probability density function of half its regular height together with its mirror imagine, horizontal bars of constant width that had been shaded to display probability density using dots, horizontal bars of constant width that had been shaded to display probability density using vertical lines, turkey box modified to indicate the mean with a solid point, and conventional cumulative distribution function (CDF). Furthermore, respondents were asked what method they would prefer for use in newspapers. For "best estimate" point estimate and turkey boxes yielded the best results. For the other graphs, people were influenced by the location of the modes. Subjects were most sure of their estimate for point estimate and bar charts, and least sure for the modified PDF and the CDF. CDFs alone were likely to mislead significantly. For "over the threshold" only the pie chart and PDF performed well, although pie chart performance decreased

with explanation. For "between thresholds" only the pie chart before explanation and CDF after explanation performed well. A 95% confidence interval was best communicated using a point estimate, followed by CDF. Before explanation people preferred bar charts and pie charts, and after explanation they preferred pie charts and CDFs.
The performance of a method depends on the information people are trying to extract. Displays that explicitly contain the information that people need perform best. In estimating the "best estimate", people tend to select the mode, unless the mean is explicitly marked. The CDF alone is not an effective way to communicate the mean. Ibrekk and Morgan (1987) concluded that a CDF plotted directly above a PDF with the same horizontal scale and with the location of the mean clearly indicated on both curves is a good approach.
Dessai mentions a number of possible experiments for in the Policy Lab. *One could compare text-based versus graphic based communication to discover the added value of graphics. Furthermore, one could compare different graphical ways of displaying uncertainty. He suggest that a good way to do this is to first ask people how they would like graphs to represent uncertainty and then to test various suggestions by public and scientists to see which work best. He also suggests to experiment with communicating more deep uncertainty and the use of scenarios, as these seem to be the most difficult to communicate uncertainty about.*
Janssen notes that there is a focus on statistical (quantifiable) uncertainty at the moment, while the more prevalent unquantifiable uncertainty is not communicated. *He suggests letting potential users see and play with different methods and to experiment with spatial uncertainty. Attention should be given to the question of "what does uncertainty mean here". One could give a clue of qualitative uncertainty, e.g. a pedigree. An indication could be given of the quality of the information, although this can be very context dependent.* One needs to be careful with the use of colored surfaces such as the ones used in kite diagrams that visualize pedigree (strength of underpinning) of knowledge. For some combinations of scores the size of the surface spanned up by each color changes dramatically if one changes the order of the axes in the diagram (each axis represents one pedigree criterion). Van der Sluijs notes that Kloprogge solved the "axe flipping" problem of kite diagrams.

In a reflection on the experiences with communicating uncertainties, Krayer von Krauss notes that uncertainty is a three dimensional concept. It includes the level, the location, and the nature of uncertainty. The level of uncertainty ranges from statistical uncertainty to scenario uncertainty to recognized ignorance and total ignorance. The location, (Willows later suggests to use the word source instead), of uncertainty includes the various areas where uncertainty can occur, such as the context (boundaries, framing), input data, model structure, calibration data, parameters, and model output (conclusion). The nature of uncertainty can be either stochastic (variability and inherent indeterminism in the underlying natural phenomena) or epistemic (incomplete knowledge, limited data, measurement error, etc.). These three dimensions can be represented in an uncertainty matrix.
The next step would be to determine the implications of the uncertainty for the decisions to be made. In order to do so, three questions will need to be answered: how sensitive is the output of the model to a certain model location, what is the magnitude of uncertainty at a certain model location, and are precautionary measures justified given a certain level of uncertainty? Determining the magnitude can be difficult as a model location can be influenced by multiple levels of uncertainty. A solution would be to do a qualitative assessment of the level of uncertainty, followed by a quantitative/qualitative assessment of the magnitude. Magnitude,

sensitivity, and influence of uncertainty can be rated on a zero to one scale and displayed in the uncertainty matrix as a bar graph. A conclusion can be drawn from the magnitude of uncertainty in the model outcome, e.g. is there a "reasonable belief" of serious and irreversible environmental danger.

Willows asks what would be the burden (e.g. stress, time, etc) of doing so much expert elicitation for an uncertainty assessment. He notes that experts should be asked not only for the uncertainty, but also for their certainty of their own answers. Furthermore, he points out that the connection between uncertainty and its consequences is useful.

Willows wonders what the scope of application is of the method sketched by Von Krauss. Can it be applied to other cases than GMOs? Von Krauss argues that for any risk where a causal mechanism exists the procedure can be used.

