Fast and frugal crisis management: an analysis of rule-based judgment and choice during water contamination events

Brian H. MacGillivray

Delft University of Technology, University of Cambridge, and Cardiff University

April 2013

I am grateful to two anonymous reviewers and to the editors of the special issue for helpful comments along the way. The research was partially funded by a Mellon Sawyer Research Fellowship at Cambridge. Send correspondence to Brian MacGillivray, Sustainable Places Research Institute, Cardiff University, 33 Park Place, Cardiff, CF10 3BA (macgillivraybh@cardiff.ac.uk).

doi:10.1016/j.jbusres.2014.02.018

Abstract

Drawing on the fast and frugal research programme, this paper describes a retrospective field study of decision making during water contamination events. It characterises three heuristics employed in real-world decision making. The credibility heuristic discriminates between signals from targets and noise from distracters on the basis of the perceived trustworthiness of the message conveyor. With the precedent heuristic, the response to an unfolding event is determined by searching for past analogues (i.e. precedents) and, if found, treating the current event in the same fashion. By contrast, the facts-trump-speculation heuristic discriminates between conflicting explanations or claims according to how they rank on pre-determined hierarchies of evidence (orders of cue validities), neglecting utilities and avoiding the aggregation of competing lines of evidence. Rather than cataloguing the biases that these heuristics lead to, this paper focuses on the structural factors which shape each heuristic's ecological rationality. In doing so, the study develops ideas about how particular infrastructure systems and forms of social organisation structure the validity of cues, the accessibility of information, and the application of particular heuristics. The study also introduces the concept of safeguards to rule-based reasoning, and the idea that heuristics can be used to rationalize decisions, and deployed strategically to persuade other social actors. The over-arching claim is that the fast and frugal programme provides a powerful framework for analysing judgment and choice in organisations, and offers a bridge between psychological and political models of organisational behaviour.

Keywords: heuristics; organizational crises; disasters; organizational decision making.

Fast and frugal crisis management: an analysis of rule-based judgment and choice during water contamination events

INTRODUCTION: PARADIGMS OF ORGANIZATIONAL DECISION MAKING

Along with its central role in economics, political theory, and sociology, rational choice theory lay at the heart of much early scholarship on organisational decision making (Renn, 2008, p 26; Simon, 1979). That is, business decisions were broadly conceived of as being structured, evaluated and resolved in accordance with the norms of utility maximisation, probability theory, and the associated hallmarks of rationality. Critics were quick to highlight the implausibility of this decision making paradigm, and empirical studies soon emerged which called into question its basic underlying assumptions (Cyert and March, 1963; Simon, 1979). For example, preferences were found to be inconsistent across time and people; individuals were seen to be satisficers, not maximisers; and search behaviour was revealed to be often local rather than exhaustive. Yet critics were slow in developing an alternative model of decision making, and rational choice theory continued to dominate the organisational literature, albeit in somewhat different forms (Simon, 1979; Jaeger, Renn, Rosa and Weber, 2001). Yet by the late 1980s the premise that organisations could be plausibly modelled as rational entities became increasingly untenable. This was largely in response to a series of high profile, costly, and often tragic organisational failures, most notably Chernobyl, Challenger, and Bhopal. The idea was not that disasters indicated or were the sole province of "irrational" organisations. Rather, these events seemed to cast doubt on the conventional ways that academics conceived of and studied *all* organizational behavior.

And so organisational judgement and choice was re-conceived of as an entirely messier and more problematic affair than rational choice theory suggested. Scholars began to focus on the "dark side of organizations" (Vaughan, 1999), on the ways that judgment and choice departed from classical assumptions of rationality, and on the central importance of norms, rituals, and social structures in shaping organizational behavior. A key idea cutting across much of this emerging literature is that organisations should be viewed as socio-technical systems, in the sense that the way they work – or fail to work – is shaped by a mixture of technical, physical, governance, organisational and behavioural factors (Perrow, 1984; Turner, 1978; Woo and Vicente, 2003). Another core claim is that there are certain intrinsic features of system design and organisation that shape the potential for crises (*e.g.* interactive complexity and tight coupling; Perrow, 1984), although there are differing views over the extent to which organisational cultures and management systems can mitigate these features (Pidgeon, 2011). A final key concept is that accidents and crises rarely simply happen, but are often preceded by a series of small-scale organisational and technical failings during an "incubation period" that can last for several years (Turner, 1978). This highlights the importance of analysing organisational responses to crises or risk issues as *processes* that unfold over time (MacGillivray *et al.*, 2011).

But the shift away from rational choice theory has not been quite as coherent as the above overview implies. Instead, the turn can be grouped – with the license of simplification – into two broad research paradigms or schools of thought. One focuses on the role of power and politics; the other is mainly concerned with bounded rationality. The former is predominantly composed of sociologists and political scientists, with

(behavioural) economists and psychologists in the latter. Of course, there has been cross-fertilisation of ideas and collaborations across these boundaries, (*e.g.* behavioural economists increasingly draw on sociological concepts), and moreover we shouldn't downplay the diversity found *within* these schools (*e.g.* Edmondson and McManus, 2007). Yet they remain in a sense competing paradigms, with their own contrasting sets of disciplinary assumptions, methodological perspectives, and organising concepts (*e.g.* choice vs. routines). The basic assumption of the power and politics model is that organisations do not possess a single, superordinate goal (Eisenhardt and Zbaracki, 1992). Instead, they are coalitions of individuals who may share some goals, but who also have conflicting interests and preferences (*e.g.* safety vs. productivity, competition between departments for funds, *etc.*). These conflicts tend to be resolved in ways that reflect the desires of the most powerful organisational actors (*ibid.*). Moreover, decision makers often attempt to change power structures by engaging in political behaviours, for example coalition formation, strategic uses of information, and so forth. By contrast, the bounded rationality school is psychological in origin, and largely neglects the social, political and cultural aspects of business decision making. The animating idea is that a range of cognitive heuristics (*e.g.* availability, representativeness, anchoring and adjustment) and biases influence how organisations select, frame, and evaluate decision problems, often in ways that sharply contrast with the norms of utility maximisation (*e.g.* Busenitz and Barney, 1997; Starbuck, 2009; Bazerman, 1998; Woods and Cook, 1999). Although this turn away from rational choice theory has led to significant improvements in our understanding of how decisions are made in organisational settings, it is not without its limitations.

