Reflections on the Communication of Uncertainty: Developing Decision-Relevant Information

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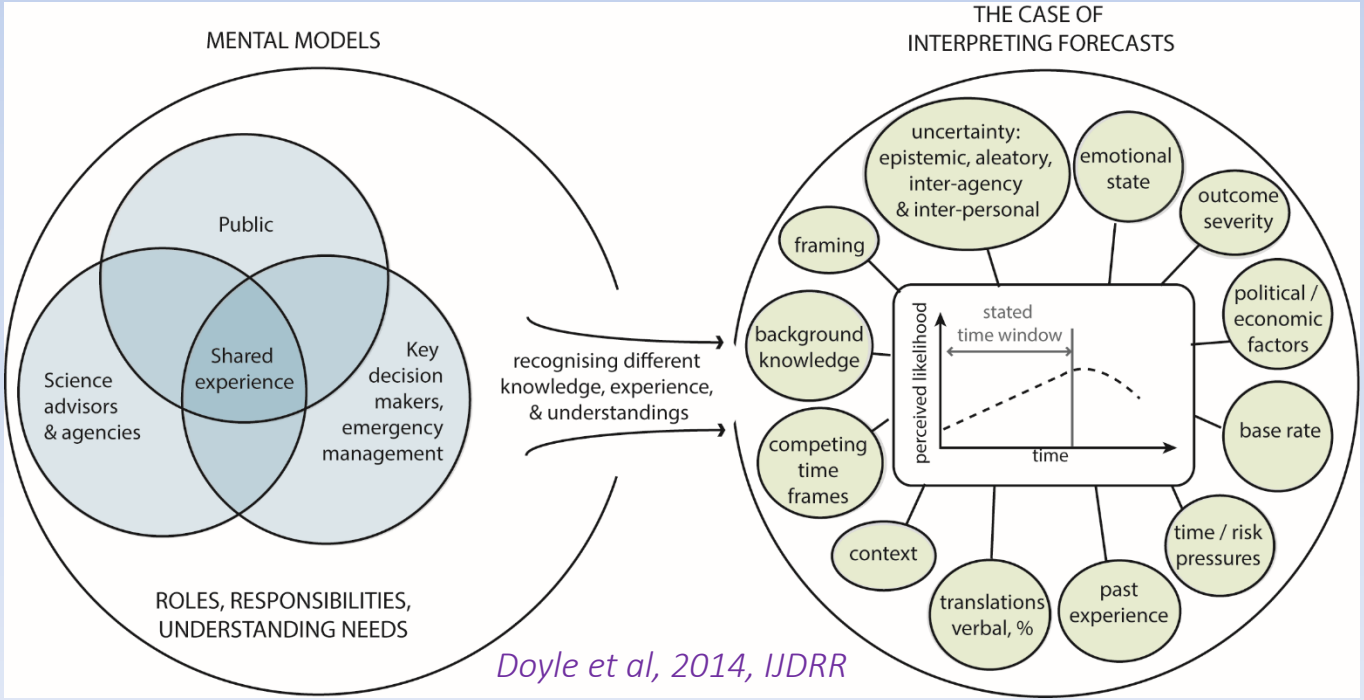
Many factors influence the understanding of uncertain science advice



Doyle et al, 2014, IJDRR

But what is ‘uncertainty’? What are the ways to improve uncertainty communications?

Uncertainty is more than information issues

- Uncertainty in the context of action *(Lipshitz & Strauss 1997)*:
  - doubt that blocks or delays action

- Sources of uncertainty for action (*also Wiedeman et al 2008; Schmitt & Klein 1996)*:
  - incomplete, unreliable, conflicting, ambiguous information, inadequate understanding, undifferentiated alternatives, disagreement among experts.

- Sources of uncertainty in advice (*van Asselt 2000; Patt & Dessai, 2005, Klein 1998*):
  - Level of the data, the level of the knowledge, level of understanding, language itself
  - natural stochastic uncertainty – *random variability or chaotic nature of the system*
  - epistemic uncertainty – *lack of knowledge of the physical processes*

- Uncertainty can cause anxiety and stress, discomfort, fear and doubt, but can also be motivational in trained personnel *(if it does not exceed their training capacity)*.
  - simulations to develop situational understanding and stress and coping capability

How communicate complex model uncertainties?

- As models become more advanced, complexity increases, number of uncertainties increase (Maslin 2013)
- Must move towards approaches that do not just suppress and reduce uncertainty, but acknowledge and incorporate uncertainty.
  - Must increase uncertainty tolerance

- Non-communication of uncertainties:
  - Limits decision-making capability
  - Can result in much deeper uncertainties due to interdependencies
- Decision makers often more comfortable with uncertainty than advisers appreciate - “uncertainty is endemic in crises”
- Need effective ways to communicate uncertain information from models and analysis techniques

Lessons from the literature

- Meta-synthesis qualitative literature review, 111 papers
  - "How do we enhance understanding of the limitations, assumptions, and alternatives, of models when people make decisions based upon their outputs?"
- Wide range of disciplines: psychology, policy, communication, law, climate change, health, geosciences, meteorology, risk analysis, environmental management.

