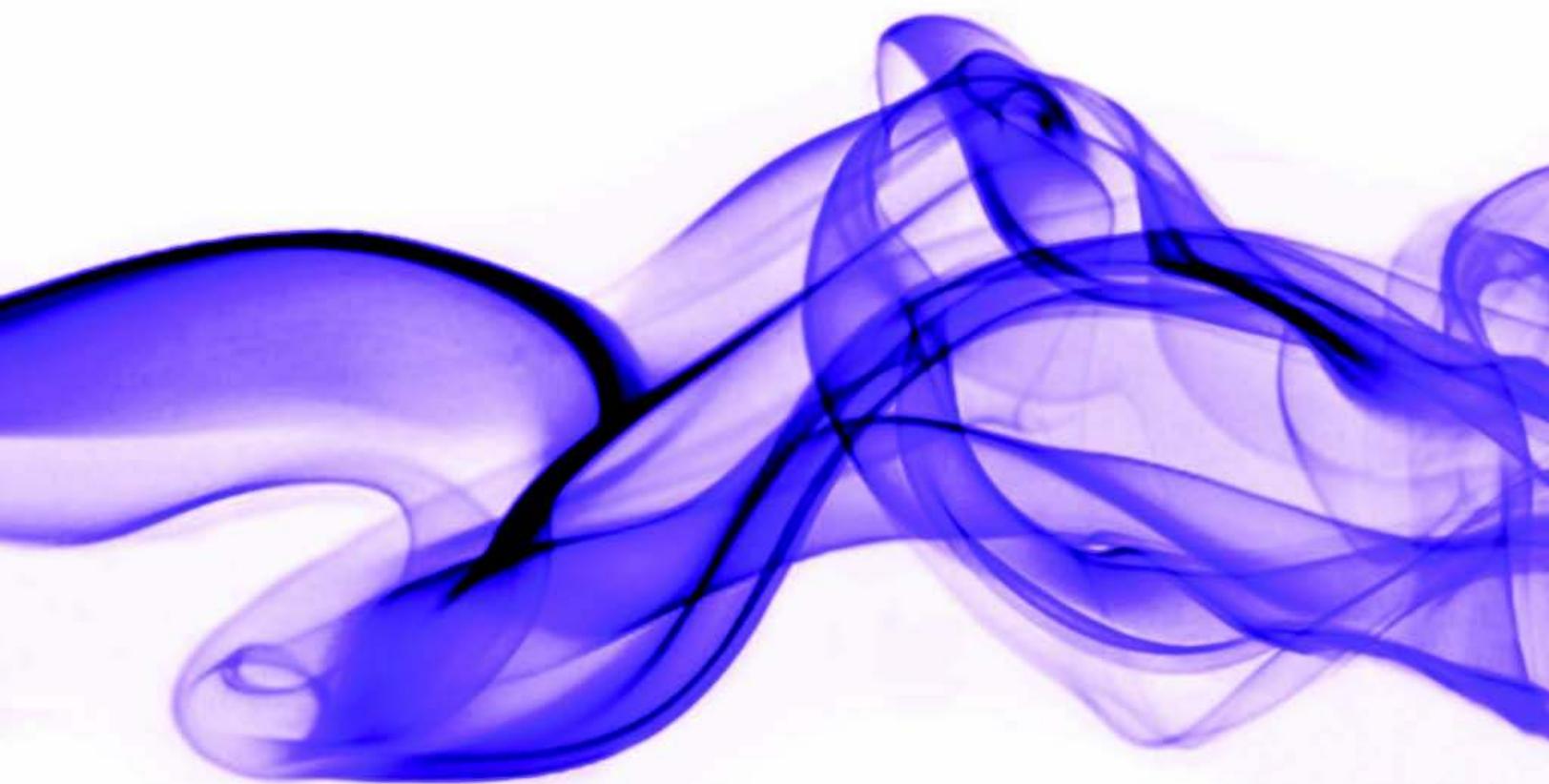


# **Risk Interpretation and Action**



**A Conceptual Framework for Research in the Context  
of Natural Hazards**

## IRDR

IRDR was established by the International Council for Science (ICSU) in 2010 in cooperation with the International Social Science Council (ISSC) and the United Nations International Strategy for Disaster Reduction (UNISDR). IRDR's main legacy will be an enhanced capacity around the world to address hazards and make informed decisions on actions to reduce their impacts. This will include a shift in focus from response–recovery towards prevention–mitigation strategies, and the building of resilience and reduction of risk through learning from experience and the avoidance of past mistakes.

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## Preface

This report is a first attempt to address a few of the many issues identified in the International Council for Science (ICSU) (ICSU, 2008) report: A science plan for integrated research on disaster risk: Addressing the challenge of natural and human-induced environmental hazards. This Science Plan is now the basis of a decade-long integrated research programme entitled Integrated Research on Disaster Risk (IRDR). This programme is co-sponsored by the ICSU, the International Social Science Council (ISSC), and the United Nations International Strategy for Disaster Reduction (UNISDR). It is a global, multi-disciplinary approach to dealing with the challenges brought about by natural disasters, mitigating their impacts, and improving related policy-making mechanisms. The IRDR programme (<http://www.irdrinternational.org/>) endeavours to bring together the natural, socio-economic, health and engineering sciences in a coordinated effort to reduce the risks associated with natural hazards. In particular, there is an acknowledgement that progress in this field requires a partnership between natural and behavioural sciences. To quote from Section 4.1 of the Plan:

“In order to reduce risk, there needs to be integrated risk analysis, including consideration of relevant human behaviour, its motivations, constraints and consequences, and decision-making processes in face of risks... The risk associated with environmental hazards depends not only on physical conditions and events but also on human actions, conditions (vulnerability factors, etc.), decisions and culture... The seriousness of the consequences of any disaster will depend also on how many people choose, or feel they have no choice but, to live and work in areas at higher risk...” (ICSU 2008)

One of the initial research components developed within IRDR involves the working group title “Risk Interpretation and Action” (RIA). This project has been prepared by an ad-hoc Working Group set up for the purpose through meetings in Wellington, New Zealand in March 2011 and Paris, France in May 2011 and approved by the Scientific Committee for IRDR in Paris (April 2011). This document is a result of those deliberations and decisions.



Gordon McBean  
IRDR Science Committee Chair

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# 1. Aim of the report

Our emphasis in this report is on the contributions that can be made to integrated risk analysis and risk reduction through the study of human behaviour and decision-making. Our aim is to provide an integrated perspective on research on risk and decision-making and offer pointers to how this can be applied to natural hazards, and outline implications for practice. This will be based on a critical overview of research and theory on the relationships between how people interpret risk and the decisions they make as a consequence of such interpretations. Our main focus will be on clarifying the key concepts and theoretical assumptions concerning the processes underlying interpretation of risk and decision-making under uncertainty so as to make these more accessible to a range of disciplines and to practitioners in the field of natural hazards. We thus hope to facilitate integrated research and its application through offering a 'conceptual tool-kit' more critically to address a range of questions including, but not limited to: Why do people seem more concerned about some risks than others? What (and who) has the most influence on their levels of concern? How do people's assessments of risk influence their decisions to take measures to prevent or mitigate the risk to themselves and/or others? How should risk information be communicated and by whom? What makes some communicators and/or risk managers more trusted than others?

These questions, of course, have been addressed many times before, not only in the specific field of disaster research but also in broader disciplines such as psychology, geography, economics and political science, to mention just a few. So what can our review add? The answer comes back to the need for integration. Our intention is not to belittle such previous contributions but, on the contrary, to highlight their significance by drawing out interconnections between different areas of empirical and theoretical research and identify areas where future multi- and inter-disciplinary collaboration could emerge to advance understanding. At the same time, previous research efforts have been unevenly spread, so that issues have received somewhat less attention than others. Among these issues, we suggest, are the following:

- Much research has been focused on single hazards. Hence, there are challenges in generalizing from one type of hazard to another, or to combinations of hazards.
- Much research has been focused on single cultures. Hence, there are challenges in generalizing from one culture to another.
- There is a strong emphasis on scientific forecasting of hazard events, less on how to communicate such forecasts effectively, and less on understanding how forecasts are interpreted and acted upon.
- There is still incomplete understanding of why and when ordinary citizens' evaluations of risk may appear to diverge from scientific forecasts.
- There is still incomplete understanding of why and when people's actual behaviour may appear to diverge from their expressed evaluations of risk.
- Within traditional research on decision-making, there is an emphasis on choice between sets of prospects of known expected value, as distinct from contexts where information is acquired through experience.
- Within policy/planning, there is an emphasis on protection or restoration of existing infrastructure, rather than redesign for greater resilience or prevention.

These issues will be considered during the course of this review, but first let us deal with the basic concepts involved in research on risk interpretation and action.

## 2. Defining risk

The concept of risk is invoked as a central issue across a wide range of policy debates. How can risks be reliably identified, how can they be managed, under what circumstances should they be accepted or rejected and, especially, how are they likely to be interpreted or ‘perceived’ by different people? These questions arise in areas as diverse as health and lifestyle, hazardous industries, pensions and investments, transport, climate change and environmental protection. It is difficult to make sense of this diversity if we attempt to define risk in terms of the kinds of events or activities we would commonly call ‘risky’. Although people tend to lump natural hazards together, see technological risks as sharing common features, and distinguish these in turn from chronic health risks (Johnson & Tversky, 1983), these are large, diverse categories. Even just within our present context of natural hazards, several categories of hazards can be distinguished relating to meteorological and/or geophysical events and their interactions and the different kinds of consequences to which they can give rise, depending on a complex mix of uncertainties. Hence, if we try to characterize risk merely in terms of the many kinds of physical conditions that are associated with danger, our chances of producing a coherent definition are extremely small.