Critically, research within the bounded rationality tradition traces its intellectual origins to Tversky and Kahneman's (1974) heuristics and biases programme, rather than to Herbert Simon's earlier work. As a consequence, research on rules of thumb in organisational decision making – whether theoretical or empirical – tends to conceive of heuristics as error-prone rather than adaptive, as broadly specified rather than well defined, and as intuitively rather than consciously applied. This leads to various methodological and conceptual problems:

- Research in this tradition tends to begin with the identification of some pathology of judgment or choice (*e.g.* a bias, or a bad decision), which is then mapped post-hoc onto one or another cognitive heuristic (*e.g.* Bazerman, 1998; Marnet, 2007). The process analysis tends to be relatively shallow or even non-existent. This stems from the view that heuristics are intuitive tools whose application is neither explicit nor accessible to the conscious mind (*e.g.* Krabuanrat and Phelps, 1998). The problem with this approach is that Tversky and Kahneman's heuristics are so broadly specified that they can be called upon, *post facto*, to account for almost any flawed choice or behaviour (Gigerenzer, 1991, 1996).
- The empirical research is mostly conducted in the laboratory rather than the field (Elbanna, 2006), and so is not particularly well suited to examining the role that politics, conflicting interests, power-relations, and organisational structures play in shaping heuristic decision making in organisational settings (Heimer, 1988; Clarke, 1992). This lack of representative design also means that the work tends to trade in some rather bold extrapolations.

- Researchers have largely neglected the question of when or in what organisational contexts the use of heuristics might be adaptive (*i.e*. ecological rationality), focussing instead on the biases that purportedly stem from their application. Yet the fact that some of the standard cognitive biases are in conflict with each other or outright contradictory (Krueger and Funder, 2004; Gigerenzer, 1991) casts doubt on the claim that they reflect universal or hard-wired failings in cognition (MacGillivray and Pidgeon, 2011). This suggests that a keener appreciation of context and its relationship to rationality is required.

However, there is an alternative concept of heuristics – to date largely neglected in the organisational studies and management literatures – that sidesteps some of these limitations. In brief, the fast and frugal research programme emphasises the importance of delineating well specified models of inference and choice, and on paying close attention to the external environments in which heuristics function (Gigerenzer and Goldstein, 1996; Gigerenzer, Todd and the ABC Research Group, 1999). Importantly, this programme acknowledges its heavy intellectual debt to Herbert Simon, who was a sceptic of dual process theories of cognition (Simon, 1997, p 129, 137) and who preferred to believe that decision makers were broadly aware of – and could articulate – the processes by which they formed judgments and reached choices. Another key principle of this program is that heuristics are not necessarily inferior to what are classically understood as "optimal" methods of reasoning. For example, the recent financial crisis has highlighted the dangers of relying on sophisticated mechanistic models for governing complicated systems (Haldane and Madouros, 2012). The basic insight is that in many cases, models purporting to describe the states and mechanisms of complex systems may

be unobtainable (Scheffer *et al.*, 2012) or perhaps dangerously misleading. In these contexts, the logic of prediction and control, and its central assumption of full or nearly complete mechanistic understanding of the relevant system, can feed rather than prevent crises (Wynne, 1992; Haldane and Madouros, 2012; Haldane and May, 2011). An alternative logic is to design and manage systems – whether water supply, climate, or financial systems – on the basis of simple rules, or heuristics, that capture the essential elements of system operation without aspiring to full description. Simulation work in line with this principle has generated novel and important insights in various settings. For example, it has shown that heuristic models of risk in financial markets can outperform the more complex techniques favoured by regulators (Haldane and Madouros, 2012), and that there may be generic rules of thumb that presage collapse or crisis in systems ranging from physiological ones to ecological ones (*e.g.* a reduced rate of recovery from perturbations; Scheffer *et al.*, 2012). What the above sketch is intended to convey is that *deliberative* heuristics may have a central role to play in how we analyse, design, and manage all sorts of systems; that this role may not necessarily be a dangerous one; and that, above all, we should take this role seriously. This article makes an attempt to do so, drawing on the principles of the fast and frugal program, albeit from a rather different methodological perspective.

RESEARCH APPROACH

Rationale

The aim of the research was to explore the role of heuristics in real-world organisational decision making. The research questions were: what heuristics are employed; what factors shape their ecological rationality; and how is their form and

function influenced by social and political factors? A retrospective field study was adopted, looking specifically at decision making during water contamination events (*i.e.* crisis situations). The logic behind this was two-fold. Firstly, crisis decision making is characterised by time constraints, limited and often ambiguous information, intense pressure, and often stark conflicts of interest. As such, heuristics are likely to be employed, and their use is also particularly likely to be shaped by social and political factors (*e.g.* power structures). Secondly, recent years have brought a series of high-profile public inquiries into the handling of contamination events in North America and Australia, focussed in large part on understanding the contexts, rationales, and implications of key decisions taken by regulators, managers, and operating staff. The data produced allows us to reconstruct – subject to limitations – the processes by which judgments and choices were reached in real-world situations. Of course, such inquiries tend to focus on decisions that have gone wrong in some sense, and so, by extension, does this study. But the intention is not to suggest that heuristics generally misfire – the choice is largely a pragmatic one. That is, the study sought to analyse heuristics via (retrospective) process analysis, and the data required for this approach is generally only available for decisions that have misfired. Yet it is also by design – by studying instances where heuristics have gone awry, we can gain insights into their ecological rationality.

Methods

The study is a retrospective analysis of decision making preceding and during water contamination events. The sample consists primarily of relatively recent, well-publicised, major incidents which occurred in the developed world (Walkerton, North Battleford, and Sydney). The data is composed of the accounts of actors involved in

decision making processes within the events (*e.g.* operators, management, regulators), supported by the accounts of those who observed or studied them (*e.g.* public inquiry heads, scholars) for context and to aid the theoretical analysis. The principal data sources are the reports, transcripts and submissions to public inquiries into those events (outlined in Table 1). The data analysis was undertaken in the spirit of the grounded theory approach (Glaser and Strauss, 1967). The initial stage was identifying the decision making processes which the inquiries focussed upon. These included, for example, judgments about the plausibility of concerns raised by operating staff, and decisions about how to respond to reports of microbiological contamination. These inferences and decisions were then analysed with the goal of discovering which, if any, heuristic underlay them. This involved scrutinising the evidence within the inquiry reports and academic case studies, tracing this back to witness testimony (in the transcripts) and evidence submissions, cross-checking these different sources and types of evidence along the way. Following in the spirit of protocol analysis, the focus of the analysis was on the *processes* or rationales by which inferences were made, and choices reached, rather than on the judgments or decisions themselves. The heuristics were then grouped into categories according to their similarities and differences. This process was performed iteratively, so that what began as series of disparate heuristics were subsumed into three well-specified, general purpose rules of inference and choice (*e.g.* an initial heuristic was "if a disease outbreak occurs, then presume the source is viral;" this was later subsumed within the larger category of the precedent heuristic). Heuristics are defined here as rules of thumb for inference and choice. There are three key elements to this definition: heuristics are rule-like, in the sense that they structure or constrain judgment; they are rules of inference or choice (*i.e. if-then*), not simply assumptions; and finally, they are

simple, frugal approaches to problem solving which ignore relevant information rather than seeking to optimize. Although heuristics are treated rather differently across and even within different disciplines – in terms of their normative status, where they reside, and whether they are implicit or explicit – this definition seems to capture some key shared understandings (see also, Gigerenzer and Gaissmaier, 2011).

