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UNDERSTANDING UNCERTAINTY

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Managing unknowns is just as important as making maximum use of what is known when responding to real world problems. Different disciplines and practice areas have established diverse ways of dealing with ignorance and uncertainty and some are outlined here. Two ways of structuring uncertainty provide insights into the nature of uncertainty: (1) a matrix distinguishing what we know and what we do not know and (2) a taxonomy of unknowns.

Integration Insights is a series of digests of concepts, techniques or real-world examples of integration in research.

INTRODUCTION

Various disciplines and areas of practice have quite different orientations to uncertainty. For some, like statistics, dealing with uncertainty is their 'bread-and butter', while in others, like law, uncertainty is largely ignored. There is also considerable diversity in positions taken on the irreducibility of uncertainty. For example, quantum physics demonstrates that some uncertainties can never be resolved, whereas in history and economics there are debates about whether certain knowledge is possible, given enough time and effort. This *Integration Insights* presents some of these differences and begins to lay out some of the complexities in developing a more sophisticated understanding of uncertainty.

Effective responses to real world problems require integration of areas of ignorance and uncertainty, as well as synthesis of discipline and practice knowledge. Two attempts to structure uncertainty are presented: (1) distinguishing between what we know and do not know and (2) a taxonomy of uncertainty. These provide significant insights, but also show that important gaps remain, where current disciplinary and practice perspectives cannot be unproblematically mapped onto existing structures.

DIFFERENCES IN EMPHASIS ON UNCERTAINTY

As Smithson (1989, 2008) and others have highlighted, uncertainty is socially constructed. One manifestation of this is that the emphasis placed on uncertainty 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 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 toward 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, standard deviations' (Attewell, 2008, p.81).

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, 2008, p.269).

Another significant difference in emphasis concerns the urgency associated with the uncertainty. Some uncertainty, as in investigating a disease outbreak or assessing intelligence, requires rapid assessment and response, whereas other uncertainty, as in investigating an historical incident or making physics measurements can generally be addressed in a more leisurely fashion.

CONFLICT OVER THE INEVITABILITY OF UNCERTAINTY

There is debate both within and across many disciplines and practice 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 allocation of effort and other resources and whether they go into accommodating uncertainty or overcoming it.

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 (Buckman, 2008). In mathematics, Gödel and others in the 1930's established that no extensive mathematical system, such as arithmetic, for example, 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 (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, such as history and economics.

In history, for example: Curthoys (2008) 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, 2008, p.201).

The debate also occurs in religion, although here it has a different cast as the debate between fundamentalism and 'rational religion'. Pickard (2008) argues that '*neither rational religion nor "religion of the heart" secures the certainty craved for'* (p.59) and that *'the need for certainty itself might be one of humanism's pathologies'* (p.57).

In some newer areas of endeavour, such as complexity science and future studies, there is a greater acceptance of irreducible uncertainties. For example, Perez (2008, p.148) points out: *'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 so many uncertainties, that 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 (2008, p.234) 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 (2008, p.266) 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 is, eliminated, or at least, controlled. While there is a steady move to accepting that there will always be uncertainties that have to be recognised 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 A STRUCTURE ON UNCERTAINTY: DIFFERENT KINDS OF KNOWNS AND UNKNOWNS

As the figure below (adapted from Kerwin, 1993) illustrates, there are three types of unknowns. Mostly we concentrate on what we know we do not know – ignorance we are conscious of.

		Meta-level	
		Known	*Unknown*
Primary level	*Known*	Known knowns	Unknown knowns (tacit knowledge)
	Unknown	Known unknowns (conscious ignorance)	Unknown unknowns (meta-ignorance)

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 organisational context. Another area where tacit knowledge is very important is politics and many political skills about timing, tactics and reading people fall into that category (Moore, 2008).

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, so that in a particular improvisational situation the musician can play without thinking about what they know (Mackey, 2008). In this case tactic 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, but 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 demonstrate and understand as we only become aware of meta-ignorance, our own personally or as a society, in hindsight. The advent of HIV/AIDS provides one 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.