There is an alternative approach, however. Rather than attempting to define risk in terms of topics, we can attempt to do so in terms of processes, and these, we suggest, may turn out to be quite general and applicable across a wide range of topics, both within the context of natural hazards and beyond. To summarize our argument, everything that is important about risk arises from uncertainty, actual or perceived, about (a) the likelihood and (b) the value of events. These two elements are not only basic to the definition of risk, but guide our actions in any context where risk is involved. Indeed, it is only because we need to act under conditions of uncertainty that the concept of risk is of any interest whatsoever. This results in people being dependent on others to provide information. These others can be scientists or government agencies, but also others within the communities in which people interact in everyday life. Faced with complex and uncertain events, when they do not possess all the information they need themselves, people’s perception of risk and how they might mitigate it, is influenced by information from others who share their interests and values (Earle, 2004; Lion et al., 2002; Paton, 2008; Paton & Bishop, 1996; Paton, Bürgelt, & Prior, 2008; Poortinga & Pidgeon, 2004). This introduces the fact that it is not just information that informs people’s thinking and action. The quality of relationships (e.g., degree to which they identify with others, trust relationships that have developed over time) with these others can make an additional contribution to the process of dealing with uncertainty. If we felt there was nothing we could ever do to affect what might happen to us, we would have no decisions to take and there would be no point in worrying about the likelihood or value of future events. However, most of the time life isn’t like that. We have choices to make, and these choices can have consequences for ourselves and others. It is because these consequences are uncertain, and may leave us better or worse off, that we talk about ‘risk’. The terms ‘risk-taking’ and ‘risk-aversion’ (or ‘avoidance’) characterize different kinds of choices under uncertainty. Yet here too the terms we use can brush over tricky questions. Does risk aversion imply merely distaste for uncertainty, or a preference for lessening the possibility of loss?

Another very commonly used term is ‘risk perception’. This has by now such a wide currency that it is probably pointless to try and expurgate it from discussion. Nonetheless, its use should carry a strong health warning. ‘Perception’ usually implies that there is something – or more precisely some thing – ‘out there’ to be perceived. The object of perception is thus distinguished from the process of perception (which is where our efforts and attention should be focused). Among other problems, this leads too readily to a way of looking at such discrepancies as may arise between the views of different stakeholders primarily in terms of whose views are more ‘correct’, whereas the far more important question is why different individuals and groups hold the opinions that they do and how they are developed, enacted, sustained, and changed.

We therefore prefer to use the phrase ‘risk interpretation’ to refer, more neutrally, to how we anticipate the outcomes of choices made either by ourselves, or by other decision-makers. In other words, the ‘events’ that we appraise in terms of their likelihood and value are very much ones that are either brought about, exacerbated or ameliorated by human decisions and human actions. In short, interpretation of risk is a special case of the interpretation of uncertain information, and risk-taking and avoidance are special kinds of actions chosen under conditions of uncertainty. How such information is interpreted and actions are chosen depends, as we shall see, on many factors. There will typically be many external constraints on the options open to decision-makers and people will not always have the time, motivation or training required to process such information analytically rather than more intuitively. Such issues, however, are part of the more general question of how systems – both individual and societal – handle and respond to uncertainty in a changing world.

Risk, then, arises from uncertainty, but how is uncertainty itself to be defined? Is uncertainty merely a state of mind – a reflection of our own incomplete knowledge – or intrinsic to the nature of the very things about which we seek knowledge? Put differently, do we live in a deterministic universe, or one in which random chance is a fact of life? Statisticians distinguish between two main types of uncertainty that can apply to predictions concerning any future event. The first (‘epistemic’, from the Greek word for understanding) arises from lack of knowledge about the distribution of possible events and the causal constraints this distribution represents. The second (‘aleatory’, from the Latin word for dice) reflects ‘pure chance’, or the randomness of any sampling from a population. Applying this distinction, however, requires that we know the parameters of the distribution we are considering. In many, if not most, real-life situations, this can be far from straightforward.

To illustrate this, consider the simple case of tossing a coin. For a true coin, we can say that the probability of heads is the same as the probability of tails, i.e., 0.5. (Strictly speaking, both probabilities are slightly less, since there is a tiny but non-zero probability that a coin could fall and balance on its edge!). What this means is that if we tossed the same coin a very large number of times, the number of heads would approximately equal the number of tails. In this example, a probability is essentially a long-run probability. This can also be termed a frequentist view of probability. However, when it comes to forecasting future events that haven’t yet happened (for instance, low-probability high-consequence disasters), there simply isn’t a distribution of previous equivalent events from which to extrapolate, although sciences such as palaeogeography (e.g., Atwater & Moore, 1992) and are working at extending our horizons to define relevant distributions. Even when we are dealing with events that happen relatively frequently in particular locations (e.g., coastal or river flooding), a judgement has to be made whether the background conditions (under which previous events have been recorded) have remained stable or have altered, for instance due to climate change. In such circumstances, probabilities cannot strictly be calculated (deductively) but only estimated (inductively). All we are entitled to demand (if not expect) from science is not certainty, but – as far as possible – a thorough, systematic, and transparent set of methods for deriving such estimates from whatever evidence is available at the time. Success and (particularly) failure in forecasting can then feed into revisions of these methods and/or highlight the need for more and better observational data. But we are still dealing with estimates, that is, interpretations of information, even in the case of ‘expert’ forecasts. Clearly, this applies with no less force to the judgements made by ordinary citizens on the basis of personal experience, but typically with a less formal understanding of the relevant physical processes.

Uncertainty concerning the likelihood of an event, however, is only part of the issue. At least as important is uncertainty over the value of the consequences.

The term 'value', however, also has its ambiguities. In a number of contexts (e.g., monetary gain or loss, and hence insurance losses as a special case), it can be a shorthand for the magnitude of any consequences. Even within the narrow context of monetary outcomes, however, it has long been known that 'objective' value (e.g., as measured in dollars) is nonlinearly related to subjective feelings of (un)desirability, technically known as 'utility' (Bernouilli, 1738/1954). A large part of the challenge of understanding how people interpret risk is making sense of the values they attach to different kinds of outcomes (actual and anticipated). This may require attention both to broader belief systems that may underpin such associations of value and to how experience may reinforce such associations or cause them to change. Even more troublesome is the case where complex events produce many interacting consequences that affect different individuals to different extents, and are evaluated in very different ways. One individual's benefit may be another's cost and the distribution of such consequences (costs and benefits) may typically be very uneven and/or unstable. Hence, impacts at the societal level will not simply be the sum total of impacts at the individual level, whether these relate to physical, psychological, social, or economic well-being.

### 3. Characterizing previous research on risk interpretation and decision-making

The literature on risk interpretation and decision-making is difficult to review concisely not just because of its size but also because of its diversity. Reflecting some of the issues raised in terms of defining risk, one can distinguish between much research that is primarily topic-focused and other research that derives from particular theoretical frameworks often specified in rather abstract terms.

On the one hand, there is much work describing levels of concern held by members of the public about perceived threats of various kinds. For instance, there are regular surveys that document citizens' self-reported experience of crime as well as their fear of crime these being far from perfectly correlated (Jackson, 2004). Several studies (some more theoretically framed than others) consider public concerns about hazardous industries, of which nuclear power generation has been prototypical. There has been considerable social science research looking at (possibly less dangerous) forms of industrial development or changed land-use (wind farms, waste storage or incineration, commercial and housing development in rural areas) in terms of their acceptability or otherwise to local communities. Such work tends to fall into historical and geographical clusters. For example, attitudes to nuclear power have been researched more frequently around the time of major accidents (e.g., Chernobyl in 1986) and/or in the context of specific policy debates about building new reactors, reprocessing plants or waste storage facilities. It remains to be seen how far the Fukushima accident of 2011 will prompt a resurgence of research on nuclear attitudes in different countries.

Similarly, there is a large body of work on the extent to which people feel that their individual health is endangered by a host of life-style factors, in particular smoking, alcohol, diet and exercise. There may

be more lessons here for the connection between risk interpretation and action, since a major concern is with persuading people to adopt healthier habits. For instance, does telling smokers that cigarettes damage their health lead them to quit smoking? The answer is: sometimes and somewhat, but not always (e.g., Eiser, Reicher & Podpadec, 1995). The more interesting question that then arises is: if not, why not? We can speculate on how far similar factors may be involved when people fail to take protective or evasive action in the face of natural hazards.

On the other hand, there is a large and growing body of literature that claims to examine general principles of how individuals formulate preferences and make decisions under conditions of uncertainty. The explicit focus here is far less on the distinctive features of any given risk or hazard, and more on the potentials and limitations of human rationality. At any rate, that is the claim. But if one is to propose general principles, one had better be sure that they really are general, and not just limited to the specific paradigms within which they have been developed. This again highlights the need for multi-disciplinary research that encompasses not just a range of natural hazards but incorporates lessons from other hazard domains, including for example health, technology, finance and personal security. All theories contain assumptions about the range of phenomena to which they can be applied, but if assumptions are left implicit and unstated, this can lead to overconfidence in a theory's generality.

Before reviewing relevant areas of work in more detail, however, a preliminary warning is in order. In trying to move from the previous literature – whether more descriptive or more theoretical – to the context of natural hazards and disasters, we constantly come across problems of scale.

The great majority of such research deals with the reactions of individuals considered singly, facing a single threat or source of uncertainty at a single point of time. This may be acceptable as a starting point, but it is clear to us that any half-way adequate conceptual framework must move beyond this to account for, or at least acknowledge, how individuals influence and are influenced by one another, how multiple hazard events occur, not in isolation but in interaction with one another, how people affect hazards and hazards affect people, and how all such interrelations are continuously evolving dynamically over time. That is why we need integrated research.