There are important limits to this methodological approach. Public inquiries are broadly concerned with seeking the truth of the events that they study – what happened, why, and with what implications – but the intentions or abilities of the witnesses called may be quite different. Major issues include blame management and imperfect recall. But inquiries are not blind to such problems, indeed their very design is rooted in the concept of triangulation. Multiple witnesses are called upon, various sources of evidence are sought (oral testimony, formal submissions, *etc.*), claims are scrutinised and cross-checked for internal and external consistencies, *etc.* In short, triangulation is built into the object and design of our study, and so whilst we are indeed analysing the claims of particular actors with particular interests, these claims have been cross-checked for consistency and coherence against multiple sources and types of evidence. For example, when an actor claims that he took a particular decision for a particular reason, we can cross-check this claim against the rest of their testimony, compare it with other witnesses' versions of events, and scrutinise whether other sources of evidence made available to the inquiry – such as internal memos or water quality monitoring records – are at odds with his claims. Of course this is the real world and not the laboratory, and so we are dealing with actors, data sources, and events that we cannot control in a strict methodological

sense. But these are the unavoidable costs of venturing out to study decision making in the wild. As such, the work should be taken as exploratory rather than confirmatory.

In the remainder of the paper, we present this classification of heuristics, discuss their ecological rationality, and explore their relationship to social and political factors.

RESULTS AND DISCUSSION

For context, Table 1 provides the basic features of the water contamination events analyzed. Table 2 characterizes the heuristics employed in managing these events. We presume no detailed knowledge on the part of the reader regarding the infrastructure and processes of water supply systems. That said, to best illuminate the form and structure of each heuristic, some technical and operational details are touched upon. In the remainder of this section, we discuss the three heuristics in turn, beginning with the credibility heuristic, the precedent heuristic, and, finally, the facts-trump-speculation heuristic.

Table 1 and Table 2 here.

The credibility heuristic: a rule for discriminating between signal and noise

Perhaps the simplest rule of thumb observed was the credibility heuristic. It can be classed as a conjunctive rule, whose purpose is to distinguish between frivolous and genuine warning messages. This is a classical task for both lay and expert reasoning. Whilst the latter tend to rely on statistical methodologies to do so (*e.g.* significance testing), these more formal methods are generally far removed from the context of crisis management. Our rule acts to discriminate between a signal from a target and noise from

a distracter, using the perceived credibility of the message conveyer as the *sole* cue (Table 2). In this context, warning messages are data which suggest concern with the safety of the drinking water supply system, and can be thought of as risk-indicators. These messages may come from people (*e.g.* concerns raised about an unsafe operating practice) or from technical systems (*e.g.* alarms indicating a failure of disinfection systems). On first glance, this heuristic seems close to tautological ("we believe those whom we find credible"), but it is not. It is a rule of thumb that involves the neglect of potentially relevant information (*e.g.* substantive issues about the signal *content*, and the costs and benefits of neglecting or acting upon it), and uses one cue (the perceived credibility of the signal's conveyor) to structure decision-making.

Now for some examples of the rule's application. To begin with, prior to the outbreak of waterborne disease in North Battleford (Hrudey *et al.*, 2006), plant operator Peter Allen raised a series of general concerns and warnings about the hazard posed by cryptosporidium (the pathogen ultimately responsible for the outbreak) to both senior management and the utility administration (Laing, 2002, p 97). Yet rather than investigate the substantive validity of these concerns (*e.g.* by exploring the pathogen's existence in source water, the effectiveness and reliability of the treatment and disinfection processes in removing it, *etc.*), management and the administration dismissed his warnings as non credible, largely because Allen only raised them in the context of negotiations about improvements in occupational health and safety or more general labour matters (Laing, 2002, p 98). As Allen stated in his inquiry testimony, "it was decided that I was the wing nut in the operation and that I didn't know what I was talking about" (North Battleford inquiry transcript, 12th October, 2001, p36-37). In large part, Allen was perceived as

using these warnings as bargaining chips in pursuit of a broader political agenda. Put simply, a judgment about Allen's credibility precluded an evaluation of the merits of his concerns.

Of course, given the high level of automation of many modern water supply systems, the conveyor of warning messages is often a machine of sorts. But credibility remains an issue here. This study uncovered cases where spurious warning messages from machines (*e.g.* alarms indicating a failure of disinfection processes) were perceived as being endemic, such that warning messages were met with the uncritical presumption that they were false positives (*i.e.* that they did not reflect a genuine problem), with limited or no further investigation by staff. This happened at minor incidents in Scotland at Oykel Bridge (DWQR, 2008, p75) and the Western Isles (DWQR, 2008, p118), where low chlorine alarms were ignored by system operators on the mistaken assumption that they were faulty readings, of which there had been several in the preceding periods. On first glance, this merely illustrates the fairly banal point that automated systems can lose their credibility, particularly during periods where they consistently raise false alarms. On closer inspection, this is crucial for water supply systems, where the relatively low frequency of microbial and chemical contamination events, combined with the typical specificity and sensitivity of detection systems, creates a tendency for false positives to dominate false negatives during routine operations (Hrudey and Leiss, 2006). This means that clusters of spurious warning messages will not be uncommon, even when alarm systems are functioning properly. During such periods, staff may mistakenly conclude that alarm systems are malfunctioning, leading to the neglect of genuine warning messages. In the words of the old fable, "even when liars tell the truth, they are never

believed." This suggests that certain structural features of water supply systems can limit the correlation of credibility with the criterion that it is purporting to predict – in this case, whether the message represents signal or noise. This tells us something about the factors that shape the ecological rationality of the rule. Another issue is how and where exactly the *threshold* is drawn for judging credibility, whether it is learned or taught socially, and whether it should embody precautionary norms in particular environments. But at root the question of when it makes sense to rely on the credibility heuristic, and when to prefer other rules or even alternative species of reasoning (*e.g.* factors based judgments, see Box 1), is a *comparative* one, and one that requires the specification and testing of alternative models of choice in controlled experimental settings (Gigerenzer and Gaissmaier, 2011). More on some of these ideas later.

