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Heuristics and biases in decision making about risk

Andrew Weyman and Julie Barnett

Introduction

One of the key themes of the risk literature over the last 50 years is the widely encountered claim that compared to experts, lay people often over or underestimate risk. Or more specifically, that they are prone to deviate from the axioms of formal logic orientated around utility maximisation.

Taking its inspiration from foundation work on gambling behaviour, the 1970s witnessed the emergence of interest within psychology and economics aimed at discovering and articulating the cognitive processes that cause people to make suboptimal choices. These earliest forays into decision making in the context of risk were limited to the consideration of cognitive components. Although contemporary commentators may take issue with what might be cast as an unreasonably narrow perspective, these insights have proved to be robust and enduring, to the extent that they have achieved the status of normal science.

In this chapter we will provide an – unavoidably partial – overview of the contribution of behavioural decision theory to contemporary understandings of decision making in the context of risk and uncertainty. In particular, we will focus on insights relating to recognised sources of cognitive bias and recourse to heuristics in problem solving, as well as debates and implications arising from the enduring legacy of this perspective. In particular we will challenge the premise that ‘flaws’ in cognitive processing are only germane to lay decision makers, to the extent that this represents a fundamental contrast with the behaviour of expert risk assessors. We will also reflect throughout on what the implications of heuristics and biases are for action – both in relation to risk communication and policy.

The extensive literature on sources of bias in decision making under uncertainty is primarily informed by insights from cognitive psychology, but it is usefully situated in relation to complementary insights from behavioural economics, social psychology, sociology and social anthropology. It is useful to conceptualise the operation of heuristics as being at the ‘micro-level’ of information processing, whilst recognising that contemplation of risk routinely does not take place in a vacuum but is embedded within – and with reference to – a broader set of orientating factors operating as filters that can affect risk perception: cognitive-affective factors, socio-political considerations and cultural background (Renn and Rohrmann, 2000). Characterising the interaction
and interdependency of these elements with traditional cognitive processing insights requires a more sophisticated level of analysis (Breakwell, 1994). Similarly, within the social amplification of risk framework, heuristics are characterised as one of the pathways that affect both individual and societal response mechanisms to risk (Kasperson et al., 1988; Kasperson, 1992).

Despite fundamental differences in perspectives, there is almost universal acceptance across the various social and behavioural science paradigms that human beings are disposed to taking mental shortcuts and adopt non-strategic approaches to the consideration of risk. There is extensive evidence that human beings are prone to exhibit an array of lapses and predictable choice biases that deviate from formal logic and rational choice – at least in the terms defined by neoclassical economics. People are also prone to taking mental shortcuts, applying simple intuitive heuristic rules of thumb and common sense reasoning strategies rather than adopting a systematic approach to the consideration of relevant variables (Renn, 2008), and these shape judgements about the probability of a risk and its seriousness. Recourse to heuristics can be both habitual and a conscious process used in the evaluation of information to inform decision making. People make extensive use of heuristics in everyday situations and heuristics are indeed an essential tool for dealing with a complex world. They draw, in large part, on prior experience and pattern recognition, allowing people to economically (in a cognitive sense) navigate their way around their world.

Before considering in more detail some of the heuristics and biases that are particularly relevant to risk, it is worth being clear about their potential benefits. Although, it is certainly the case that because heuristics are approximations they have the potential to embody a range of recognised biases and errors. For example, people are prone to inductive errors, apparent in the tendency to apply old (successful tried and tested) solutions to new contexts (whilst omitting to take account of important differences), or infer familiar patterns or trends from small but consistent samples. A notable potential pitfall is the tendency to over-apply ‘old’ heuristics, for example failing to take account of novel differences when encountering what at first sight presents as a familiar situation to which a familiar solution might be applied. However, under most circumstances heuristic-based choices are highly adaptive, reflect internally consistent processes and are well suited to speedy decision making. Under most circumstances heuristics provide a sufficient, if not always optimal, solution. In such situations, recourse to heuristics can be beneficial and serve us well (Ross, 1977).

Simplifying complex problems can also sponsor the recognition of linkages and solutions that might have taken longer or remained undiscovered if a more systematic approach had been adopted.