TITLE (uncertain* OR assumption* OR limitation*)
AND TITLE-ABS-KEY (communicat* OR convey* OR represent* OR *visualis* OR *visualiz*)
AND TITLE-ABS-KEY (model* OR simulat* OR comput* OR forecast* OR predict*)
AND TITLE-ABS-KEY (hazard* OR fire* OR earthquake* OR aftershock* OR hurricane* OR volcan* OR tsunami* OR storm* OR flood* OR tornado* OR risk OR climate* OR medic* OR weather OR science OR scientific)
AND TITLE (communicat* OR convey* OR represent* OR *visualis* OR *visualiz*) OR (model* OR sim ulat* OR comput* OR forecast* OR predict*)
AND LANGUAGE (english)
AND NOT TITLE-ABS-KEY (food OR finance OR financial OR gun OR injury OR oil)

Lessons from the literature

- the need for clear typologies to identify and communicate uncertainties,
  - Language used is often muddled (linguistic uncertainty), need to standardize for context
  - Clearly defining and identifying to avoid misinterpretations of uncertainty characterizations
- the need for effective engagement with users to identify which uncertainties to focus analysis and communication resources upon,
  - Trust, epistemic differences, ethics, participatory approaches
- how to manage challenging uncertainties
  - ensembles, confidence, bias, consensus and dissensus
- methods for communicating specific uncertainties
  - maps, GIS, graphs, tables, probabilities, timeframes
- the lack of evaluation of many techniques and approaches; particularly visualisations which can unintentionally mislead or misrepresent.

Language / Typologies of uncertainties

- A typology guides scientists through a process of identifying and classifying, articulating and prioritising critical uncertainties.
- Prevents assumptions that statistical output = comprehensive account of uncertainty
- Choice of typology depends on context, many general systems exist
  - Multiple typologies may be required
- Should be co-developed, and represent how events evolved over time
- Can include scores for qualification of knowledge base and value-ladenness of assumptions,
  - value-ladenness of practical aspects, epistemic, disciplinary-bound epistemic, socio-political issues

Level, Nature, Location of uncertainty

Location of uncertainty ↓	Level of uncertainty (*from determinism, through probability and possibility, to ignorance*)			Nature of uncertainty		Qualification of knowledge base			Value-ladenness of choice		
	Statistical Uncertainty	Scenario Uncertainty	Recognication ignorance	Epis-temic	Varia-bility	-	0	+	-	0	+
Context											
Expert judgment											
Structure											
Implementation											
Parameters											
Inputs											
Data											
Outputs											

Janssen et al (2005); Walker et al (2003)

- "in filling in the matrix, one should be aware that the level and nature of the uncertainty that occurs at any location can manifest itself in various forms simultaneously"

Kloprogge et al (2005) – pedigree matrix, potential value-ladenness of assumptions

Type of value-ladenness	Practical	General epistemic	General epistemic	Disciplinary-bound epistemic	Socio-political	Socio-political	Influence on results
Criteria → / Score ↓	Influence of situational limitations	(Im)plausibility	Choice space	(Dis)agreement among peers	(Dis)agreement among stakeholders	Sensitivity to view and interests of the analyst	
2	Choice assumption hardly influenced	The assumption is plausible	Hardly any alternative assumptions available	Many would have made the same assumption	Many would have made the same assumption	Choice assumption hardly sensitive	The assumption has only local influence
1	Choice assumption moderately influenced	The assumption is acceptable	Limited choice from alternative assumptions	Several would have made the same assumption	Several would have made the same assumption	Choice assumption moderately sensitive	The assumption greatly determines the results of the step
0	Totally different assumption had there not been limitations	The assumptions is fictive or speculative	Ample choice from alternative assumptions	Few would have made the same assumption	Few would have made the same assumption	Choice assumption sensitive	The assumption greatly determines the results of the indicator

Important to account for epistemologies

- Typology schemes can help bridge epistemological and cultural differences between disciplines … acknowledge and account for different uncertainty perspectives
- People have different 'science models' related to different 'epistemic cultures'
  - Kuhnian: Science evolving (more comfortable and trusting if uncertainty present)
  - Classical: Science search for absolutes (distrusts uncertain information and source)
- Epistemology, different 'ways of knowing' – what is objective and a 'true'
  - Describes practices, arrangements, mechanisms, and history of professional expertise
  - Different between disciplines, professions, training, experience
- Different uncertainty-decision making tolerances
  - Scientists: reduce epistemic uncertainty; Engineers: accept uncertainty as core to innovation; Others: reduce, suppress, acknowledge, etc.
- Different uncertainty ethical standards between science, engineering, law journalism