Box 1 here.

The precedent heuristic: a rule for reasoning by analogy

The second rule of thumb observed was the precedent heuristic. It works by categorising individual events as part of a (typically larger) class of historic events. In the context of crisis management it functions as follows: search for precedent(s) for unfolding event (*i.e.* historic analogue(s)), and if identified, then treat the current event in the same fashion as they were. It is a form of reasoning by analogy, the underlying principle being *treat like cases alike*. The analogues may range from single, near-replicas of the particular event or phenomenon being considered, to a larger set of approximate comparators. We start with an example of the former. Immediately prior to the North Battleford outbreak, one of the operators voiced concerns about the problems posed by

operating the plant with zero settling in the solids contact unit (SCU) (Laing, 2002, p 101, 144). Briefly, the SCU was relied upon to clarify the water (via chemical coagulation, flocculation and sedimentation) before the rapid sand filtration process, and its suboptimal performance was later identified as the proximal cause of the Cryptosporidium outbreak. A key reason for marginalising these concerns was the *precedent* of the "trouble free" period the previous year, when the plant had operated under those very same circumstances without incident (*i.e.* where the SCU was operating without a key piece of equipment, and not achieving adequate settling, yet no harm to the population resulted) (Saskatchewan Environmental Society and Nature Saskatchewan, 2002, p5). This case doesn't tell us a great deal about the ecological rationality of the heuristic – beyond highlighting the problems of relying on a single precedent, and by extension, the dangers of over-generalising. That is, the heuristic wasn't misapplied in the sense of the two cases being fundamentally different in some way (*i.e.* the analogical mapping was not spurious), instead, the issue was more one of sample size. That is to say, the water system *had* indeed been at significant risk during the earlier "trouble free" period of operation, and it was only due to system redundancies, safety margins, and pure chance that harm had not resulted during this period. And so the precedent it had set was misleading. In industries characterised by a propensity for rapid change (*e.g.* in technologies, working practices, external environments), or where cause-effect relationships are complex and stochastic (*e.g.* where sub-optimal process operation does not always lead to adverse consequences in output), reliance on small sample sets in analogical reasoning may be particularly problematic. Put another way, a larger training set seems required, so that the heuristic's application captures a broader picture of the underlying system variability. And so we'd plausibly expect to see the precedent heuristic

drawing on larger sets of analogues in these sorts of environments, two examples of which we discuss below.

Both examples involve public health officials seeking to find the source of disease outbreaks within their communities, which is central to limiting their spread and for guiding options for treating the ill. We begin with Walkerton, where health officials were informed (on May 19th 2000) of symptoms within the population that were consistent with infection by a particular strain of *E. Coli* (O'Connor, 2002, p 9). At this stage, the officials were unaware of problems with the water supply system. Their initial response was to adopt the default presumption that the outbreak was likely food-borne, and this served to guide their early investigations into the source of the outbreak (O'Connor, 2002, p 69, 70, 75). Their training and experience told them that that food is by far the most prevalent source of outbreaks with symptoms of that nature (in developed nations). More specifically, given the limited case-specific details which they had at the outset, the officials reasoned that the most sensible presumption was to defer to precedent, or base rates (*ibid.*). We saw the same logic at work in North Battleford. Here, on learning of evidence of an outbreak of enteric disease (April 12th-13th, 2001), the town's chief medical officer presumed that viral pathogens – either transmitted by food or person-to-person – were the likely source (given the base rates), and structured his investigations accordingly (Laing, 2002, p 135, 138, 186). In both cases, the initial presumptions turned out to be wrong. The point is not that deferring to base rates is unwise; to the contrary, it is an entirely reasonable strategy when there is limited or ambiguous case-specific evidence.

An important question, however, is whether those default presumptions are flexible starting points, open to adjustment as case-specific evidence begins to accumulate. Walkerton is an excellent example of this: as evidence emerged suggesting that water rather than food was the source of the outbreak (*e.g.* the very young and the elderly had contracted bloody diarrhoea), the public health officials issued a precautionary boil water advisory on May 21st 2000, a full two days before tests confirmed that the drinking water supply was contaminated (O'Connor, 2002, p 80-81). North Battleford provides us with a contrasting example. Here, the town's medical health officer remained of the view that the outbreak was most likely viral in origin up until April the 23rd 2001, and by extension transmitted by food or person-to-person, making only cursory inquiries into one of the town's two water supply systems as potential sources (Laing, 2002, p 137). This was despite a growing volume of confirmed cryptosporidium infections in the population (a protozoan rather than viral pathogen), and no obvious common factor to suggest food-borne or person-to-person transmission as a source. This fixation or anchoring on the base-rates markedly exacerbated the scope of the waterborne outbreak.

These two contrasting cases should *not* be taken as illustrating the differences between rule-based and probabilistic styles of reasoning, with the Walkerton officials being the archetypical Bayesians in contrast to North Battleford's heuristic thinkers. Instead, it shows us the different ways in which the *same* rule of thumb can be applied in broadly similar situations, highlighting the central importance of flexibility. Rules, particularly those applied deliberatively and explicitly, are never quite rules, both in the sense that there is inescapable semantic and substantive ambiguity in how they are

interpreted (Wittgenstein, 1958), but also in the way that their conscious nature means that they are always, at least in principle, open to critical scrutiny and over-riding. The key lesson of the two cases seems to be that heuristics are *not* problematic *per se*, but can become so when we treat them as *laws* and neglect their rough and contingent nature. We return to this idea later, when we discuss the concept of safeguards or hedges in rule-based reasoning.