**The history of heuristics**

The initial interest in heuristics and biases was set against a backdrop of statistical decision theory that produced rational and normative models of risk-based decision making (Reid, 1999). The central assumption was that rational human decision making would require individuals to make choices that maximised the subjective expected utility, that is, a combination of the subjective probabilities of outcomes and their utility (utility meaning their usefulness or their ability to satisfy) (Savage, 1954). The work of Simon followed, introducing the concept of ‘bounded rationality’ (Simon, 1955). This descriptive, rather than normative, view suggested that maximising subjective utility is too demanding given humans’ finite cognitive capacity and thus simpler decision rules – heuristics – are applied. An example of Simon’s simple decision rules is that of satisficing – a mixture of satisfying and sufficing. Here, rather than searching through all alternatives for the best solution, the search continues until a solution is found that
is acceptable in terms of meeting aspirations (Simon, 1956); satisficing relates to sufficiency rather than maximal utility.

During the late 1960s and early 1970s, in the wake of public controversies around technological risks, an evident unwillingness to take expert assurances at face value and a growing appreciation of the role of risk perception came a series of highly influential studies by Daniel Kahneman and Amos Tversky (Kahneman and Tversky, 1972, 1979; Tversky and Kahneman, 1973, 1974). Their central premise was that judgement under uncertainty, rather than being the product of systematic algorithmic processing, is prone to be conducted through reference to a finite number of simplifying heuristics and an array of definable cognitive biases. Critically, the central claim is that features of the choice object(s) and the configuration of the representation of uncertainty can sponsor systematic and predictable deviations from rational choice.

Interestingly, another important player in this arena – Gerd Gigerenzer – explicitly distances his own focus on ‘fast and frugal reasoning’ from the focus on subjective expected utility and also heuristics and biases, eschewing the juxtaposition outlined earlier. Rather, he points out the similarity of the two perspectives:

Both views accept the laws of probability and statistics as normative, but they disagree about whether humans can stand up to these norms.

(Gigerenzer and Goldstein, 1996: 650)

Gigerenzer suggests that Simon’s views are often misrepresented – the boundedness to which he refers is not imposed by classical rationality but rather by the real world constraints of time constraints, knowledge and computational power, to which might reasonably be added ‘boundaries of knowledge’ in the sense of shared world view (Douglas and Wildavsky, 1982). Gigerenzer’s own work on heuristics (Mousavi and Gigerenzer, 2014) reflects this broader ‘ecological rationality’. More recently, insights on heuristics and biases have been harnessed in the contemporary influential public policy orientated text Nudge (Thaler and Sunstein, 2008). Here, the focus is on configuring the choice architecture to take account of decision biases. Running with rather than against the grain is claimed to offer the answer to the neoliberal dilemma over social engineering versus choice, for example use of auto-enrolment defaults for pension investment and organ donation, playing on inertia and status quo bias.

Heuristics – a characteristic of lay and expert judgment

Casting risk assessment and its management as a technical, objective process has led many scientists and policymakers to conclude that insights on heuristics simply reflect a component of broader knowledge deficit and lack of sophistication in lay understandings of risk; however, this is not an area where there are necessarily marked distinctions between lay and expert decision makers. In fact, both are susceptible to decision bias effects and prone to apply heuristics, particularly when dealing with unknown and uncertain issues that lie at or beyond the boundaries of their knowledge (Kunreuther et al., 2010; MacGillivray, 2014). Expert use of heuristics runs the risk of being problematic when making decisions about complex phenomena, particularly where these are without precedent or unknown to science. Under these circumstances, science and engineering disciplines have little option other than to resort to often quite sophisticated but, nonetheless, rules of thumb, educated guesses, intuitive judgement and relatively crude theoretical models, for example selecting a subset of variables for manipulation in models designed to predict uncertain future outcomes, or assessing the degree of fit with some wider classification.
Ultimately, all scientific theories and models are heuristics – they are all simplified, although often complex and rigorously tested, approximations to reality. In engineering, failure models for complex systems are inevitably limited to the imagination of their architects. Similarly for natural phenomena, weather forecasters focus on those variables they consider to be primary influences. Under most circumstances these models satisfice. If they did not, they would not be used. It is only when unforeseen novel interrelationships and alignments of variables occur that their limitations tend to become manifest and recognised (Reason, 1997).