Patt proposes to look at the potential of various methods to mislead, such as the "axe-flipping" problem of kite diagrams. Kite diagrams invite to compare the area colored in the diagram, but mislead in doing so, as there is no 1:1 relation between the uncertainty and the area. Kloprogge's traffic light diagrams solve the axe-flipping problem, as they fill a block (a triangular segment of the diagram) rather than score on the axes and draw a line between them. Melse and Petersen note that they are too difficult and take too long to interpret. Van der Sluijs notes that people can just look at the color: the greener, the better it is. However, the traffic light diagrams shown also didn't have a 1:1 relation, as a 50% score on the height of a triangle is not the same as 50% of the area of that triangle. This problem however can be solved by using a logarithmic scale along the axes so that each unit increment in score adds an equal area to the total colored surface in the diagram. Weiss adds that when using colors, it is better to use blue-green, rather than green, because of colorblindness.

Melse notes that it is more important to become aware of the strengths and weaknesses of different methods and in what contexts they can be used, rather than trying to design one method. One could investigate what kind of associations people have when they see certain graphs. This shows what information they communicate. Funtowicz notes that one cannot design against all possible misuse. It is better to define tradeoffs and keep it as simple as possible.

De Marchi questions what it is we're trying to communicate: whether it is communicating uncertainty or communicating uncertain information. Krayer von Krauss replies that he sees it as communication of uncertainty of uncertain information. They are two separate but connected things.

Halffman suggests playing with game settings, such as betting or monopoly. One can present information and let people decide. Such a game can be played several times, with high risk and with low risk.

6. Uncertainty communication to non scientific audiences: process, language, and trust

De Marchi presents experiences from the TRUST project and other projects with food risk communication and consumers. Comments e-mailed by Hare are taken into account in the presentation. Focus group participants in the TRUST project are aware of uncertainty. They recognize and underline the many risks and uncertainties that are present in the food market and their relevance in relation to safety, quality, ecology, ethics, etc. Furthermore, issues are never framed in terms of risk alone, but in much broader terms. The context (e.g. framing, information, features, and ethics) is important for the view on risk and research. Innovation, industrialization, and globalization have created improvements and an increased possibility of choice. They have also created new risks and enhanced different types of uncertainty, affecting the possibility of a "responsible choice" (compatible with one's preferences and values). While GM food is regarded with some reserve, there is no a-priori stigmatization. Existing concerns regard quality of research, presence of vested interest, existence and distributions of risks and benefits, and possibility of long-term negative effects. The availability of accurate information and the possibility of choice are regarded as unconditional rights.

Responsibility of actors is a key variable (e.g. who's doing the research). All actors in the food chain should be held responsible for promoting and assuring safety. Both legal liability and moral responsibility are involved in safety considerations. Regarding food, diffuse skepticism prevails, attributed to the intricacy of the food chain and multiple interactions between its components, the influence of powerful interest lobbies, and the presence of major constraints for consumers' choices, including manipulation through distorted information.

Trust is a pivotal point in all discussions about food safety. Both interpersonal trust and systems trust are important. Interpersonal trust is impaired by lack of direct acquaintance with operators in the food chain. Systems trust is weakened by diffuse skepticism in the competence, efficiency, efficacy, and integrity of dedicated systems. Systems trust can sometimes approach interpersonal trust, when consumers rely on a certain brand, distributor, or certification. These are taken to stand for reliable people. Confidence can serve as a "substitute" for trust, when people recognize the inevitable dependence on expert systems and existence of a structural uncertainty built into those systems. De Marchi notes that people appreciate and are willing to accept uncertainty if scientists have done their best. Performance of people in the food chain should be improved, rather than people's trust in communication. Trust should come as a consequence of that.

De Marchi suggests to first test how individuals react to information and then to test the same persons in focus groups and look at the differences.

In his comments, Hare also asks whether it would be possible to carry out research on the response of people to conflicting research results, identifying what are the conditions under which different research is accepted, dismissed, or ignored because other research conflicts with it.

In her presentation on people reacting to uncertainty, Guimarães Pereira notes that there are many different ways to present uncertainty. One can make a clear statement and make disagreement and controversy among experts explicit to show obvious complexity and uncertainty. One could also use tools in which uncertainty is intrinsic, or to use models parameterization in scenarios. Explanatory frameworks (proxies) and metaphors, such as cultural theory, can be used as well. Finally, the "further studies needed" approach can be used.

People are concerned with the reliability of climate change models and the time span of scenarios was difficult to imagine and posed problems for credibility as well. They noted that the credibility of models could be improved my making runs for the present day and comparing these with real data. Unstated assumptions and arbitrariness in scenarios caused issues of trust and credibility to emerge.

Abstractions of uncertainties through metaphors and explanatory frameworks are difficult to comprehend. They are useful, but may be misleading. People had a tendency to understand the perspectives from cultural theory as addressing behavior towards natural and human systems rather than uncertainty.

People complained about the many uncertainties and controversies, but were not surprised ("life is full of uncertainties"). They would rather be aware of it. The confrontation with uncertainties had a reassuring effect. It smoothened the lay-expert divide and encouraged involvement and empowerment in the debate. This created opportunities for action, and for influencing how the future could evolve.