The facts-trump-speculation heuristic: a non-compensatory approach to weighting evidence

The third rule of thumb observed was the facts-trump-speculation heuristic. Its function is to discriminate between competing explanations or claims based on pre-determined (but possibly implicit) hierarchies of evidence (orders of cue validity). It has some structural commonalities with the credibility heuristic, a key distinction being that the former focuses on the interpretation of a discrete signal, whilst the latter is concerned with *multiple lines of evidence.* It is a non-compensatory approach to weighting evidence, functioning as follows: when faced with conflicting explanations or claims about a phenomenon, order them according to a predefined hierarchy of evidence (cue validities), and treat the highest ranked line of evidence as true. The explanations or claims with which we are concerned may relate, for example, to weaknesses in the water supply system, to the causes of unfolding events, or to the most effective solutions to problems. Often these types of claims or explanations come into conflict, and this heuristic offers a simple way of discriminating between them. The rule's underlying principle is simple enough: explanations or claims with the strongest factual or evidentiary basis are to be preferred to those resting on mere plausible hypotheses, speculations, or more broadly

lacking a powerful evidentiary basis. On first glance, it may appear more of a rule of logic than a rule of thumb – or what philosophers call a universal generalisation (*e.g.* "all bachelors are unmarried;" Schauer, 2003). In other words, are facts not better than speculations as a matter of definition? Not so. The key points are that the rule involves the neglect of utilities; does not attempt to aggregate competing lines of evidence (instead treating the strongest line as true); and is based on hierarchies of evidence (cue validities) which are inevitably contingent, socially constructed and context dependent (*e.g.* in some decision-making tasks, the available speculations may do more interpretive work for us than what are classified as stronger forms of evidence).

To flesh out these concepts, we first need to briefly outline two classes of evidence that have special significance for crisis management in the water supply sector: measures of microbial safety and of process reliability. Although there is some overlap between the two, the former describe the microbiological quality of the water itself (*e.g.* colony counts, *E. coli*), whereas the latter describe the reliability or performance of particular steps or processes in the water supply system (*e.g.* chlorine residuals, turbidity levels, pH). The measures of microbial safety – particularly those indicating faecal contamination – have traditionally been viewed as the strongest evidence of the safety of the water supply system (or unsafety), although recent years have seen a growing emphasis on measures of process reliability (*e.g.* Ashbolt *et al.*, 2001). We now move to some instances of the heuristic's application.

Recall that at North Battleford, some months prior to the outbreak itself, there was a "trouble free" period during which the plant operated without adequate mixing in the

solids contact unit. The role of this unit is to clarify the water. It essentially works by letting suspended material settle by gravity, which in turn is crucial for the removal of pathogens. During this period, two operating staff raised concerns about the hazards posed by operating in these conditions (Laing, 2002, p 87). The plant supervisor brushed off those concerns about system safety by noting that, at the time, the turbidity and chlorine residual measures were within normal parameters (measures of process reliability) (*ibid.*). As the subsequent inquiry revealed, he failed to seriously consider what the function of the solids contact unit was, or the potential implications of operating without achieving adequate mixing in it. Thus, the evidence of process reliability (the "facts"), as reflected in the reassuring turbidity and chlorine residual measures, served to trump the concerns raised by the operators. Although no outbreak occurred during this phase, the water supply system was at considerable risk. This points to one limit of the facts-trump-speculation heuristic, namely that even strong forms of evidence often bear only a stochastic relationship to the reality that they purport to represent. Put more blandly, the measures of process reliability are proxies for risk, rather than infallible indicators. Take turbidity levels first. This measure is useful because pathogens are more likely to be present in highly turbid source waters, and, moreover, high turbidity levels render any pathogens that are present more resistant to disinfection. However, it is also true that high levels of pathogens, such as cryptosporidium, can be found in source waters within normal bounds of turbidity. By the same token, the presence of chlorine residuals post-disinfection is a reliable indicator that most disease causing organisms have been removed. Yet this measure is largely irrelevant with regard to pathogens that are resistant to chlorination, such as cryptosporidium. This problem is by no means unique to the incident that we described; we observed several instances wherein tentative or speculative

concerns about system safety were (wrongly, as it turned out) dismissed with reference to the more concrete evidence reflected in monitoring results. The point, by now perhaps laboured, is that this non-compensatory rule – where the strongest line of evidence is treated as true – draws on generalisations (cue orderings) and so will inevitably misfire in certain contexts. The question then becomes: in which particular contexts will the rule misfire, and how might its performance compare with alternative species of reasoning?

Drawing on Todd *et al.* (2011), we can tentatively suggest that its ecological rationality will be limited in situations where a) the hierarchies of evidence upon which it is based are uncertain, or b) where there is low or moderate variability in cue weights (*i.e.* the cue validities are not highly-skewed), or c) where the hierarchies are context dependent (*i.e.* the cue validity orderings are unstable). These characteristics seem roughly true of water supply systems, where even the strongest forms of evidence of system safety bear an imperfect relationship to the states of the world that they seek to represent, and where ideal cue-orderings shift depending on a range of contextual characteristics. Although of course this is a rough intuition, rather than a formal treatment. A second issue is that we are dealing with public health issues – where the costs of action and inaction are asymmetric – and so neglecting utilities seems particularly problematic (Hrudey and Leiss, 2003). Perhaps a modified form of the rule might be more ecologically rational in this context. In one such modified form, the decision-maker would treat the strongest line of evidence as true, whilst allocating resources to *investigate* the line of evidence suggesting the worst-case scenario. This can be thought of as a sort of maximin safeguard, or precautionary hedge. The question of safeguards – in terms of which ones exist, when they are applied, and with what costs and

benefits – has been largely neglected in the heuristics literature. This is probably because heuristics have been predominantly conceived of as residing at the subconscious level. But if we take seriously the idea that people are often aware that they are relying on rule-based reasoning (*e.g.* Kruglanski and Gigerenzer, 2011), it seems more than plausible to think that they might be using them alongside certain safeguards or corrective hedges. Indeed, the ancient legal concept of equity – a safeguard against the injustices that can stem from the mechanical application of rules – and Plato and Aristotle's arguments in favour of it, reflect this very idea (Schauer, 2003).