Availability bias

We will now outline the most widely evidenced forms of cognitive bias and situations that sponsor recourse to heuristic judgement and are most pertinent to risk, starting with availability bias, which is arguably the most widely applied to risk. Our intention here is to go beyond the more routinely encountered focus on impacts on lay decision making by highlighting situations in which equivalent effects on expert risk assessors and risk managers might reasonably be predicted.

The ease with which outcomes can be brought to mind (recalled and visualised) increases their subjective salience and perceived likelihood (probability) of occurrence.

The ease with which consequences can be visualised, particularly if they are widespread, catastrophic or enduring, for example extinction of a species, can sponsor a myopic response such that the magnitude of consequences comes into sharp focus. This can outweigh or divert attention from issues of probability or provide a cue for inflating probability estimates (Tversky and Kahneman, 1973, 1974; Lichtenstein et al., 1978).

In the case of expert risk assessors with a large amount of relevant experience, availability biases may operate in a positive manner, leading to timely identification of effective mitigation measures; however, prior experience of similar events and outcomes, particularly where these are profound or catastrophic, may increase the cognitive availability of the magnitude of potential loss to the extent that this floods the consideration of key differences in the vectors of harm. Such instances may sponsor overly cautious, excessive risk averse assessments. It is also important to recognise that, for experts, the focus on loss can extend beyond the threat posed by the hazard to issues of reputational damage in the event of ‘getting it wrong’ (Power, 2006).

The availability heuristic appears to be sensitive to ‘base-rate effects’. For example, when people are asked to assess a probability, such as the likelihood of rain in London described in the forecast as ‘slight’, their rating will very likely be higher than for an equivalent forecast (of ‘slight’) in Madrid. The reason for this is that they are drawing upon a heuristic that characterises perceived base rates for the two cities (see Wallsten et al., 1986). In this instance their intuition is likely to be substantially correct; however, sensitivity to perceived base rates can constitute a source of bias (Windschitl and Weber, 1999).

Availability effects are relevant to risk managers. The ease with which outrage and dissatisfaction with the government and its agencies can be brought to mind by specialists, policymakers and ministers may highlight vulnerability. This in turn may sponsor excessive caution and risk aversion and may divert the focus to issues of secondary risk management (personal and institutional consequences, for example eroded trust, reputational damage), rather than primary risk management (see Power, 2006).

In short, heuristics subject to availability bias may yield positive results in instances where an individual’s memory (personal and/or mediated) of previous events corresponds well with
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the objective properties and trajectory of actual events, but they may lead to overestimates if recall is amplified by strong imagery of high magnitude (catastrophic, large scale, irreversible) undesired consequences or, plausibly, underestimates if recall of analogous events is limited, for example no personal experience or historical precedents.

An absence of hazard-specific knowledge has the potential to increase the propensity to draw analogies with other high consequence risks that are believed to share one or more features. Unsurprisingly, more recent events tend to be of greatest salience. By extension, a number of closely coupled events of a similar type tend to amplify recency bias (Marx et al., 2007). Such effects have been widely cited as sponsoring ‘read-across’ from one risk agenda to another, for example bovine spongiform encephalopathy (BSE) impacting on beliefs regarding risks associated with veterinary medicines (Weyman and Williamson, 2007) and genetically modified foods (Marris, 2001). These read-across effects, probably more prevalent within lay populations, might be considered as inappropriate but they are indicative of the features of the issue or event that are considered to be most salient – and these may not relate to technical properties of the risk.

Representativeness bias

The tendency to over-infer patterns and linkages relating to the future from a restricted sample, for example a small number of cases of a common type, a single or subset of attributes or traits, or a subset of interactions between variables.

In its most basic form representativeness relates to the process of inductive inference, that is judging the likelihood that a given object (or phenomena) relates to a particular class of objects, or that an event is the product of a recognised process. Some authors suggest that human beings are hard-wired in their disposition to seek pattern recognition.

