**CONVERSATION ARTICLE:**

**Post-truth, ivory towers, or diverse priorities? Scientists must share their experiences to increase understanding of how research evidence and uncertainty influences decision-making**

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Scientific research can inform decision-making from the levels of policy to practise. As evidenced from recent science advisory reports {<http://www.pmcsa.org.nz/wp-content/uploads/PMCSA-Risk-paper-2-Nov-2016-.pdf>; <http://eppi.ioe.ac.uk/cms/Portals/0/PDF%20reviews%20and%20summaries/Science%202016%20Langer%20report.pdf?ver=2016-04-18-142701-867>}, and institutional initiatives {<http://digitalcommons.fiu.edu/cgi/viewcontent.cgi?article=1272&context=fce_lter_journal_articles>; <https://wintoncentre.maths.cam.ac.uk/>}, scientists are increasingly motivated to undertake and communicate research that might inform and influence decision-makers. However, the will to abandon intellectual ‘ivory towers’ { <http://www.theaustralian.com.au/higher-education/science-communication-vital-in-posttruth-world/news-story/5edb913aa122bb91b4c8ef8a793682df>} does not in itself ensure a more prominent role for science in decision-making. If the proposed appointment of climate change sceptics {http://www.theaustralian.com.au/news/world/the-times/trump-picks-climate-change-sceptic-scott-pruitt-to-lead-epa/news-story/96e8292aa0789ff09b1586630b1acb30}{https://www.washingtonpost.com/news/energy-environment/wp/2016/12/06/yup-trump-met-with-al-gore-but-his-transition-tells-a-very-different-story/?tid=a\_inl} and anti-vaccination proponents {http://www.sciencemag.org/news/2017/01/exclusive-qa-robert-f-kennedy-jr-meeting-trump-proposed-vaccine-commission} to positions in the new White House administration signifies a prioritisation of emotions, personal beliefs, and social media savviness above objective facts (aka. the *post-truth world*), ensuring a role for research evidence in decision-making may be one of the greatest challenges currently facing the science community.

In July 2016, the authors of this article assembled at the Australian Academy of Science (AAS) in Canberra {https://www.science.org.au/} with a consortium of their early- and mid-career peers for the Theo Murphy High Flyers Think Tank entitled *An interdisciplinary approach to living in a risky world* {https://www.science.org.au/think-tanks/risky-world}. A prominent objective of the meeting was to better understand and improve how scientists from diverse disciplines communicate research evidence to decision-makers under conditions of risk and uncertainty. The associated recommendations report {LINK TO REPORT WEBSITE} was released by the AAS today. The purpose of this article is to highlight some of the key findings and recommendations from this report.

**COMMUNICATING SCIENCE IN AN UNCERTAIN AND RISKY WORLD**

All scientific research is subject to varying degrees of uncertainty\*. Consequently, even the most scientifically-informed decision-making contains positive and negative risks (see this link for definitions of risks and uncertainties) {http://www.pmcsa.org.nz/wp-content/uploads/PMCSA-Risk-Series-Paper-1\_final\_11May2016.pdf} resulting from the uncertainty by which desired or adverse outcomes could result.

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*\*Scientific uncertainty can arise from incomplete knowledge (aka epistemic uncertainty) and from variability intrinsic to the phenomena that is being researched (aka statistical or aleatoric uncertainty). A goal of scientific research is to reduce epistemic uncertainties through study and experimentation, and to improve the accuracy by which aleatoric uncertainties are defined using modelling and statistics.*

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The extent to which scientific uncertainty influences decision-making is often unclear and difficult to evaluate. For example, published uncertainties in climate change projections have been used as a way to rebuke and discredit scientific evidence {<https://www.theguardian.com/sustainable-business/climate-change-communication-uncertainty>} and delay policy action {<https://theconversation.com/why-climate-uncertainty-is-no-excuse-for-doing-nothing-32924>}}. Alternatively, uncertainties associated with environmental health risks {<http://www.sehn.org/ppfaqs.html>} and future seismicity risks {<http://www.chchplan.ihp.govt.nz/wp-content/uploads/2015/03/Natural-Hazards-Part.pdf>} have been used to justify health, engineering, and land-use policy developments of a precautionary nature. Reporting on the status of the Great Barrier Reef in the past has omitted any form of uncertainty. While the importance of including a quantitative uncertainty assessment has been recently recognized {<https://www.qao.qld.gov.au/reports-parliament/managing-water-quality-great-barrier-reef-catchments>} it remains unclear how best to quantify the uncertainty and communicate it in a way that facilitates decision making.