Another interesting aspect of the heuristic is that what passes for fact and what counts as speculation – in other words, the hierarchies of evidence or cue-orderings on which the rule draws – is in part socially constructed. This does not simply mean that those hierarchies are contingent – which we discussed above – it calls our attention to the roles of politics, power, and interests, in shaping how the heuristic is applied. Doing so also leads us to consider whether the rule might be applied in a justificatory or strategic way. In other words, that the rule might be (implicitly) called upon to rationalize decisions taken on other grounds, or to persuade other social actors. A case in point is the Sydney contamination event. By way of background, between the 21st and 28th of July 1998, routine and follow-up sampling had detected low-to-high levels of protozoan contamination at various points within Sydney's water supply system (McClellan, 1998, p 29-39). Making sense of these results was a complex affair, as the pattern of contamination was changing from day-to-day, both in terms of the levels detected and the areas implicated (Stein, 2000). Nevertheless, the initial view – held by the water company and the public health agency – was that the contamination was likely localized, perhaps

arising from pockets of negative pressure which were allowing untreated water into the system (McClellan 1998, p 35). Reflecting this, a boil water notice was issued for a small part of the system on the 27th of July. On the 29th of that month, the situation changed radically. Contamination was detected in sediment at the bottom of one of the clear water tanks at a major plant (Prospect plant, which served the majority of Sydney), and in its downstream reservoir (Potts Hill) (McClellan, 1998, p 40-41). On account of this, discussions in Sydney Water's Operations Room that evening were converging upon the view that: a) the source of the contamination was further upstream than previously thought; b) that the contaminants had likely dispersed throughout a far broader area of the system (the Prospect Plant served the majority of Sydney), and c) that a far broader boil water advisory was required.

This convergence was challenged when Sydney Water's chairman arrived at the Operations Room, voicing his skepticism that the scope of the alert should be extended to cover the entire Prospect system. At the onset of the ensuring debate, one of the senior operations staff (Mackender) drew attention to the contamination detected in one of the clear water tanks at Prospect (McClellan, 1998, p 50). Yet the chairman (Hill) marginalized these data-sets (that particular tank was offline at the time), and focused instead on the recent clear readings immediately downstream of the plant. Mackender countered by noting the utility's recent experience of obtaining clear readings from areas later found to be contaminated (*ibid.*). On this basis, he was unwilling to dismiss Prospect as the source of the contamination. The chairman responded:

"I don't want to know about your theory, I want to work on the actual data you've got [showing] where there is a problem." (*ibid.*)

Throughout the discussion, Hill repeatedly stated "tell me the facts," and "where have you actually observed this parasite? Where have you actually observed it?" (*ibid.*) As Mackender noted, his "best technical assessment of what could happen" (McClellan, 1998, p 51) was reduced to being, in Hill's eyes, mere speculation. As Mackender recalled:

"I think he listened to what I had to say [regarding Prospect being potential source of contamination] and took the bits that he wanted to hear and made a decision. Now, he may have put less weight – he may have put less weight on my "speculation" and more weight on the part where we had numbers…" (*ibid.*)

In short, the monitoring results that were suggestive of localized contamination were framed by the chairman as concrete facts, as valid evidence, whilst the technical arguments which spoke to a far broader extent of contamination were dismissed as "speculation" or mere "theories," and the data which seemed to support these claims was simply ignored. Ultimately, the views of the technical and operational staff – those individuals who best understood the system – were marginalized in favor of the Chairman's view that they should limit the boil water notice to "the minimum area that could be demonstrated based on the facts." (McClellan , 1998, p 57) Put another way, the Chairman's construction of the facts trumped what he argued were the mere speculations and theories of his technical staff. The public inquiry concluded that the Chairman

seemed influenced by concerns for the water company's reputation and commercial interests, rather than the protection of public health (McClellan, 1998, p 69). This serves to illustrate that questions of what facts should be treated as relevant, and of how to distinguish between facts and speculation (*i.e.* the ordering of cue validities), can be resolved in ways that favor hierarchies of power and particular organizational interests. On this reading, the Chairman seems to have called upon the heuristic to *justify* rather than make his decision – in appealing to an explicit if rather idiosyncratic hierarchy of evidence, and in forcefully arguing that the stronger line of evidence should be treated as true. In social settings, reason-giving is a central element to persuasion, and if those reasons can be formulated in a way that seems to accord with a useful (and perhaps widely used) heuristic, then all the better for the persuader. Heuristics can be seen then as tools that might be deployed strategically in social settings, and quite possibly in ways that are problematic.

CONCLUSIONS

Drawing on a retrospective field study of crisis management in the water supply sector, this paper has characterized three rules of thumb employed in real-world decision making: the credibility, precedent, and facts-trump speculation heuristics. Each heuristic has an underlying logic, can function in data sparse conditions, and allows for rapid decision making. As such, they lend themselves to crisis decision making. However, as they are inductive methods, they are of course no strangers to error. Taking its lead from the fast and frugal research program, this paper has focused not on cataloguing those biases, but rather on exploring the structural factors which shape each heuristic's ecological rationality. In doing so, it has drawn upon and sought to extend the concept of

ecological rationality, introducing ideas about how particular infrastructure systems and forms of social organization structure the validity of cues, the accessibility of information, and the application of particular heuristics. This has been largely neglected in the heuristics literature to date – partly because of the lack of field studies, but also due to the conception of heuristics as intuitive tools, residing within the subconscious of individuals. Yet once we conceive of heuristics as applied consciously, deliberatively, and as subject to negotiation and social construction, we open up promising possibilities for exploring the relations between rule-based reasoning and social, political and organizational structures. It also opens up hitherto untraveled conceptual avenues, suggesting that we need to think about the safeguards that might be built into the application of rules, and also to explore the way that heuristics might be used to rationalize or justify inferences and choices, and perhaps as tools deployed to persuade other social actors. However, it also suggests limits on how narrowly we can define models of heuristics. That is, it implies that the precise form that rules take in particular instances will be shaped by power structures, contingencies, organizational histories, and personal experiences. Whilst this does not challenge their explanatory power, it does suggest limits on predictive capacity. Nevertheless, the fast and frugal program is a powerful framework for analyzing judgment and choice in organizations, and offers a bridge between psychological and political models of organizational behavior.

References

Ashbolt, N.J., Grabot, W.O.K. & Snozzi, M. (2001). Indicators of microbial water quality, in Water quality: guidelines, standards and health (Eds. Fewtrell, L. and Bartram, J.), IWA, London, 43-59.

Bazerman, M.H. (1998). Judgment in managerial decision making (4th Edition), Wiley, NY.

Busenitz, L.W. & Barney, J.B. (1997). Differences between entrepreneurs and managers in large organizations: biases and heuristics in strategic decision making, Journal of Business Venturing, 12, 9-30.

Clarke, L. (1992) Context dependency and risk decision making, in Organizations, uncertainties, and risk (Eds. Short, J.F. and Clarke, L..), Westview Press.

Cyert, R.M. & March, G. (1963) A behavioral theory of the firm, Englewood Cliffs, NJ: Prentice-Hall.

DWQR (Drinking Water Quality Regulator) (2008). Drinking water quality in Scotland 2007: Annual report by the drinking water quality regulator, available at http://www.dwqr.org.uk/technical/annual-report.