Scenarios are, at first look, often seen as confused crystal ball images: intangible futures and extreme situations unconnected to people's expectations. There is a quest for compromise scenarios, which may be seen as a way to avoid thinking of uncertain effects from unthinkable elements. Putting numbers on people's own images of the future may be seen as helpful.

People can cope with a lack of knowledge and with uncertainties, although reaction to uncertainty also depends on the overall trust in the source. The interpretation of the knowledge is contested, rather than the knowledge/information itself. Justifications (rationale) seem to be more important than the uncertainties.

Melse responds that often there are conflicts of certainties (disagreement and controversy) rather than uncertainties. Credibility is not a characteristic of information, it is a product of interaction, of a relation; it is co-produced. Uncertainty and credibility thus always function in a context of relations. They can't be left out in communication of uncertainty. Furthermore, there is an issue of empowerment, there needs to be an "action perspective" for participants. There is more interest in what choices are to be made than in the knowledge on which to base the choices. Knowledge is depoliticized. One needs to create a space for feedback, discussion, and interpretation. People can make sure they understand a report only in direct contact with the authors and scientists.

Petersen summarizes that it is important to give people the opportunity to review and judge the providers of a report and his or her choices and reasoning behind those choices.

De Marchi notes a relation between the type of question people ask and the trust issue. People ask questions such as 'How do you know', 'Have you considered combined effects', 'How much experience do you have', etc. If one presents a neutral source, such as a model, people want to know how you got your result. If it comes from a source they trust, fewer questions are asked.

Guimarães Pereira responds that scientists are excused if they make a mistake, but models are not.

Funtowicz notes that some divisions are bureaucratic. People don't appreciate this. They have a more complex view on a problem than administrators and scientists. If this is not taken into account, credibility is lost.

Petersen suggest that we may test in the policy lab what the difference in impact is of information presented by a person compared to by a computer screen.

Patt notes that uncertainty is connected to emotion. In the human brain, reason is not separated from emotion. Emotion is a function of many things people are not even necessarily aware of. One could design an experiment on this. Having information come from a computer screen makes it too abstract. The lack of interpersonal relations is a shortcoming in such research. *One could ask people not only for their rational responses to information, but first of all one could ask them to identify emotional responses. This should be done first, because else it will be used as justification. Halffman suggests finding issues that people get emotional about.*

Halffman argues that the normal mode of communicating at RIVM is the issuing of a report. The experiments should thus also use a report as the main medium.

De Marchi points out to pay particular attention to non-verbal communication and accents and to look at people's record of credibility. She also makes a case for not testing too many things at a time. She recommends making a clear choice of what to test.

Melse notes that it is difficult to establish criteria for what is “better communication”. Another way to say this is “how can we play our game best and how can we get done what we want to”. Considering the possibilities to access information nowadays, Funtowicz points out that all information will leak and become public (e.g. on the internet); no information will remain secret. Reporting will need to take that context into account.
Krayer von Krauss suggests looking at this in terms of newspaper articles and news. *One could design an experiment with a fictive article that is attacking the credibility of the source of other articles. What does this do with trust?*

7. Closing

Funtowicz remarks that making uncertainty information more precise can hamper communication, making it too complex. There is something as fruitful vagueness. He also encourages the RIVM to extend the good work to other institutions.
Weiss hypothesizes that uncertainty can paralyze advocacy.
Funtowicz notes that to tackle the issue of uncertainty, we need to change the game. We need to jointly produce meaning and the justification of taking action.
Hope is expressed that other countries and their environmental assessment agencies take up thinking and discussing on uncertainty communication, as has been done in the Expert Meeting, as well.

Van der Sluijs summarizes some highlights from the meeting.
General:

- Looking at the problem framing of what uncertainty communication is about, the range of frames includes:
  - uncertainty communication as opposed to reporting
  - communicating information that is uncertain
  - communicating 'uncertainty information'
  - communicating results obtained with tools (e.g. models) that have uncertainty associated with it
  - uncertainty versus conflicting certainties
  - jointly producing meaning respectively a rationale for action, based on uncertain information
- Uncertainty communication is not a neutral exercise. Uncertainties are used strategically.
- Does uncertainty paralyze the policy process? Does it paralyze advocacy?
- To tackle uncertainty we have to change the game. We need a reflexive epistemology. Using the post normal tools transform the scientists themselves.

Scales:

- To what extent are the various scales complementary?
- Scales tend to favour quantifiable uncertainty
- Single aggregated scale versus multiple dimensions scale
- How do audiences understand probability? Frequentistic or Bayesian?
- How do stakeholders judge uncertainty?

Graphics

- Fitness for function
- What should the audience of the graph be able to do with it?
- Graphs can be misleading

Uncertainty and trust

- There is a strong relationship between uncertainty and trust
- Cultural dimension
- Importance of emotion