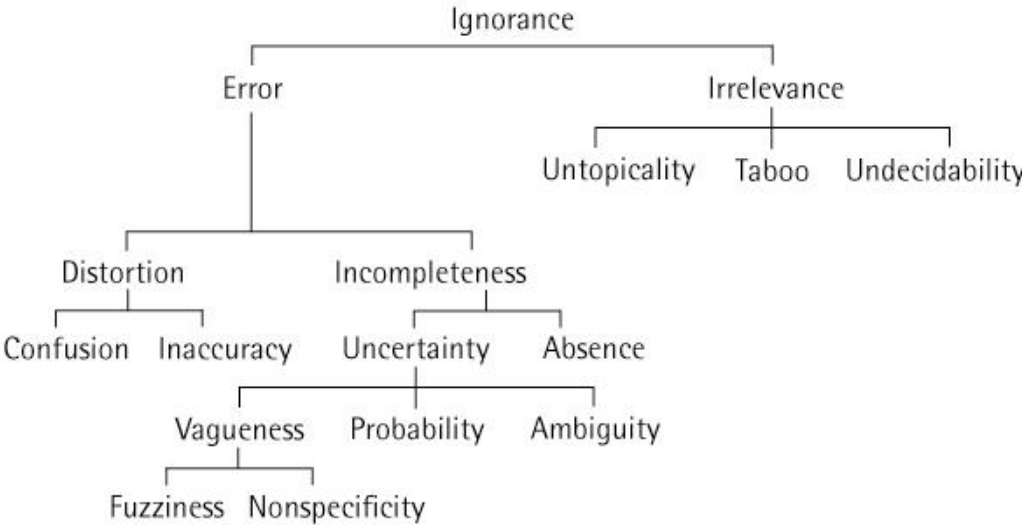
The field of future studies takes unknown unknowns seriously. The focus on blind spots and challenging assumptions is aimed at uncovering unknown unknowns before we are surprised (or devastated!) by their occurrence (Delaney, 2008).

PUTTING A STRUCTURE ON UNCERTAINTY: A TAXONOMY OF UNKNOWNS

A second approach to structuring uncertainty (Smithson, 1989) teases unknowns apart in a different way, providing a ‘taxonomy’, as shown in the figure below.

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 inattention. 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.



Error: Distortion

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.

The field of intelligence, for example, demonstrates how this practice area puts considerable effort into minimising 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 (Longford, 2008). 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.

Error: Incompleteness

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 'known unknowns' in the earlier figure and is a primary driver which stimulates us to gain further knowledge.

In turn, uncertainty can be further subdivided into 'vagueness', 'probability' and 'ambiguity'. Uncertainty occupies a special position as one of the most manageable kinds of ignorance. (Although we use the term uncertainty throughout this *Integration Insight*, it would be more accurate to use ignorance as the overarching term. However because ignorance generally has pejorative connotations, we stay with the more acceptable overarching term 'uncertainty'.)

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, 30 minute or 3 hour drive away. 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 of maintaining an unclear situation so that a perception can be created of achievement without actually having to deliver anything specific.*' (Moore, 2008, p.178).

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 landings will reveal heads and half tails. Despite the pervasiveness of probability in our lives, Hájek (2008) 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 (2008) demonstrates that as a society we are still quite illiterate in terms of accurately using the probabilistic understandings that are well established. This is true 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 (2008) instructs 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 (e.g. that a particular book will become a bestseller) can be quantified in a logically coherent way. Much research and debate regarding economic behaviour (see Quiggin, 2008) trades on this idea. Also as Hájek (2008) and Jones (2008) point out, 'degree of proof' in legal cases often is 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.'

Much of statistics tackles problems which combine vagueness and probability (Attewell, 2008). 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, the third aspect of uncertainty, 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 if it is a stolen item. Ambiguity is prominent in the law, where nuances of interpretation can be critically important (Jones, 2008).

Irrelevance

The second main arm in the taxonomy of ignorance presented in the figure 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.

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. Curthoys (2008) 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, and 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*' (p.134) but also want the truth, which may be that '*the national past may not be entirely or even mainly praiseworthy*' (p.134). 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 (2008) also provides examples of undecidability, in that history is always produced *'within and for specific cultural frameworks and perspectives'* (p.131). 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, 2008, p.275) where '... *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".'*

This taxonomy is useful in distinguishing between different kinds of uncertainty and in demonstrating more concretely how different disciplines and practice areas focus on different aspects of uncertainty. We have shown, for example, that the field of intelligence highlights distortion and tools for dealing with it, whereas statistics focuses on vagueness and probability. Conversely, the taxonomy also demonstrates 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.

CONCLUSION

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 the full range of disciplinary and practice perspectives 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, which can greatly contribute to effective integrated responses to real world problems

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PREVIOUS ISSUES

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