The transparent characterisation and inclusion of uncertainties is considered best-practice when publishing scientific research in peer-reviewed journals. However, the scientific community lacks consensus about the most effective approaches and pathways toward communicating science and uncertainty to decision-makers. For example, are absolute {<https://theconversation.com/confused-about-your-cancer-risk-from-eating-meat-heres-what-the-figures-mean-49888>} or relative probabilities { <https://theconversation.com/laquila-charges-leave-earthquake-scientists-on-shaky-ground-10301>} more effective when publically communicating risk? Should uncertainties be included in weather forecasts and emergency-related phenomena such as bushfire trajectories and tsunami inundation extents?

Our group { <https://www.science.org.au/think-tanks/risky-world/group-4>} discussions at the Think Tank revealed that across our diverse fields of expertise, our risk communication experiences and perspectives, our lexicons, our target audiences, the types of risks we communicate (economic vs life and death), and the cultures and protocols of our host institutions are highly variable.

However, we achieved this consensus: **we do not live in a post-truth world** (where science evidence is offered but not considered in decision-making) **nor in an ivory tower world** (where science evidence is needed by decision-makers but not offered). Rather, we live in a world with increasing diversity and complexity in decision-making. This world offers real challenges {https://theconversation.com/trump-has-embraced-pseudoscience-and-its-deceptive-tactics-in-a-post-truth-world-70134} yet also provides ample opportunities for scientists with diverse skills and priorities to communicate and engage with decision-makers; from those who acquire, interpret and communicate scientific data, to those who engage in science arbitration, advocacy, and honest brokerage {<http://rogerpielkejr.blogspot.com.au/2015/01/five-modes-of-science-engagement.html>}.

**RECOMMENDATIONS FOR IMPROVING RISK AND UNCERTAINTY COMMUNICATIONS TO DECISION-MAKERS**

In our report {LINK TO REPORT ON-LINE PUB}, we recommend **a standardised procedure** for scientists to adopt when undertaking evidence-based risk communications with decision-makers. Key elements of this procedure include the **development of an interdisciplinary risk and uncertainty communication lexicon** to ensure lessons learned may be more easily translated across distinct scientific disciplines, and a request that **scientists explicitly state the motivations that underlie their scientific experimentation and modelling processes** in risk communications so that decision makers can better understand the role of the science in assisting with their decision-making.

Given the diverse nature of science and the types of decisions it may inform, **we also recommend that high priority be given to the solicitation and publication of interdisciplinary contributions from both scientists and decision-makers that explicitly describe how scientific research evidence and uncertainty of all forms was considered within decision-making scenarios**. Descriptions should include (i) whether the scientific evidence was solicited or offered to decision-makers, and how; (ii) how the scientific research including uncertainties was communicated, and to whom; (ii) how this research was received and considered by decision-makers, if known; and (iii) how the scientific research and uncertainties influenced the ultimate decision, if they did.

If the results from scientific models were not used in the decision-making process, it will be important to understand why. Was it because scientific uncertainties were not understood, inadequately represented {https://theconversation.com/lost-in-translation-confidence-and-certainty-in-climate-science-17181}, or exceeded tolerable thresholds? Or perhaps the models themselves were not easy for decision-makers to understand and modifications are required to increase their utility {<http://yieldwise.agmodelling.com/#/>}? Were other societal, political, or fiscal factors prioritised? Are all of these factors able to be objectively analysed and justified? And what approaches are available to scientists who conclude that science evidence has been unjustly de-prioritised by decision-makers?

In our experience there is large variability in the extent to which decision-makers provide open-access documentation to the science community and general public as to how scientific advice they received informed the decision-making process. Both the public and the media have a role to play in encouraging these forms of documentation. It is largely unknown how scientific uncertainty influences the perceived credibility and ultimate uptake and application of the research evidence. The influence of public and media communications, structured science communication workshops, involvement in science advisory panels, and other science engagement strategies on science evidence uptake and the understanding of scientific uncertainty by decision-makers remains sparsely documented.

A more unifying language across the science community, and a concerted effort to document risk communication experiences following the ethical guidelines inherent to the scientific method, may benefit both decision-makers and the scientists that aim to contribute their work to decision-making processes and policies.

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