Edmondson, A.C. & Mcmanus, S.E. (2007). Methodological fit in management field research, Academy of Management Review, 32 (4), 1155–1179.

Eisenhardt, K.M. & Zbaracki, M.J. (1992). Strategic decision making, Strategic Management Journal, 13, 17-37.

Elbanna, S. (2006). Strategic decision-making: Process perspectives, International Journal of Management Reviews, 8(1), 1-20.

Gigerenzer, G. (1991). How to make cognitive illusions disappear: Beyond "Heuristics and Biases," European Review of Social Psychology, 2, 83-115.

Gigerenzer, G. (1996). On narrow norms and vague heuristics: A reply to Kahneman and Tversky, Psychological Review, 103, 592–596.

Gigerenzer, G. & Gaissmaier, W. (2011). Heuristic decision making, Annual Review of Psychology, 62, 541-482.

Gigerenzer, G. & Goldstein, D.G. (1996). Reasoning the fast and frugal way: Models of bounded rationality, Psychological Review, 103(4), 650–669.

Gigerenzer, G., Todd, P.M., & the ABC Research Group (1999). Simple heuristics that make us smart, Oxford University Press, USA.

Glaser, B. G. & Strauss, A.L. (1967). The discovery of grounded theory, Aldine de Gruyter, New York.

Haldane, A., & Madouros, V. (2012). The dog and the frisbee, Federal Reserve Bank of Kansas City's 36th economic policy symposium, August 2012, paper available at: http://www.bankofengland.co.uk/publications/Documents/speeches/2012/speech596.pdf

Haldane, A., & May, R.M. (2011). Systemic risk in banking ecosystems, Nature, 469, 351-355.

Heimer, C.A. (1988). Social structure, psychology, and the estimation of risk, Annual Review of Sociology, 14, 491-519.

Hrudey, S.E. & Leiss, W. (2003). Risk management and precaution—insights on the cautious use of evidence, Environmental Health Perspectives, 111, 1577-1581.

Hrudey, S.E., Payment, P., Huck, P.M., Gillham, R.W., Hrudey, E.J. (2003). A fatal waterborne disease epidemic in Walkerton, Ontario: comparison with other waterborne outbreaks in the developed world, Water Science and Technology, 47 (3), 7–14.

Hrudey, S.E. & Hrudey, E.J. (2005). Safe drinking water: Lessons from recent outbreaks in affluent nations, IWA Publishing, London, UK.

Hrudey, S.E., Hrudey, E. & Pollard, S.J.T. (2006). Risk management for assuring safe drinking water, Environment International, 32 (8), 948–957.

Jaeger, C.C., Renn, O., Rosa, E.A. & Weber, T (2001). Risk, uncertainty, and rational action, Earthscan, UK.

Krabuanrat, K. & Phelps (1998). Heuristics and rationality in strategic decision making: An exploratory study, Journal of Business Research, 41, 83-93.

Krueger, J.I. & Funder, D.C. (2004). Towards a balanced social psychology: Causes, consequences, and cures for the problem-seeking approach to social behavior and cognition, Behavioral and Brain Sciences, 27, 313-376.

Kruglanski, A. & Gigerenzer, G. (2011). Intuitive and deliberate judgments are based on common principles, Psychological Review, 118, 97–109.

Laing, R.D. (2002). Report of the Commission of Inquiry into matters relating to the safety of the public drinking water in the City of North Battleford, Saskatchewan, Department of Justice, Government of Saskatchewan, Regina, SK, 372 pp.

MacGillivray, B.H. & Pidgeon, N.F. (2011). Humility needed in decision-making, Nature, 475, 455.

MacGillivray, B.H., Alcock, R.E. & Busby, J.S. (2011). Is risk-based regulation feasible? The case of polybrominated diphenyl ethers (PBDEs), Risk Analysis, 31 (2), 266-281.

Marnet, O. (2007). History repeats itself: The failure of rational choice models in corporate governance, Critical Perspectives on Accounting, 18, 191-200.

McClellan, P. (1998). Second interim report. Sydney Water inquiry, New South Wales Premier's Department, Sydney, NSW (1998a).

O'Connor, D.R. (2002) Report of the Walkerton inquiry. Part one: the events of May 2000 and related issues, The Walkerton Inquiry, Toronto, ON.

Perrow, C. (1984). Normal Accidents: Living with high risk technologies, New York, NY: Basic Books.

Pidgeon, N.F. (2011) In retrospect: Normal accidents, Nature, 477, 404–405.

Renn, O. (2008) Risk governance: Coping with complexity in an uncertain world, Earthscan, UK.

Saskatchewan Environmental Society and Nature Saskatchewan (2002). Final submission to North Battleford water inquiry, available at http://www.justice.gov.sk.ca/nbwater/pdf/finalsubmission-ENVSOC-NATURESK.pdf

Schauer, F. (2003). Profiles, probabilities and stereotypes, Cambridge, MA: Belknap Press.

Scheffer, M., Carpenter, S.R., Lenton, T.M., Bascompte, J., Brock, W., Dakos, V., van de Koppel, J., van de Leemput, I.A., Levin, S.A., van Nes, E.H., Pascual, M. & Vandermeer, J. (2012). Anticipating critical transitions, Science, 338, 344-348.

Simon, H.A. (1979). Rational decision making in business organizations, The American Economic Review, 4, 493-513.

Simon, H. A. (1997). Administrative behavior (4th Edition), Free Press.

Starbuck, W.H. (2009). Cognitive reactions to rare events: Perceptions, uncertainty, and learning, Organization Science, 20(5), 925-937.

Stein, P.L. (2000). The great Sydney water crisis of 1998, Water, Air and Soil Pollution, 123 (1-4), 419-436.

Sunstein, C. (1995). Problems with rules, California Law Review, 83 (4), 953-1026.

Todd, P.M. Gigerenzer, G. and ABC Res. Group (2011). Ecological rationality: Intelligence in the world. New York: Oxford University Press

Turner, B.A. (1978). Man-made disasters, Wykeham Science Press, London.

Tversky, A. & Kahneman, D. (1974). Heuristics and biases, Science, 185 (4157), 1124-1131.

Vaughan, D. (1999). The dark side of organizations: mistake, conduct, and disaster, Annual Review of Sociology, 25, 271-305

Wittgenstein, L. (1958). Philosophical investigations, Oxford: Basil Blackwell.

Woods, D.D. & Cook, R.I. (1999). Perspectives on human error: Hindsight biases and local rationality, Handbook of applied cognition, Wiley & Sons, NY, 141–171.