## 4. Individual decision-making under uncertainty: Beyond ‘rational choice’

The ‘rational choice’ model, developed initially within classical economics, has been the starting point for much research in this area. In highly simplified form, this approach assumes that decision-makers compare the prospects of alternative actions in terms of two attributes: the benefits or costs of each possible outcome and the probability of each outcome. The product of the benefit (or cost) and probability then defines the ‘expected value’ (EV) of each outcome, and it is assumed that this, and this alone, determines preference. In other words, a ‘rational’ decision-maker should always prefer the option (or portfolio of options) with the most positive expected value.

This model has been subject to empirical and theoretical challenges over many years. Especially pertinent for a discussion of decision-making under uncertainty has been experimental work involving a paradigm termed ‘the standard gamble’ in which participants are required to indicate their preference for either of two options. Typically, one option (A) is presented as ‘sure thing’ chance of a specific outcome, for example, a guarantee of winning \$10. This is then compared with a second option (B) which could be a 1-in-10 chance of winning \$100 but a 9-in-10 chance of winning nothing. According to rational choice theory, in this example, participants should be indifferent between the two options since both have the same EV, specifically  $1 \times \$10 = \$10$  for A;  $(0.1 \times \$100) + 0.9 \times \$0 = \$10$  for B. In fact, research shows that participants fairly reliably tend to prefer option A when choosing between certain and uncertain gains. However, if the problem is stated as a choice between losses, option B tends to be preferred. In Kahneman and Tversky’s (1979) Prospect Theory, which consolidates much of this research, this is expressed by saying that individuals tend to be ‘risk-averse for gains’ but ‘risk-seeking for losses’. Risk in this context is identified with uncertainty, option B being termed ‘risky’ because it is uncertain and not because it is associated with a more negative EV.

Kahneman and Tversky (1979) further stress that terms such as ‘gain’ and ‘loss’ are not absolute but relative to an implied reference or comparison point. In the example above, this is simply \$0, but in many cases this is not so. For instance, if one’s salary were suddenly cut by 50%, this would doubtless be experienced as a loss, even though there would still be a positive entry into one’s bank account. In other words, outcomes are only perceived as gains or losses when compared with a reference point that typically represents one’s expectations. This is illustrated even more forcefully by the fact that decision-makers’ preferences can be changed simply by altering the verbal description of a problem so as to imply a different reference point. The effect of such framing manipulations is to present the same outcome as though it is a gain (thereby inducing risk aversion in the sense defined above) or as a loss. For example, Tversky and Kahneman (1981) had participants imagine a choice between two preventive medicine programs to combat a serious epidemic, from which the expected death toll was 600. In one condition, the choice was between (A) a programme that would “save 200” and (B) one that had a 1/3 probability of saving 600, but a 2/3 probability of saving nobody; in this condition 72% preferred A. In another condition, the same dilemma was presented as one between (C) where 400 would die and (D) where there was a 1/3 probability of nobody dying, but a 2/3 probability of 600 dying; in this condition, 78% preferred D. This is because the ‘lives saved’ frame implies a comparison with 600 deaths, whereas the ‘lives lost’ frame implies a comparison with 0 deaths.

There is some evidence from the field of health communication (Rothman & Salovey, 1997) that messages can differ in their effectiveness depending on whether they are framed in terms of gains or losses. For instance, messages framed in terms of possible losses (e.g., disease progression or death) appear more effective at encouraging participation in screening or self-examination of symptoms (Rothman et al., 1999).

However, messages that encourage individuals to adopt self-protective behaviours (e.g., using sunscreen to avoid skin cancer, Detweiler et al., 1999) appear more effective when framed in terms of gains. There are important questions concerning what kinds of message framings are likely to be most effective in the context of natural hazards (McClure & Sibley, 2011; McClure, White & Sibley, 2009), where greater safety demands, on the one hand, detection of any increased threat (through scientific monitoring and attentiveness to warning signs) and, on the other hand, both anticipatory and reactive protective measures (e.g., more robust defences to buildings and infrastructure; evacuation procedures).

A further important issue when considering the relevance of cost-benefit analysis to natural hazards is the differing time frames within which each judgement is made. While the costs of acting to mitigate are immediate, the benefits may not be apparent for years, decades or longer. This affects whether or not people prepare. For example, Paton et al. (2008) found that many people who believed that preparing for wildfire events was important would not do so until a fire event was imminent (e.g., see flames, smoke). The reason for this was that the perceived benefits of preparing at this time (even though it would generally be too late for preparation to be effective) became evident. This poses methodological challenges in terms of assessing costs and benefits at any given point at time, as well as raising issues about which stakeholders are involved in any exercise to elicit perceived costs and benefits.

## 5. Heuristics

Another important concept emerging from the critique of the 'rational choice' approach is that of cognitive heuristics. These refer broadly to implicit decision rules or criteria that individuals appear to use to arrive at decisions without engaging in precise calculations. Reliance on heuristics can be particularly appealing if individuals lack complete information, or the time and/or motivation to process such information more carefully. Early studies (Kahneman & Tversky, 1973; Tversky & Kahneman, 1974) were focused mainly on identifying (and naming) specific heuristics and showing some of the errors (especially in terms of probability judgments) to which they give rise. For instance, the availability heuristic states that events are judged to be more probable if it is easier to recall similar instances from memory, or to imagine such events in the future. This is not, in itself, 'irrational', since more probable events could well have occurred more frequently in the past and so be easier to remember. However, this way of thinking is vulnerable to bias, since people may give disproportionate weight to a few memorable events (for instance if they receive widespread and vivid press coverage) without recognizing that their memory and attention is selective. Also widely cited is the representativeness heuristic. This refers to the tendency to judge an event (or combination of events) as more probable if it appears more 'typical' within a given context or category. This can take the form of a failure to recognize the asymmetrical nature of many associative relationships (e.g., confusing the sensitivity and specificity of diagnostic tests). For example, in many organizations the great majority of secretarial staff will be female. However this does not mean that the great majority of female staff will be secretaries. Hence a man who jumped to the conclusion that a female staff member was a secretary would be exhibiting reliance on this heuristic – as well as perhaps certain other attitudes!

Of special relevance to judgment of risk is work by Slovic and colleagues (Finucane et al., 2000; Slovic et al., 2002, 2004) on the affect heuristic. In general terms, this states that cognitive judgment (e.g., of probability and or the value of outcomes) can be strongly influenced by affective or emotional reactions. One feature of this is that evaluations of future events or prospects tend to become oversimplified. For an event (or hazard, or policy) with multiple consequences, a 'rational choice' calculation would demand that the decision-maker evaluate each possible consequence independently and weight it by its probability, then summate all these separate value X probability products to yield an overall approval or preference score. In other words, the separate consequences, good and bad, should be traded off against each other. There is no a priori reason why the evaluation of one consequence (or aspect) should depend on how any other consequence is evaluated. The null hypothesis is that these separate evaluations should be uncorrelated with each other. In fact, the evidence suggest otherwise. If an event or prospect is emotionally charged, individuals tend to resist acknowledging that it can have both clear benefits and clear costs. If they like or desire it, they will see it as have more benefits and fewer costs. If they dislike or fear it, they will see it as having fewer benefits and more costs. The tedious business of estimating the total value of the portfolio of separate benefits and costs is avoided by relying on the feelings elicited by the prospect, considered as a single entity. Thus there are good things you feel good about, and bad things you feel bad about, and not a lot of room for doubt in between.

At first reading, research on heuristics offers a somewhat depressing view of people's capacity for rational decision-making. Among other implications, we supposedly jump to conclusions on the basis of partial or irrelevant information and are easily misled by our emotions or sensationalist reporting. This view is not simply depressing. Taken at face value, it is politically dangerous, not least within the field of risk management and disaster prevention. It can offer a justification for authorities, who of course regard themselves as better informed with scientific expertise on their side (and by implication but with less justification, immune to heuristics and biases), to dismiss any opposition or dissent from ordinary citizens as ill-informed and irrational (Eiser & van der Pligt, 1979). Needless to say, this is a poor basis for dialogue. However, it is important to look critically at the evidence from which such inferences are derived.

In particular, the 'standard gamble' paradigm is designed to test a number of axioms of the rational choice model as embodied in classical economic theory. It is not a serious attempt to simulate the kinds of dilemmas that need to be addressed by policy-makers or ordinary citizens when faced by real-life hazards. The most striking aspect of the paradigm is that the probabilities and values of the outcomes to be considered are defined by the researcher. Even the uncertainties are known and defined. The only question is whether the research participant will prefer a certain outcome to a 'riskier' gamble where the outcomes could turn out much better or worse (but unrealistically with nothing in between the often starkly contrasted options presented). Consider the Tversky and Kahneman (1981) example of the imaginary epidemic. How could one ever know, in advance, the likely effectiveness and associated uncertainties associated with the alternative preventive measures? Similarly, many experiments provide participants with statistical information (e.g., the proportion of objects or people belonging to a given category possessing a specific characteristic). Such statistical information is simply provided as a certain fact, without any questioning of how it could be known in any real-life context. In other words, a large part of experimental work on cognitive heuristics presents participants with a description of the decision problem, whereas, outside the laboratory, decision-makers rarely have a ready-made description to work from. Instead, they need to make their own estimates of the likelihood and magnitude of different consequences from their own experience.

There is an increasing body of literature showing that such decisions from experience result often in very different choices from decisions from description, even when 'descriptions' convey accurately in advance the information that could eventually be gained experientially from complete sampling of the evidence available (Barron & Erev, 2003; Hertwig et al., 2004). This appears to apply particularly to assessment of rare events that might not be directly experienced if sampling of potentially available data is incomplete (Rakow & Newell, 2010), and so may be especially relevant to natural disasters and hazardous events with a long return period.