The contiguous occurrence of a small number of sequential/related events (which may in probabilistic terms be random or rare), particularly over a short time frame, tends to give rise to what Tversky and Kahneman term ‘belief in the law of small numbers’ (1971). These authors go on to conclude that the phenomenon is not limited to lay populations – it is also apparent amongst scientists and engineers and others with formal training in probability theory (Tversky and Kahneman, 1971; Kahneman and Tversky, 1972). A high profile example is the ‘string’ of large-scale UK railway accidents in the late 1990s and early 2000s (Southall in 1997; Paddington in 1999; Hatfield in 2000 and Potters Bar in 2002), which led to much speculation of a trend associated with railway privatisation. Statistically, the small number of cases makes it impossible to draw firm conclusions; however, the arising structural and regulatory impacts have undeniably been far-reaching and enduring.

A number of studies have demonstrated that people can be insensitive to changes in base rates and base values (see, in particular, Tversky and Kahneman, 1974). Typical findings from experimental work in this area are that people tend to focus on the frequency of cases (numerator) rather than denominator values. This can be particularly problematic when making comparisons between two or more pieces of evidence based on different sample sizes. Other findings indicate a failure to take account of base rates and highlight a tendency to focus on frequencies or proportions of increase, for example a 100 per cent increase in cases of Ebola in the UK (currently, at least) will only affect a very small number of individuals. Where people recognise changes in base rate, the issue tends to be not so much that they ignore this (most people have some grasp of the implications of the ratio of cases to sample size) but that they fail to make sufficient adjustment, that is people can be insensitive to changes in predictive inferences that arise from changes in sample size.
Unrealistic optimism bias

Overconfidence in the ability to manage, avoid or avert harm.

Unrealistic optimism has traditionally been cast as one of a range of biases of attribution over issues of cause and effect (see, in particular, Weinstein, 1980, 1984), but it can also arise as a product of group deliberation and decision-making processes. As elsewhere, findings highlight susceptibility amongst scientists and specialists as well as lay people (see Kloprogge et al., 2007). A notable and paradoxical finding with respect to expert risk assessors is the claim that the more information they are provided with on an unknown quantity, the less likely they are to exhibit overconfidence (Slottje et al., 2008).

By volume, the largest contribution to insights on unrealistic optimism relate to individual decision making and perceptions of personal vulnerability, notably in the lifestyle health domain, supplemented by a smaller number on workplace risk and driver behaviour (see, for example, McKenna, 1993; McKenna et al., 1991). These studies focus on individual volition as the basis for exposure – in contrast to exposure resulting from essentially external influences and impacts that extend beyond the individual. Headline findings highlight a tendency for individuals to view themselves to be at less risk than others exposed to equivalent sources and levels of harm. Typically when asked to estimate relative vulnerability, individuals rate themselves at below average risk on a given criterion (Weinstein, 1980, 1984). A number of studies point to a related tendency towards overconfidence in the ability to recognise sources of harm and manage associated risks (Weyman and Clarke, 2003; Weyman et al., 1995).

In part, this seems likely to be attributable to the more common experience for most individuals that exposure does not result in negative outcomes, that is on most occasions many people are lucky, salient variables do not align in ways that provide a pathway for harm (Reason, 1997) or the world does not turn out to be as risky as the experts had led us to believe. Levels of expressed optimism can also be time sensitive – perceived risk tends to be diminished when the consequences are distant rather than in the near future (Bjorkman, 1984).

From the perspective of motivating cautionary behaviour in others, further sources of attribution bias are of potential relevance, notably self-serving and self-other biases. A general finding is that victims (including potential victims) are disposed to externalise causality such that they are disposed to blame others. Externalising in this way tends to inhibit motivation to adopt cautionary behaviour (see Jones and Nisbett, 1971; Ross, 1977). Conversely, when confronted with positive outcomes people are prone to attribute this to their capacity and skill at avoiding harm (whereas it may owe much to good fortune), which may sponsor unrealistic optimism in their capacity to manage equivalent risks effectively in the future. Interventions to highlight and increase the salience of personal vulnerability and enhance self-efficacy represent core assumptions of a number of psychology behaviour change models.

Cognitive framing effects and bias

The manner in which issues are presented can impact upon the range of variables considered and choices in the context of uncertainty. A large body of evidence highlights how the manner in which choices are framed (how risks and uncertainties are portrayed and who portrays them) can impact upon the choices that people make.