Woo, D.M. & Vicente, K.M. (2003). Sociotechnical systems, risk management, and public health: comparing the North Battleford and Walkerton outbreaks, Reliability Engineering and System Safety, 80 (3), 253-269.

Wynne, B. (1992) Misunderstood misunderstanclng: social identities and public uptake of science, Public Understanding of Science 1, 281-304.

	Brief outline of events	Key sources of data
Walkerton, Ontario, Canada, 2000.	Following heavy rainfall, an influx of manure from a nearby farm contaminated one of the wells at Walkerton, overwhelming the water supply system's already inadequate disinfection barrier. A litany of failures impeded the discovery of and response to the contamination, including substandard operating practices (*e.g.* the failure to monitor chlorine residuals), inadequate regulatory oversight (*e.g.* the removal of a mechanism to ensure that the local medical officer of health and the provincial regulator were informed of adverse water quality results), and attempts at cover-up on the part of the utility's senior operator. Combined, these failures markedly increased the scope of the outbreak. In total, 2,300 illnesses and 7 deaths were attributed to the pathogens *Escherichia coli* O157:H7 and *Campylobacter jejuni.*	Public inquiry report (O'Connor, 2002). Inquiry transcripts, October 2000-October 2001, available at http://mail.tscript.com/trans/walkerton2000.htm Selected submissions to the inquiry, *e.g.* from provincial government, the relevant union, *etc.* (not available at central source). Academic case studies, for context and insight rather than raw data (*e.g.* Hrudey *et al.*, 2003; Woo and Vicente, 2003).
North	North Battleford's surface water system was contaminated with	Public inquiry report (Laing, 2002).

Battleford, Saskatchewan, Canada, 2001.	*Cryptosporidium* (a protozoan pathogen), which most likely came from the upstream sewage treatment plant's effluent. The pathogen breached the defenses of the water supply system and reached customer taps, largely owing to the sub-optimal operation of the solids contact unit (SCU). As symptoms of enteric disease emerged in the population, a failure on the part of the outbreak investigation team to rigorously consider water as a potential source, together with a significant time-lag before involving the environmental regulator, ultimately delayed the issuance of a boil water notice. In total, between 5,800 and 7,100 people were infected.	Inquiry transcripts, September 2001-January 2002, available at http://mail.tscript.com/trans/nb2000.htm Submissions to the inquiry, available at: http://www.justice.gov.sk.ca/nbwater/ Academic case studies, for context and insight rather than raw data (*e.g.* Hrudey et al., 2006; Hrudey and Hrudey, 2005; Woo and Vicente, 2003).
Sydney, Australia, 1998.	Moderate to extremely high levels of *Cryptosporidium* and *Giardia* cysts were detected in parts of Sydney's water supply system, in both raw and treated water. The pattern of contamination changed from day-to-day, both in terms of the levels detected and the areas implicated. With hindsight, it is thought that heavy rainfall washed	Public inquiry report (McClellan, 1998). The transcripts and submissions are stored at the state archives, but are liberally reproduced within the report itself. Academic case studies, for context and insight

	animal fecal matter from polluted catchment areas into watercourses and dams, which the filtration system was unable to handle as it was experiencing operational difficulties. The water utility was severely criticized for its response to the early stages of the event, with the public inquiry head concluding that concerns for its commercial reputation appeared to override the interests of public health. However, no incidence of disease was observed, possibly because the cysts were not of an infective type.	rather than raw data (Stein, 2000).

Table 1: Basic features of the contamination events discussed in the paper, and key sources of data

	Rule form
Credibility heuristic	If the *conveyor* of the warning message passes a threshold of perceived credibility, then treat the message as being a signal from the target; if not, treat the message as being noise from a distracter.
Precedent heuristic	Search for precedent(s) for unfolding event (*i.e.* historic analogue(s)), and if identified, then treat current event in the same fashion as they were.
Facts-trump-speculation heuristic	When faced with conflicting lines of evidence relating to a phenomenon, order them according to a predefined (but possibly implicit) hierarchy of evidence (cue validities), and treat the highest ranked line of evidence as true.

Table 2: The heuristics observed

In the years running up to the Walkerton contamination event, the provincial government had put in place a series of deregulatory reforms and initiatives (O'Connor, 2002), which led to a reduction in regulatory inspections, technical assistance, and enforcement more broadly. These factors were later directly implicated in the waterborne disease outbreak (O'Connor, 2002). Yet it is far from the case that hazards of the deregulatory agenda only came to light after the event. Both before and during the implementation of the agenda, senior officials, ministers, and cabinet members within the provincial government received numerous specific and ultimately prophetic warnings that their reforms would threaten the safety of the drinking water supply (O'Connor, 2002, and specifically, the Walkerton inquiry transcripts, June 27th, 2001). These came from a range of sources, including the public union and from within the regulatory agency itself. The government responded to these concerns in a rather lackadaisical manner (see generally, O'Connor, 2002). Apparently, one reason for this relative disinterest was a judgment about the messengers' credibility, but this doesn't mean that the credibility heuristic was at work.

To elaborate, in testimony at the public inquiry, the provincial Premier Mike Harris suggested that the objections raised by the union may have been something of a veil behind which their sectional interests lay (*i.e.* protecting the employment status of their members), and mused that the warnings raised from within the regulatory agency were perhaps part of a bargaining strategy, or a mask for bureaucratic self-interest (Walkerton inquiry transcripts, 29th June, 2001). The implication was that the conveyors of the

warnings had vested interests in opposing the government's deregulatory agenda (as their budgets, and the livelihoods of their members, were at stake). However, Harris stated that, although there was reason to question the credibility of the messengers, their claims were nevertheless investigated – given their potential public health implications and the need for due diligence – although by implication with less scrutiny than had the messengers passed muster. In other words, source credibility was a factor that informed his view of the claims, but one factor that was weighed alongside other aspects of the decision-problem, rather than a rule that structured the Government's decision-making process. Of course, there are reasonable grounds to suspect that Harris' recollection may be somewhat strategic, with his claims perhaps a convenient way of justifying the relative neglect of the warning signals (indeed, in the Government's written submission to the inquiry, they remained of the view that deregulation had little or nothing to do with the tragedy). But this is orthogonal to our basic point, which is that Harris is *describing* a decision-process – factors based judgment – that is at times difficult to separate empirically from heuristic reasoning, yet which nonetheless has different structural features, justifications, strengths and limits (Sunstein, 1995; Schauer, 2003).

Box 1: Distinguishing between rule-based reasoning and factors based judgments