Closely related to this is a tendency for people to treat small samples of data as more representative of the total distribution than they really are. Kahneman and Tversky (1971) use the phrase 'the law of small numbers' to refer to people's readiness to over-generalize from small sets of data. By definition, low-probability disasters will occur very infrequently within a short time period (or within a narrowly defined geographical area). If one has not personally experienced a disaster, reliance on personal experience may lead to an underestimation of the statistical risk. This can also lead to overconfidence in the effectiveness of safety procedures, the reliance of building and infrastructure, and such like, essentially because these have not yet been fully put to the test. The other side of the story, however, is that, if a disaster does occur within the small sample of cases one experiences or is aware of, one may over-generalize to regard all apparently similar hazards as more dangerous than the statistics would otherwise suggest. Do nuclear accidents of the scale of Chernobyl and Fukushima, 25 years apart, 'prove' that all nuclear power stations are basically unsafe? Supporters of nuclear power would likely say not, since these were extremely rare events in the context of the nuclear industry worldwide, and one can point to exceptional factors or circumstances, which do not (hopefully) apply elsewhere. Opponents, by contrast, would likely dispute whether such factors are that exceptional, and argue that even two such events within 25 years are two too many. A great deal of the argument, therefore, boils down to the validity or otherwise of treating particular events or observations as representative.

## 6. Decisions from experience

Risk perception and decision making from experience differs from that based on statistics or other information (Weber, 2006; Weber & Lindemann, 2007). People attend to multiple characteristics of risks, including not only the severity of the threat or magnitude of potential consequences, but also their ability to do something about the risk, uncertainties and ambiguities about the risk, and what they know about the hazardous processes creating the risk in question (Fischhoff, 2009; Morgan et al., 1992; Morgan et al., 2002;

Slovic, 2002; Witte, 1994). In all of this, experts differ from non-experts, and experts in one area are likely to differ from those with other expertise (e.g., Barke & Jenkins-Smith, 2006; Bostrom, 1997). Just as people differ in their amounts and kinds of expertise, they differ in the extent and type of their personal experience.

To ask how individuals base decisions on experience is effectively to ask how people learn from their observations and the consequences of their decisions. Before considering how learning works, let us remind ourselves of the basic function it needs to serve. Responding appropriately in the face of risk involves, first and foremost, an ability to discriminate potentially dangerous situations from ones that are more probably safe. A framework for considering the costs and benefits of different decisions derives from a classic theory of visual perception known as Signal Detection Theory (SDT, Swets, 1973). The basic problem this theory addresses is that of describing the 'discrimination performance' of a perceiver faced with the task of identifying whether or not a piece of stimulus information is evidence of a 'signal' or merely 'noise'. For instance, how does a radar operator tell the difference between a blip on a screen due to an approaching aircraft and one due to atmospheric disturbance? How reliably can a remote sensing system detect abnormal seismic activity? How well can a doctor diagnose a particular condition from a set of clinical symptoms?

This can be represented in terms of a cross-tabulation (see Figure 1) where one axis represents the true properties of the object or stimulus (e.g., signal vs. noise) and the other axis represents the perceiver's response or decision (e.g., treat as signal vs. treat as noise). Each of the resulting cells then has a distinct meaning. Treating a real signal as a signal constitutes a 'true-positive' or 'hit'; treating a signal as noise constitutes a 'false-negative' or 'miss'; treating what is actually just noise as a signal is a 'false-positive' or 'false alarm' and treating noise as noise is a 'true-negative' or 'correct rejection'. SDT describes the performance of decision-makers or systems in terms of two parameters: sensitivity or discrimination ability (the proportion of correct responses, i.e., accuracy) and criterion or response bias (the tendency to give response in one direction, e.g., to say the 'signal' is present, or that the patient has the condition, regardless of the actual facts of the matter). This second parameter (criterion) is reflected in the type of errors made and not merely their number. Specifically, adoption of a relatively 'risky' criterion will result in some ambiguous pieces of information being over-interpreted as a 'signal' (reflected in more false-positives, or false alarms), whereas a more cautious (risk-averse) criterion will result in more false-negatives (misses), i.e., ambiguous information being over-interpreted as 'noise'.

Actual Risk	Dangerous	Safe
Danger	Hit	Miss
Safety	False Alarm	Correct All Clear
Learning	Maybe be difficult to distinguish false alarm from hit	Misses may be fatal, or consequences sporadic

Figure 1: Cross-tabulation of decision-outcome combinations, including potential sources of error in learning from feedback following decisions

So what determines the choice of a criterion for any decision problem? The first thing to appreciate is that no one criterion is any more correct than any other in an absolute sense. It all comes down to what kinds of errors we are prepared to accept and what kinds we are anxious to avoid. (Ideally, we don't want any errors, but that just amounts to saying that we aspire to a situation where we achieve perfect discrimination, in other words where information is ambiguous. In such an ideal world, we'd have no need to choose a decision criterion since there'd be no uncertainty.) Of major importance in the choice of criterion are the anticipated costs and benefits of different decision outcomes. With natural hazards, the costs of a miss (a failure to detect or predict a hazard event) can be catastrophic. By itself, this should push decision-makers in the direction of adopting a cautious criterion, where the chance of a miss is reduced at the price of accepting more false alarms. But the costs of false alarms are not necessarily trivial either, especially if they occur repeatedly. They may induce complacency or cynicism among populations at risk if warnings of imminent disasters fail to materialize. Furthermore, preventive measures (e.g., evacuation) may often cause disruption to normal life and economic activity. The important lesson here is that there is always a balance to be struck, and it is best if this is made explicit. We live in an uncertain, not an ideal, world.

This then leads on to several questions that are at the heart of the issue of risk interpretation and action. How should different costs and benefits be valued? Whose costs and benefits should be given most weight? How fair is any distribution of costs and benefits between different parties or stakeholders, between different groups within societies, between geographically separate regions and between present and future generations? These questions are intensely ethical and not merely empirical, but at the same time it is vital that ethical debates are informed by the best available empirical evidence. Next, how well can any such costs and benefits be anticipated? This bears on the more general question of how we learn from experience, and here there is much empirical evidence from which lessons can be drawn. The original formulation of SDT dealt with one-off discriminations between signals and noise, but not with how such discriminations are improved through learning and feedback concerning the outcome of such discriminations. For this reason, a third row ('Learning') has been added to the standard 2 X 2 table of decision-outcome combinations in Figure 1.

All learning is dynamic. That is to say, the knowledge, or rather, beliefs gained through learning change constantly over time as new information is acquired. Such beliefs can take many forms, but one of the most important is the ability to predict events. Broadly, predictions can be based on observations of events that co-occur (associative learning) and/or observations of the consequences of one's own or others' behaviour (instrumental learning).

To understand how beliefs change through either type of learning, we need to consider what happens when our predictions appear to be confirmed, or not, by feedback from experience. Fairly obviously, beliefs are strengthened by apparently confirmatory feedback and weakened by apparently contradictory feedback. As a result, apparently correct decisions should be ‘reinforced’ (i.e., should be more likely to be repeated) and apparently incorrect decisions should be revised. But why the qualification ‘apparently’? For at least three reasons: first, because the evidence itself may typically be uncertain and incomplete; second, because individuals appear biased towards interpreting ambiguous information as consistent with their prior beliefs (e.g., Darley & Fazio, 1980; Russo et al., 1996, 1998, 2008) as well as maintaining closer social relationships with others who share their views (Newcomb, 1961, 1981); and third, because – for both humans and other animals – survival, or merely the business of everyday living, requires that predictions and hence decisions have constantly to be made, even on the basis of uncertain and incomplete evidence.

If a decision is followed by a good outcome, this will make the decision-maker more confident that the decision was correct. This in turn will increase the probability of making the same decision under similar circumstances in the future, and if the outcome is still favourable, the decision-maker will become even more convinced. Laboratory experiments have shown that even animals will adopt an implicit logic not too unlike a rational choice model of preference: the more favourable the outcome, and the greater its relative frequency, the stronger will be the tendency to repeat the chosen course of action (Rescorla & Wagner, 1972). However, there is a major constraint on such ‘rationality’. Such choices will not only reflect previous learning but will shape future learning by constraining the kinds of feedback the decision-maker will receive. Put differently, the sampling of the ‘problem space’ (of decision-outcome contingencies) will be biased and incomplete (see Eiser & Fazio, 2008; Fazio, Eiser & Shook, 2004).

The original formulation of SDT was useful as a way of conceptualizing uncertain information (in terms of distributions of noise and signals of different strengths) but did not focus specifically on problems of incomplete information. Nonetheless, we can adapt an extended SDT framework to consider how the choice of criterion constrains the decision-maker’s opportunity to learn from experience. First of all, let’s suppose someone adopts a cautious or risk-averse criterion. This should lead to fewer instances of damage or disaster as a consequence of inadequate protective or preventive measures. The price of this is a greater number of false alarms. But how reliably can false alarms be distinguished from hits? In many contexts this can be very difficult. Research has shown that animals (and humans) can be quick to learn to avoid situations in which they have been hurt or frightened in the past and that such learnt avoidance behaviours (e.g., certain phobias) can be very persistent. Part of the reason for this is that, once one starts avoiding such situations, one is not only rewarded by feelings of relief from stress, but also never puts one’s fears to the test by seeing if the danger is (still) real. Put differently, one can’t tell the difference between a hit and a false alarm unless one can tell what would have happened in the absence of such evasive or protective action.