Prospect theory highlights how manipulating the reference points in uncertainty scenarios can impact on decisions. Of the array of framing effects identified, the most widely evidenced are ‘domain effects’ – the semantics of framing an option as the probability of a ‘gain’ or a ‘loss’. When people are presented with uncertain choices of equal outcome value, casting them as a
‘gain’ or a ‘loss’ can impact upon their preferences in predictable ways (Kahneman and Tversky, 1979). In one of the classic framing experiments participants were asked to make a choice between two differentially framed uncertain options for curing a life threatening disease – one gain and one loss of equivalent objective value. Respondents showed a greater preference for the option that emphasized the ‘number of lives saved’ (positive frame) compared with the alternative ‘number of lives lost’ (negative frame) (Tversky and Kahneman, 1981).

Cognitive framing insights are widely used in marketing and public policy domains with the overt aim of influencing the behaviour of target audiences, for example for smoking cessation, a gain frame such as ‘having more healthy years to spend with your grandchildren’ has been found to be more effective than the more traditional loss frame. Similarly, but perhaps less positively, in commercial advertising for labelling of foodstuffs we can observe a tendency for producers to frame products as ‘X% fat free’, rather than containing ‘Y% fat’. The importance of framing in terms of how, for example, cost-sharing responsibilities might be promoted to stakeholders is not hard to see. Situating forecasts of the effectiveness of pest or disease mitigation measures in a loss frame ‘the adoption of mitigation measure X will still result in the loss of 75% of species Y’ might be predicted to elicit a different response from ‘the adoption of mitigation measures X will result in 25% of species Y being saved’.

Applications of framing insights are predominantly restricted to communication media, although more fundamental reconfigurations of choice architecture have been attempted (see Thaler and Sunstein, 2008). The central claim here is that configuring information in ways that take account of loss and gain decision biases can nudge people to select the uncertain option preferred by the communicator. Notice that the perspective here is not one of providing neutral or objective information, but rather one of intentionally configuring the semantics in ways that play on people’s propensity to make mistakes. Although effects have been demonstrated in laboratory settings, the overriding picture is one of modest impacts when applied in isolation, rather than as a component of a comprehensive multi-faced or layered approach (Weyman and Kelly, 1999). Semantic framing is not a silver bullet. Although it can be important to consider how information on uncertainty is framed and how this may impact on its interpretation by others, a caveat to the overt use of message framing with the intention of sponsoring a desired interpretation is that if it is too transparent there is a risk that it may ‘...lead to suspicions of manipulation’ (Fischhoff, 1995: 137).

From the perspective of communication, message source can also operate as a framing effect in so far as some sources may be viewed as more credible, reliable, informed or more trusted than others, and this may vary depending on the orientations of the target audience and characteristics of the issue over which there is uncertainty.

**Conclusions**

In conclusion, we have seen that both experts and lay actors alike share essentially common cognitive traits and are susceptible to the operation of heuristics and biases. This perspective challenges the rational actor assumptions, which continue to be fundamental to the modelling and fiscal policy manipulations of economists. The juxtaposition of heuristics and biases against rational actor assumptions gives the superficial impression that most decision making is flawed and non-rational; however, the balance of evidence is that inferentially most people make internally consistent, logically coherent decisions most of the time. One potential legacy of the partial focus on non-rational components is to reinforce the disposition of policymakers that the public are irrational. Another legacy is that there has been much less work on characterising instances where the expert model is flawed and incomplete – an issue that we have sought to address in this chapter.
Evidence about the operation of heuristics and biases has largely been derived from experiments in laboratory settings and consequently much less is known about how such variables operate in real world environments. In such real world decision-making settings, in contrast to most of the classic choice experiments, the probability of particular outcomes are often unknown or uncertain and thus the quality of choices that are made are not simply a function of heuristics but will reflect, for example, the nature and the sophistication of underlying mental models. This applies to relatively mundane, comparatively simple issues such as pension choices, as well as the complex, for example mapping potential failure modes for a nuclear power plant. In sum, heuristics and biases are one of a range of phenomena necessary to provide a comprehensive account for decision making in the context of risk.

References


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