Shared management of uncertainty

- Involve co-developed typologies and shared prioritisation of uncertainty
  - Focus analysis and communication only on those decision relevant uncertainties
- Participatory approaches for developing communication protocols; 'two-way communication' that: (e.g., Patt, 2009; Fischhoff and Davis 2014)
  - Prioritises needs of stakeholders
  - Decision-makers identify the important uncertainties (e.g. scenario planning)
  - translational discourse to communicate and manage uncertainty (Faulkner et al 2007)
  - shared ownership of uncertainty knowledge
  - pluralism (different perspectives), post-normal science – subjectivity of risk; social history of knowledge.
  - Co-production of knowledge; joint fact-finding for collective decision-making on key uncertainties

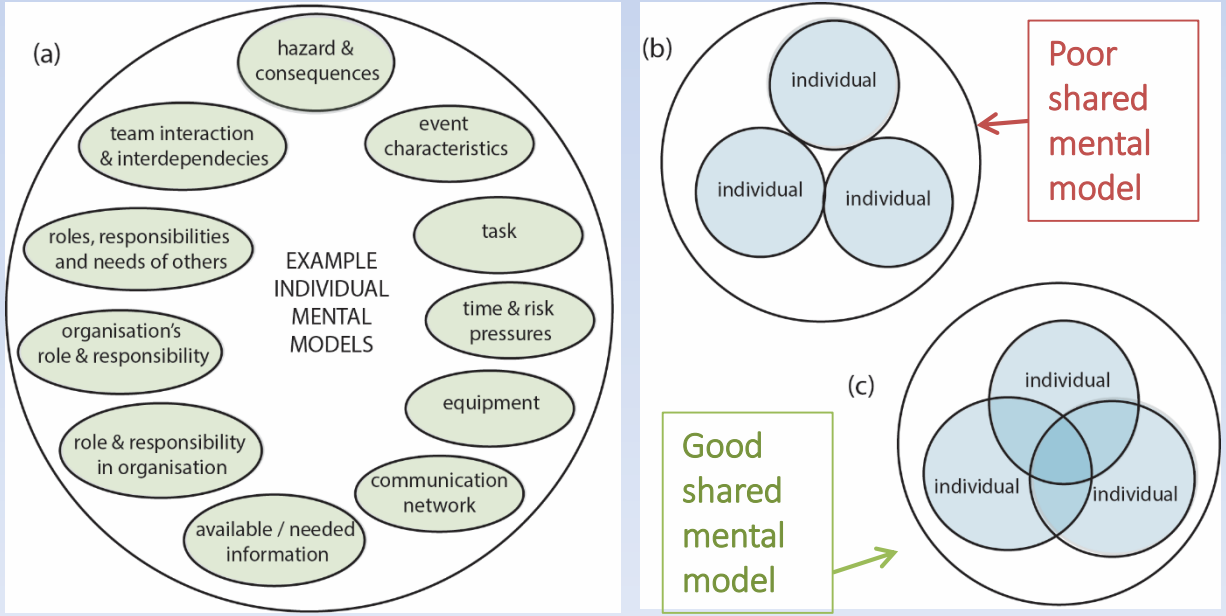
Inter-agency work = additional kinds and sources of uncertainty; often not considered

- Uncertainty related to communication and information
  - source of uncertainty itself (as to what to communicate); has sources of uncertainty within it; is a cause of future uncertainty.

- Uncertainty in the source & interpretation varies between groups
  - Advisors: uncertainty in assessment of processes and predictions, what to communicate
  - EM: uncertainty in applying information, with uncertainty due to complex response settings and impact of decisions, what to do & what others will do

- Uncertainty cascades: magnified through sequential and iterative information search, evaluations and decisions.
- Uncertainty: also due to response expectations (roles, responsibilities; discipline; training); different mental models of response; different rules and procedures; different information management and processing approaches.

Shared mental models: "The perception of, understanding of, or knowledge about a situation or process that is shared among team members through communication."