The above example describes a situation in which the protective measure chosen is effective in avoiding an actual threat, but is over-used in situations where no threat exists. Not all avoidance behaviours, however, rely on firm evidence of effectiveness. For example, many people may engage in superstitious rituals, adopt fad diets, or undergo unnecessary medical procedures, as ways of warding off personal misfortune or diseases which either wouldn’t have happened anyway, or from which they would have spontaneously recovered. If nothing bad then happens, people (and not just patients, but doctors too, Gigerenzer, 2002) will believe that such actions were effective forms of protection. Not only will this mean that such actions will be reinforced (repeated), it will mean that people may come to ignore real signs of danger or recommendations for more effective forms of protection.

Now let's consider situations where individuals adopt a risky criterion, that is, treat some threats as less dangerous than they really are. This can arise in many contexts where instances of unsafe behaviour are not immediately or inevitably followed by damage or disaster. In other words, people get away with behaving dangerously. Not all cases of dangerous or even drunk driving lead to accidents, and arriving unharmed at the end of such a drive may inflate false optimism in one's driving ability (or capacity for alcohol). Many dangerous health behaviours are linked only probabilistically to actual diseases (even cigarette smoking and lung cancer) and, importantly, such effects can be delayed for many years, to the point that they would be unlikely to be recognized without the contributions of medical epidemiology. In the meantime, such behaviours typically provide much more immediate gratification. Psychologists refer to such cases as examples of partial or delayed reinforcement. The point in each case is that individual experience often provides uncertain evidence of the actual level of danger. This can also take the form of a discounting of warnings, in other words, regarding valid protective advice as false alarms simply because such advice must, by its very nature, be probabilistic. An example could be hurricane warnings, where the strength or trajectory of the hurricane turns out to be less damaging than originally forecast. This does not mean that the warnings were excessively alarmist at the time they were given. Nonetheless, it can in some instances lead to people being somewhat complacent about the level of risk, with the result that they may discount the urgency of future warnings. In addition, as least in Western cultures, many people appear to show an optimistic bias whereby they judge their own risk from hazards to be lower than that of others (Weinstein, 1980). This bias is likely to be aggravated with rare events for which people lack personal experience, such as earthquakes (Spittal, McClure, Siegert, & Walkey, 2005).

Natural hazards vary enormously in the 'reinforcement schedules' they impose on safer and less safe forms of individual behaviour and policy. Most geophysical hazards (less so for tsunamis than for earthquakes and volcanic eruptions) are reasonably predictable in terms of where they are most likely to happen (although prediction of impacts at a very local level can be more difficult and/or contentious). However, predicting when they will occur is far more challenging, particularly when these are extremely rare occurrences. By contrast, weather-related hazards may happen more frequently, and be recognizably associated with particular regions and/or seasons, but the intensity of any impacts may be less predictable, not least with the effects of climate change. Anecdotal evidence of novel weather patterns, animal behaviour and growth of crops and flora is increasingly being supported by more systematic analysis (e.g., Miles et al., 2000). In all such cases, it is likely that individuals will use their own personal experience alongside any scientific evidence that can be made available when deciding on their response (if any) to the hazards in their environment. Just as science often has to do the best it can with incomplete data, so too personal experience will be selective and often based on a small sample of events. However, it is far from clear that people in all walks of life (including science) recognize the extent to which their decisions are based on information that is not merely incomplete, but even biased by their own previous decisions and commitments in the direction of confirming their existing judgements. Overconfidence in our own judgements is the price we pay for needing to be decisive in an uncertain world. Identifying such overconfidence is one of the tasks of science, as well as of other forms of critical analysis. But this is only part of the difficulty. Correcting gaps and biases in our knowledge requires more than an open and inquiring mind. It can take time and effort and involve upfront costs as well as risks, actual and perceived.

The calculus of the benefits of correct decisions and costs of incorrect ones also needs to incorporate the costs of gaining more information to reduce uncertainty and hence avoid more errors. The costs of extra information may not always be justified by the outcomes of improved decision-making.

## 7. Trust in others

These, then, are some of the lessons that can be drawn from research on how individuals process information and draw inferences from their experience. But we make very many of our decisions not merely as individuals, but as members of groups and communities linked together in complex sets of social relationships. This affects the motivational basis for many forms of action, since we need to take account of others' needs and expectations as well as our own. We also often need to rely upon other people to fill in gaps in our own understanding of events and to provide guidance on appropriate actions. But whom can we rely upon, and for what kinds of information or guidance? This raises the question of how risk interpretation and action is influenced by our trust in others. This is of central importance in the field of natural hazards where ordinary citizens may need to rely on scientific experts to provide information concerning the severity and/or urgency of any threat, and on risk managers within government, industry or other institutions to take many of the decisions required to protect them from such threats.

Trust, however, is not a unitary concept. Among other aspects, we need to distinguish between trust in others' knowledge or expertise on the one hand, and their motivation, honesty and integrity on the other hand. This closely parallels the SDT distinction between discrimination ability and criterion setting (White & Eiser, 2007; Paton, 2008). We want other people on whom we need to rely both to know what they are doing and to use their knowledge in a way that does not compromise our safety and well-being for some inappropriate motive, such as personal profit. When we consult doctors for medical treatment, we are putting our trust not only in their expertise, but in their integrity to prescribe the treatment that was most appropriate for us and not merely the one that was most profitable to them personally, e.g., in terms of insurance payments or inducements from pharmaceutical companies. But at the same time, there is a balance to be struck between the cost of treatment (to both patient and provider) and its likely health benefits. When we take a flight, we are putting our trust in a whole range of professionals and manufactured systems, and this includes assuming that everyone will be making the right kind of judgments about when to take off and land, for example, taking account of weather and any other hazards. Most of the time, we follow a routine without thinking deeply about how others make decisions on our behalf, but when an event disrupts this routine, as when volcanic ash leads to the lengthy closure of air space, and regulators need to decide if it is safe enough, or too dangerous to fly, the balancing of benefits and costs to all parties becomes exposed.

Experimental and survey research has demonstrated that people are sensitive to cues regarding the competence (discrimination ability) and motivation (criterion setting) of others responsible for controlling risks and/or communicating advice about the extent of any risk. This involves differentiations between various actors and agencies in terms of how they are evaluated with respect to different aspects of trustworthiness. Gratifyingly, in many situations 'independent scientists' are seen as particularly likely to be well-informed and honest. This process can be influenced by the fact people rarely access and interpret scientific information. They often receive it after it has been filtered and interpreted by agencies (e.g., influenced by their political and cost benefit interests) and the media (e.g., social amplification). Climate change research illustrates how trust in scientific sources can be affected by others' interpretations. By contrast, industry representatives, although also seen as fairly knowledgeable, are often mistrusted since they are seen as making decisions or offering advice that is motivated by concerns for personal profit. Friends and family are highly trusted in terms of their motivations, but seen as less knowledgeable. Also pertinent is research on factors that can lead to a gain or loss in trust. There is a good deal of truth in the adage that trust is easy to lose and difficult to rebuild (White & Eiser, 2006; Paton, 2008). A dilemma faced by many risk managers is how far to go in admitting one's mistakes. Such admissions can help bolster one's perceived honesty, but weaken one's perceived competence. However, failing to admit a mistake and then being discovered in the deception is the worst combination.

Trust, then, is partly dependent on attributions of responsibility for decisions that produce benefits and costs, or mitigate or exacerbate any risk (McClure, Walkey & Allen, 1999). With natural hazards and disasters there are many of these, both on the part of ordinary citizens on the one hand and that of regulators or policy-makers on the other. Many hazards turn into disasters through negligence or lack of foresight at several levels. Casualties and losses from earthquakes depend not simply on their magnitude but on the proximity of centres of population, the quality of buildings and infrastructure and the extent of compliance with, and enforcement of, building regulations (where these exist). But responsibility for earthquake damage is not the same as responsibility for the earthquake itself. For hazards, such as earthquakes, that cannot be prevented and only predicted with difficulty, it is understandable that many people will adopt a fatalistic attitude that such events are beyond their control (McClure, Allen & Walkey, 2001; McClure, Sutton & Sibley, 2007). A policy challenge here is that of convincing people that, nonetheless, there is much they can do that is within their control, such as securing furniture and fittings, preparing stores and planning what to do if forced to evacuate.

Trust is also influenced by the quality of the transactions that occur between people and sources of information. One construct that has been used to illuminate how trust develops is empowerment (Paton, 2008; Paton et al., 2008; Paton, Smith, Daly & Johnston, 2008; Paton et al., 2009). This work demonstrated how trust is a function of the interaction between empowered people and empowering settings. Thus, certain community characteristics (e.g., levels of active participation) and competencies (e.g., collective efficacy) provide an input into creating empowered people who can identify and represent their hazard management needs. Whether these are enacted is a function of the degree to which they interact with agencies that create empowering settings (e.g., responsive to community needs). These interact to influence trust beliefs, with trust mediating the relationship with intentions and preparation.

This is also an area where we need to be sensitive to cultural factors (Becker et al., 2008, Paton et al., 2008). Fatalistic attitudes may be underpinned by religious or spiritual beliefs of various kinds. The influence of spiritual or religious fatalism may be influenced by the phase of disaster being examined. While it may undermine decisions to prepare, it may facilitate recovery. For example, the cultural fatalism within Buddhist beliefs may have assisted recovery in Thai populations affected by the 2004 Indian Ocean tsunami (Paton & Tang, 2009). While not a religion per se, a component of Confucianism promotes long term thinking, perseverance and the importance of preparing for future adversity and these cultural qualities may translate an implicit fatalism into a degree of preparedness. This is an area requiring more work. Furthermore, any discussion of personal responsibility needs to take account of people's actual or perceived freedom of choice. In what sense can people be said to 'choose' to live in an earthquake-prone zone, for example? A company executive who moves to a highly paid post in San Francisco may be thought of as having more freedom of choice than a labourer in an impoverished part of Istanbul or a Kashmiri village. Yet even in such a case, "an offer one can't refuse" may trump concerns about risk as effectively as a real fear of losing one's livelihood if one were forced to relocate. As in other contexts, caution has costs as well as benefits, and these costs have to be borne upfront and balanced against the less certain costs of being caught up in a disaster, and the foregone benefits if no disaster occurs.

Once again, however, this emphasis on an assumed calculation of costs and benefits by individuals needs to be balanced by attention to more social processes. The default option for most people in most situations is to adopt the attitudes and practices that are normative within their community and reference group. Often the easiest – and least effortful – way of dealing with uncertainty is to avoid making a personal decision at all, but to leave decisions to others, to copy what others do and to carry on as before.

This again will be mediated with trust, but the importance of mere imitation should not be underestimated. Several decades of research on conformity processes shows that people will copy one another in their judgments and behaviour even where such others are no better placed or informed than they are themselves. Again, since much of the published literature on such processes has a very narrow cultural base (predominantly North American, and even within such culture, mainly involving college students), there is a huge need, as well as opportunity, to examine how such less formal processes of information exchange operate in many of the cultures and communities most affected by natural hazards, where ready access to electronic and printed media may be limited and rates of literacy may often be far lower.

Yet there are dangers in exaggerating the homogeneity of any culture or social group. Typically, societies will offer a repertoire of interpretative frameworks, albeit within a dominant world view, and such diversity may help adaptability to changed circumstances. There is much evidence that risks may be appraised differently even within single cultures and that such differences in appraisal will have consequences for behaviour, for example in relation to protection against flood risk (Grothmann & Reusswig, 2006). There is also evidence of some individual differences in personality and cognitive style that are reflected in people's confidence in their ability as decision-makers, their willingness to make a decision at all as opposed to procrastinating or avoiding responsibility, and how much they prefer 'closure' to continuing uncertainty (e.g., Janis & Mann, 1977; Webster & Kruglanski, 1994).

Social processes are also strongly implicated in the way risk messages come to be interpreted, and reinterpreted, over time. Kasperson (Kasperson et al., 2003) uses the terms 'social amplification' and 'social attenuation' to describe how different kinds of risk are picked up (or not) by the media and other agents and attract greater or lesser attention. In emergencies, people do not simply attend individually to information about what to do, but often try to evaluate it collectively through comparing their interpretations with those of others – a phenomenon known as 'social milling' (Mileti & Peek, 2000, 2002; Mileti & Sorensen, 1990). People will converse with each other about the significance of any risk message, so that what emerges from such 'social milling' is a composite of people's individual interpretations. This process may be greatly accelerated and widened through the internet and use of information communications technology.

Cross-cultural psychology distinguishes between universal and culture-specific factors (Paton et al., 2010a and b). From this it becomes possible to develop and test cross-cultural equivalence in adaptive processes. That is, cross-cultural comparison should be based on comparing across cultural dimensions rather than countries. Work on cross-cultural equivalence should be complemented with research into culture-specific mechanisms such as *Jishubo* in Japan and the *Hakka Spirit* in Taiwan. The latter work can also deconstruct these constructs to explore similarities and differences in deep structure processes and examine the cultural underpinnings of their development and action to identify the degree to which such mechanisms could be transferred to other cultures.

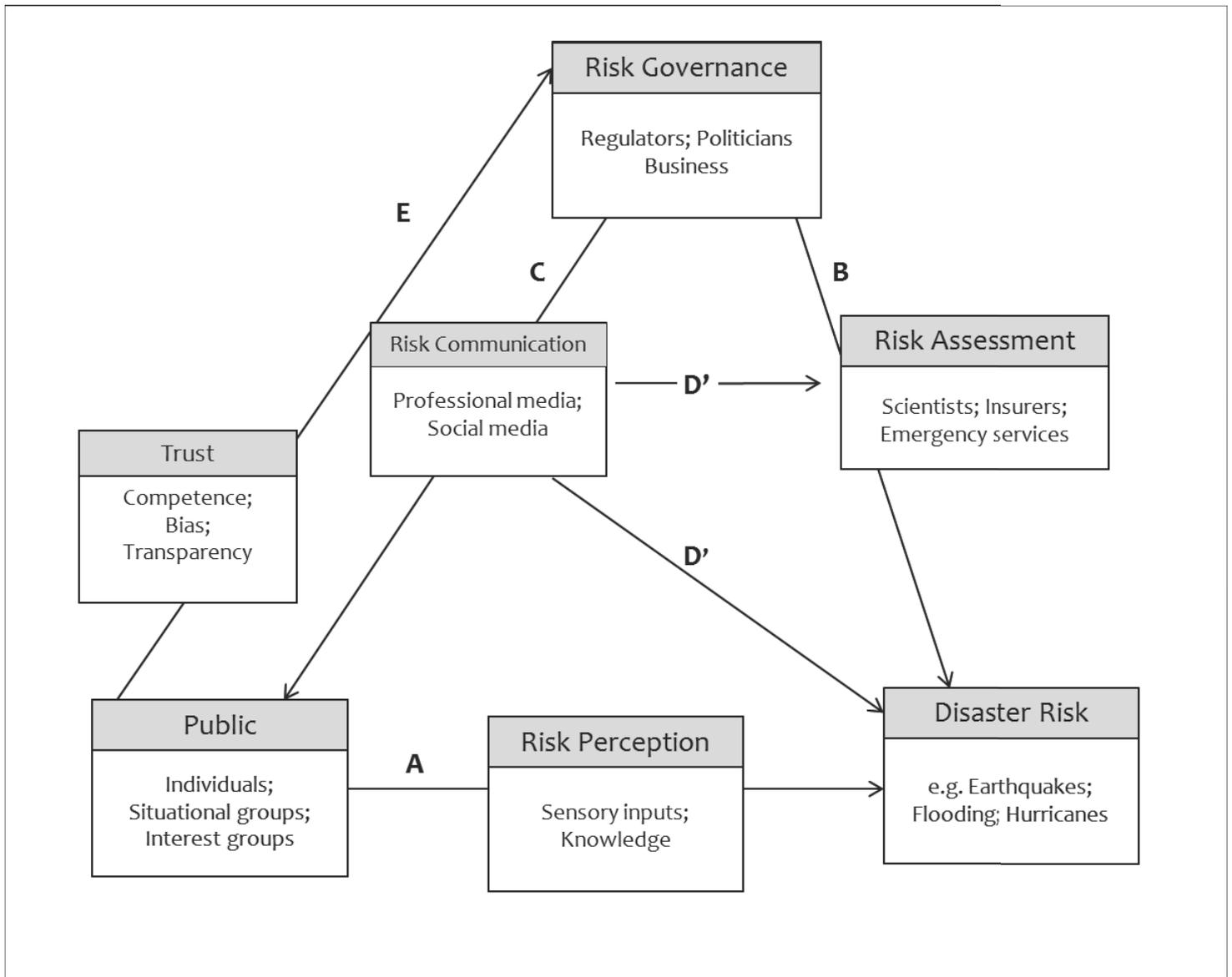
## 8. Complexity, scale and social context

As noted, applying lessons from previous research on risk and decision-making to the context of natural hazards is especially challenging because of the increase in scale and complexity, and the fact that we need to consider the interactions between the decisions made by several actors rather than those of individuals considered singly. Different actors may have different levels of access to relevant (e.g., scientific) information, but this is only part of the story. They will also have separate, sometimes opposing, interests, and may evaluate different outcomes very differently. The aspects of risks (physical, economic, political) borne by different actors will often be different, and many decisions may have the effect (if not the intention) of transferring risk onto other groups, whether those with less economic or political power, those living further away (e.g., in a different country or jurisdiction) or future generations. This clearly raises important ethical issues.

Scaling up from the individual to the societal level requires more than a consideration of social collectives and communities as single entities. Communities are not simply groups of individuals who happen to be categorized together, but groups of individuals who interact and communicate with one another. These interactions and communications are what turn groups into social systems. Integrated research on risk interpretation and the integration of social systems are thus intimately interconnected.

Attempts to study risk interpretation and action at the level of social systems, however, are still relatively uncommon. Consider, once again, the issue of trust. Johnson (1999) has argued that much of the previous research on public trust in risk/disaster managers has focused on perceptions of the different stakeholders separately and attempts to compare to see who is more or less trusted. However in reality, he argues, individuals have to place their trust in whole systems of risk/disaster management, which will depend on the interplay of these different agents. So, for example, to what extent can we believe messages from official regulators that come to us through the media given: a) the pressure on them from industry, b) reporting biases of the media, c) competing scientific opinions and so on. A conceptualization of this process is shown in Figure 2. Moreover, the public may trust the various actors in some respects but not others, e.g., scientists, to accurately assess the risks but not necessarily to be most concerned about the economic impacts (Johnson & White, 2010). This model is still in its infancy and further research is needed linking to a mental models approach (Morgan, Fischhoff, Bostrom & Atman, 2002) to improve our understanding of how the public conceptualizes not just the hazard but the hazard management system and how trust and distrust can emerge from these perceptions of competing interests and perspectives.

Figure 2: A schematic representation of the hazard management system for disaster risk from the perspective of the public



The various linkages within this system include:

A) Public → Disaster Risk. Members of the public, either as individuals or groups try to make their own appraisal of the risks. We refer to this as Risk Interpretation. It is based on sensory inputs, knowledge, beliefs and values. If the public has high levels of confidence in their own perceptions they will act accordingly without too much recourse to consideration of other sources of information (e.g., press, official statements etc).

B) Risk Governance → Disaster Risk. Those responsible or liable for managing risk (e.g., government, regulators, business etc) will be trying to base their response to more technical assessments that are conducted through more formal Risk Assessment. This will be carried out by a range of organizations including scientists, insurers and emergency services.