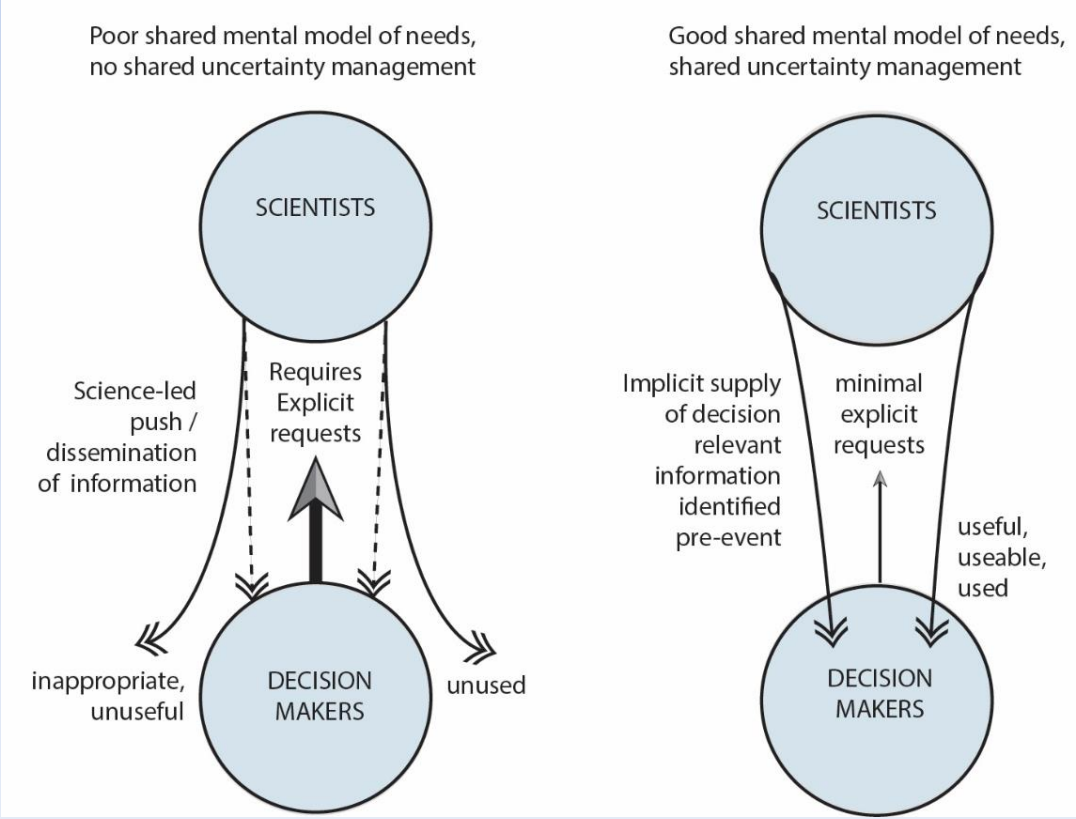
- Includes concepts, relationships and their role within the system
- Effective communication: individual integrates their mental model within over-arching response mental model

- Effective teams move from explicit requests to implicit supply of information (timely/anticipated)
- Not just providing all uncertainty information – must understand needs to meet requirements.

Ways to improve future response capability

- Undertake multi-organisational and multi-disciplinary planning activities, collaborative exercises and simulations
  - Develop similar mental models, facilitate future response capability, identify areas to improve, enhance communication , test response and logistics
- Team training: series of experiences over different environments
  - Enhance: naturalistic decision-making, decision skills, effective teams
  - cross training, positional rotation, scenario planning, collaborative exercises and simulations, shared exercise writing tasks, train the trainer, workshops, seminars, specific knowledge sharing activities
- Participatory communication protocols and uncertainty management pre-event
  - Co-production of knowledge; joint fact-finding for collective decision-making on key uncertainties; shared ownership of uncertainty

Conclusion: “decision-relevant uncertainties”



- Consider decision-makers throughout the entire science generation process, from initial problem formulation, not just ‘dissemination’
- A code of practice for engagement process vital: funding, leadership, ethical standards
- Vital to communicate useful, useable, and used information; that meet the ethical principle of “audience relevance” and is ‘socially’ and ‘morally’ responsible (O’Neil, 2002; Daedlow et al 2016).

Thank you for your time!

For our related papers: https://tinyurl.com/doyle-papers or e.e.hudson-doyle@massey.ac.nz

- Hudson-Doyle, Paton & Johnston (2018) Reflections on uncertainty communication: decision-relevant information. Proceedings of the ISCRAM Asia Pacific Conference, Wellington, NZ, 2018;
- Doyle, Johnston, Smith & Paton (2018) Communicating model uncertainty for natural hazards: a qualitative systematic thematic review. International Journal of Disaster Risk Reduction (In Press);
- Doyle, E.E.H., Paton, D. (2017) Decision-Making: preventing miscommunication and creating shared meaning between stakeholders. Advances in Volcanology. DOI: 10.1007/11157_2016_31
- Doyle, E. E. H., Paton, D., Johnston, D (2015) Enhancing scientific response in a crisis: evidence-based approaches from emergency management in New Zealand. *J of Applied Volcanology 2015,* 4:1
- Doyle E. E. H., McClure, J., Paton, D., Johnston, D. M. (2014). Uncertainty and decision making: Volcanic crisis scenarios. *Int J of Disaster Risk Reduction*. 10, 75-101

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