C) Risk Governance → Risk Communicators → Public. Risk managers will attempt to communicate their assessment of the risk to the public, generally through traditional media channels, i.e., Risk Communication. The messages may or may not be all that the risk managers believe to be true.

D) Risk Communicators ---> Disaster Risk/Risk Assessment. The professional media, in many countries at least, rarely takes the risk managers messages at face value and often seeks to make its own appraisals of the disaster (D', Risk Interpretations) and those assessing it (D''). Moreover, modern technology also allows other members of the public to record and communicate their own assessments of the risk via use of video and social media and the internet (D'). This provides a potentially useful but problematic way of communicating disaster risk.

E) Public ---> Risk Communicators---> Risk Governance. If the public feels unable to assess the risks itself it then has to decide what to believe in terms of the communication it is receiving from risk managers, filtered through the professional media, and directly from professional and social media. The degree to which the public thinks these sources are competent, has their interests at heart and is being open and transparent will determine how much trust the public has in them.

Recent research by Paton (2006) and others has developed a generic model of community resilience, which takes into account many of the psychological and social factors that influence whether people prepare for hazard events. The model explores a number of indicators of resilience, and the interaction (pathways) between them (Daly et al., 2009). The indicators of most relevance can be grouped into three areas: (1) Personal - where people need to know that actions they do can make a positive difference for themselves, their families and their neighbours (outcome expectancy and action coping); (2) Community - where residents actively participate in their communities to identify and discuss their issues and risks and determine collective solutions (community participation and problem articulation); and (3) Institutional -where communities are supported by civic agencies that encourage and empower community-lead initiatives and where mutual trust and respect exist (empowerment and trust).



Figure 3: A model of community resilience, showing selected indicators at each level (personal, community and institutional) and relationships between them (adapted after Paton, 2006, and presented in Daly et al., 2009)

## 9. From risk to action

Assessing risk is one thing; acting on the basis of such assessments is another. A pervasive misconception is that ordinary citizens typically fail to protect themselves from hazards because they are ignorant of ‘the facts’, irrational in how they interpret information, or both. Similar assumptions are also invoked to explain instances of supposed over-reaction to hazards deemed less serious by experts or policy-makers. Previous research underlines the importance of improved risk communication, but this is not a panacea. Risk communicators are not always sufficiently trusted, and one needs to understand why. Likewise, citizens may not always respond (as authorities hope) to risk warnings, not because they are ‘irrational’, but because they feel severely constrained in terms of the options open to them (as when evacuation in the face of a less-than-certain hazard will result in a loss of livelihood and means of supporting one’s family). These constraints must be understood and anticipated in any plans for disaster prevention and risk mitigation.

When conceptualizing preparedness, it is important not to see it as an all or none process. Some people decide not to prepare (Paton, Smith & Johnston, 2005). Others may be interested but need more guidance. These starting points are different and informed by different interpretive and decision processes and intervention must acknowledge this. At the other end of the preparedness spectrum are those that have acted and whose continuing to do so may require engaging with them in different ways.

Other things being equal, we would expect people to choose actions or activities that enhance or protect their health and well-being and avoid actions and activities that put themselves and their families at risk. So why is there any gap between risk interpretation and action? For a start, other things very often are not equal. The same activities can have the potential for both enhanced well-being and/or harm. Profitable activities can be relatively dangerous, and vice versa, as with farming on fertile slopes of volcanoes or flood-prone river valleys. As we have argued, the calculus for what constitutes a ‘rational’ choice in such contexts is beset by uncertainties concerning both the likelihood and personal value of different outcomes. Furthermore, although one might, in the abstract, imagine choices which optimize benefit while minimizing risk, such choices may simply not be available, or affordable, for many people in many real-life situations.

There is another vital distinction that is often overlooked. Beliefs or expectations about the extent of any hazard are often not the same as beliefs or expectations about the consequences of any recommended or contemplated course of action. The latter, rather than the former, are the primary drivers of behavioural decisions. Another way of putting this is that general attitudes concerning hazards (e.g., a hurricane or earthquake) differ from attitudes towards more specific acts to be undertaken in the face of such hazards (e.g., evacuation, or making one’s home more secure). A lot of this boils down to whether people think such acts will be effective and/or within their own control anyway. Research on individual health behaviour (e.g., smoking, alcohol use, dietary behaviour) contains several examples of so-called ‘attitude-behaviour discrepancies’. These typically involve people engaging in habits that they know and admit to be damaging to their health. Such ‘discrepancies’, however, may be more apparent than real. Often acknowledgement of long-term health risk is off-set, at least partly, by expectations of more immediate gratification. But, probably just as often, such habits are supported by a whole set of pessimistic self-beliefs, based on personal experience, that changing one’s habits will be very difficult and trying to do so is likely to end in failure (and so yield no health benefits) (Eiser & Sutton, 1977).

Again, many lessons can be drawn from policy initiatives to influence health behaviour, such as combating cigarette smoking. Of course one needs to start with evidence-based messages that cigarette smoking (say) is dangerous.

Fifty years ago, these messages were new, but they are no longer, so (although new generations must still be told about the risks), something else is needed, since many smokers still continue, and many young people take up the habit, despite 'knowing' the risks, at least in general terms. This 'something else' involves analysing the factors that make it difficult for many people to make healthier choices and then intervening to make such healthier choices easier (and unhealthy choices more of a hassle). With smoking, this has involved, on the one hand, a recognition of the addictive nature of nicotine and the development of smoke-free nicotine products to help smokers quit, but, on the other hand, major initiatives to change the whole social milieu within which smoking occurs, through banning or restricting tobacco advertising, vending machines, smoking in bars and other public places, and not least through increasing the price of cigarettes through taxation. In other words, the approach taken in many countries involves (a) at the level of the individual, a finer-grain analysis of the reinforcement contingencies (perceived costs and benefits) that make it difficult, and sometimes well-nigh impossible, for individuals to overcome immediate obstacles to achieve a longer-term gain (or reduction of risk); and (b) at the level of the society, a re-engineering of the environment to make the healthier, or safer, option more and more likely to be the default choice for many people. In the space between individuals and society as a whole, moreover, much can be, and is being, done. For many, if not all, difficult decisions and life-changes, individuals need social support – from family, friends and their local community. Not only are these typically highly trusted to have one's interests at heart, they can also provide models for imitation and practice of improved behaviour. Conversely, if social support is lacking, or even acts against behaviour change (as in many groups and cultures where unhealthy behaviour is the norm, Lazuras, Eiser & Rodafinos, 2009a, 2009b) attempted policy initiatives by more remote government authorities or even health professionals are far less likely to succeed.

How analogous are – or could be – policy initiatives for disaster reduction in the context of natural hazards? At the individual or more micro level, there are opportunities for interventions to make preventive or protective measures more accessible and affordable. This could include micro-insurance schemes for farmers in developing countries. In more developed countries, grants and other fiscal instruments can be used to incentivize more sustainable behaviours such as lower energy consumption. At the societal or more macro level, there are measures that need to be put in place for which governments must carry the primary responsibility. These include: setting up and/or maintaining properly organized facilities for the monitoring of natural hazards and the forecasting of hazard events; defining and enforcing regulations to prevent unsafe land-use, building practices and other industrial activities that compromise environmental safety; protecting vital infrastructure; and planning for emergencies, e.g., in relation to evacuation and relief provision. In many such cases, what needs to be done is broadly already known – what are needed, more typically, are the economic resources and the political will to confront special interest groups that are often more powerful than the government itself. International cooperation has an important part to play here, not only through the pooling of scientific knowledge and sharing of resources, but also through providing examples of best practice and even moral pressure from other states who can also be put at risk through poor practice by their neighbours. There are, however, very many cases where the best that can be hoped for is a mitigation of risks that have developed historically, especially through population movements and the growth of large cities in vulnerable locations.

Once again, though, the involvement and support of local communities is vital. Conversely, when local communities mistrust national governments or international agencies, there will be huge difficulties in putting policies into practice.

## 10. The way forward

Ultimately all research on natural hazards and disasters, whether from a natural or behavioural science perspective, is to offer some knowledge that might help prevent death, damage and distress in some measure. This is, ideally, knowledge for the common good as well as for its own sake. Yet this ideal must be tempered by awareness that the translation of research into practice is frequently beset by obstacles of many kinds. Access to such knowledge may be limited, and those who have it may choose not to share it, nor to use it for the common good.

Our focus in this report has been on what lessons we can draw from previous research in terms of how best to conceptualize how people interpret risks and choose actions based on such interpretations within the context of natural hazards. This context is one defined not just by vulnerability to some physical event, but also by social relationships. The judgements and choices underlying risk interpretation and action, then, are not merely personal, but also interpersonal. However, we must stress that this is still a work in progress. We find a literature that, while varied and extensive, is not, as yet, especially well integrated.

Many natural hazard researchers appear to specialize in specific hazards, to some extent, for example earthquakes, or floods, leading to a lack of cross-fertilization in some areas of research. The lack of cross-fertilization leads to discontinuities in how risk decisions and related factors are conceptualized. For example, geographers and risk analysts interpret vulnerability somewhat differently, so that they may talk past one another in discussions of how to improve data and models. More research on social and research networks within the field of natural hazards could help point to ways of promoting better integration (see e.g., Börner et al., 2010; Schummer, 2004).

There is increasing acknowledgement of the role of human behaviour in influencing whether hazard events do or do not develop into disasters. However, this acknowledgement is only sporadically accompanied by a more than superficial analysis of the factors that determine human behaviour and observable differences between individuals and social groups in their feelings, cognitions and actions. This imbalance in research activity and funding, and proposals for research on disasters and risk decisions, is exemplified by the recently released National Research Council (NRC) (NRC, 2011) report on U.S. national earthquake resilience. The report outlines 18 areas of funding. In only one of these areas are social sciences named explicitly at the top level, and behavioural sciences seem virtually absent from the top-level discussion. In contrast, physics is named specifically in one of the lines proposed for significant funding, as is performance-based engineering. Nevertheless, the research agenda is proposed as an integrated, interdisciplinary research agenda.

By and large, integrated risk assessments are lacking, and where they do exist, integration with the social and behavioural sciences is weak. We could use better integration across the different types of decisions people make about hazards and disasters, from avoidance through mitigation and adaptation – that is, from individual, institutional and political decisions about prevention and investments in resilience, through immediate responses and decisions in events, to post-event decisions. Better understanding of the characteristics of and constraints imposed by different decision contexts would be useful.

The quality of data available to allow for more integrated risk assessments is also uneven. Data quality issues can stem from lack of monitoring technologies, insufficient funding, or suppression of data or delay (e.g., of disease outbreak information by governments). There have been major technological advances in earth observation and Geographical Information Systems (GIS).

As argued by Carrara, Guzzetti, Cardinali and Reichenbach (1999), advances in GIS have been hailed as offering potential means of forecasting a range of natural disasters, including landslides. However, although considerable progress has been made, diffusion of this technology is still hampered by factors such as problems in acquiring appropriate data, the complexity of predictable models and a variety of other factors such as a preference for data that can be acquired at a low cost rather than data that are the most relevant and predictive. Even in the context of tsunami warning systems, where there have been major recent advances, there are also gaps and challenges. Tsunami warnings until recently have not incorporated what is known about what makes warnings effective, and tsunami warning systems do not effectively incorporate or address the social milling (Mileti and Sorensen, 1990; Mileti and Peek, 2000, 2002) that happens in disasters (NRC, 2010). Some attempts have been made to develop a more holistic model for effective warning systems, such as that for volcanoes in New Zealand (Leonard et al., 2008).

At the same time, much research within the social and behavioural sciences, such as some of that reviewed in this report, has progressed in rather abstract contexts. This means that a good deal of vigilance is needed when trying to extend the conclusions of such studies to the field of disaster research. While many of the theoretical principles identified by such work may indeed have a high degree of generality, it is also important to look critically at the paradigms employed, since these may fail to incorporate factors that are crucial to much real-life decision-making. We have, for example, highlighted the fact that many laboratory experiments on decisions under uncertainty do not deal with the kind of uncertainty that arises from limited access to statistical information, nor with the updating of estimates based on feedback from experience. This is not a general criticism of experimental research within psychology and other behavioural sciences. The whole point of the experimental method is to look at the effects of some variables while controlling for others. What is important is that the variables or processes being considered are the relevant ones. Feedback from experience is most certainly a process that can be investigated experimentally – a century of research on learning theory demonstrates this quite clearly – it is just that its relevance has not always been recognized in research on decisions under uncertainty.

Yet any method that tries to look at the effect of ‘independent variables’ while controlling for others has a major limitation. It is not well suited (though few methods are) to the study of dynamic interactions within complex systems over time and space. Natural hazards and disasters are prime examples of complex dynamical systems. The primary interaction of interest has been human actors and the natural hazard. Take away the hazard, and the people are safe. Take away the people, and we are left merely with a geophysical or meteorological event, not a disaster. But there are, of course, very many other interactions over all kinds of scales. The hazard events themselves have complex dynamics, and interact with other events. Likewise, the human actors are not isolated decision-makers making one-off choices independently of everyone else. Natural hazards and disasters highlight, often most graphically, our social dependence on one another. Yet we have to start somewhere, to find some thread to pull that may disentangle part of the knot. One such thread is how we, as individuals and as members of social networks, interpret risk and act upon our interpretations.

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# Appendices

## About IRDR

The impacts of natural hazards continue to increase around the world; the frequency of recorded disasters affecting communities has risen significantly over the past century. Although earthquakes and tsunamis can have horrific impacts, most disaster losses stem from climate-related hazards such as hurricanes, cyclones, other major storms, floods, landslides, wildfires, heat waves, and droughts.

The Integrated Research on Disaster Risk (IRDR) Programme is a decade-long integrated research programme co-sponsored by the International Council for Science (ICSU), the International Social Science Council (ISSC), and the United Nations International Strategy for Disaster Reduction (UNISDR). It is a global, multi-disciplinary approach to dealing with the challenges brought by natural disasters, mitigating their impacts, and improving related policy-making mechanisms. Unfortunately, there is a great shortfall in current research on how science is used to shape social and political decision-making in the context of hazards and disasters. Addressing this problem requires an approach that integrates research and policy-making across all hazards, disciplines, and geographic regions. The IRDR Programme endeavors to bring together the natural, socio-economic, health, and engineering sciences in a coordinated effort to reduce the risks associated with natural hazards.

The IRDR programme has three research objectives:

- Characterization of hazards, vulnerability, and risk
- Understanding decision-making in complex and changing risk contexts
- Reducing risk and curbing losses through knowledge-based actions

Three cross-cutting themes support these objectives:

- Capacity building, including mapping capacity for disaster reduction and building self-sustaining capacity at various levels for different hazards
- Development and compilation case studies and demonstration projects
- Assessment, data management, and monitoring of hazards, risks, and disasters

Attainment of these three research objectives through successful projects will lead to a better understanding of hazards, vulnerability and risk, and an enhanced capacity to model and forecast the risk; a better understanding of the decision-making choices that lead to risk and how they may be influenced, and how this knowledge can be better used towards disaster risk reduction.

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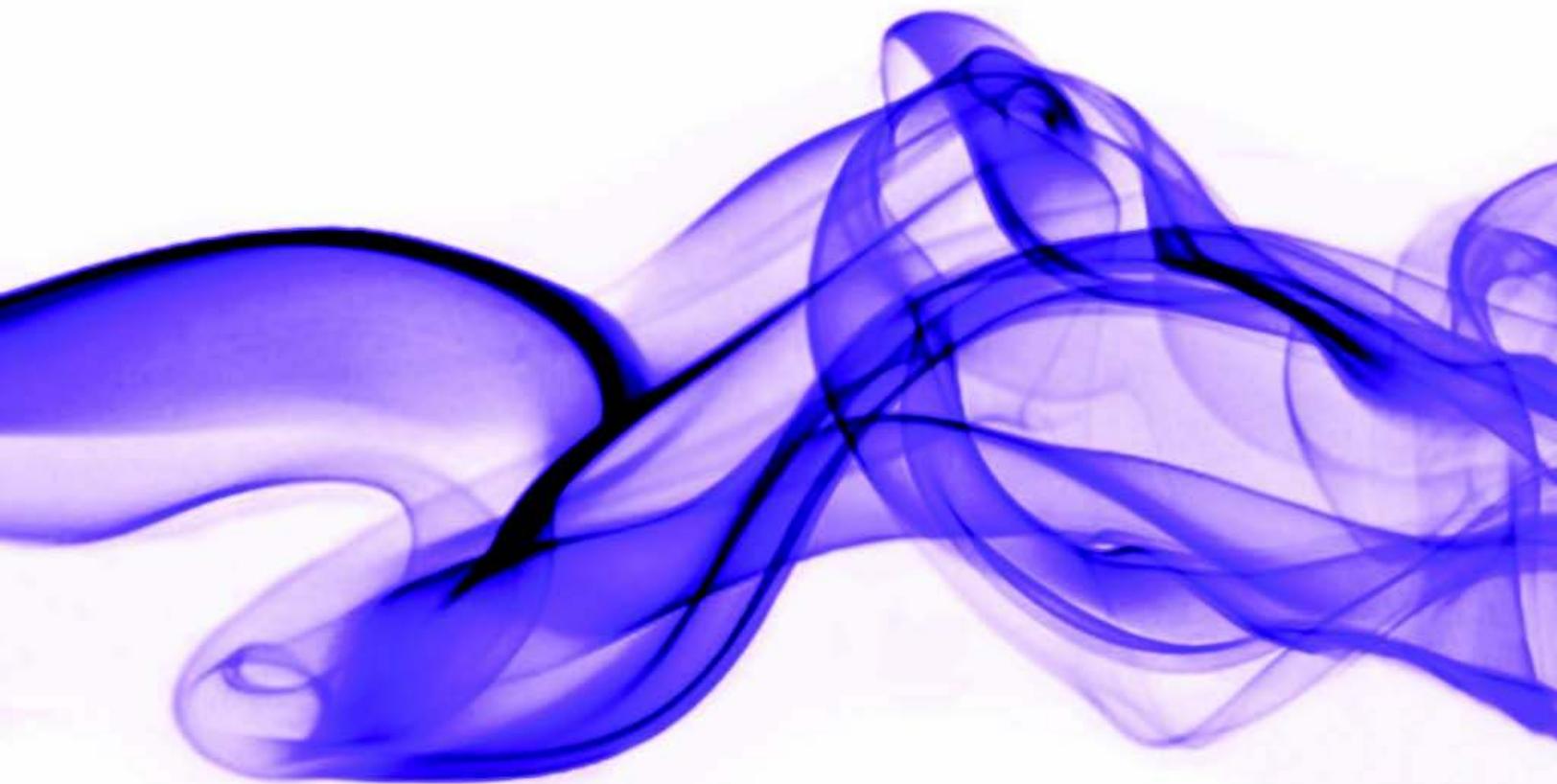
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Integrated Research on Disaster Risk IPO  
c/o CEODE, CAS  
B713, No. 9 Dengzhuang South Road  
Haidian District, Beijing 100094, P.R. China  
+86 10 8217 8917  
[connect@irdrinternational.org](mailto:connect@irdrinternational.org)

[www.irdrinternational.org](http://www.irdrinternational.org)