EXPERIENCE-BASED AND DESCRIPTION-BASED PERCEPTIONS OF LONG-TERM RISK: WHY GLOBAL WARMING DOES NOT SCARE US (YET)

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Abstract. It should come as no surprise that the governments and citizenries of many countries show little concern about climate change and its consequences. Behavioral decision research over the last 30 years provides a series of lessons about the importance of affect in perceptions of risk and in decisions to take actions that reduce or manage perceived risks. Evidence from a range of domains suggests that worry drives risk management decisions. When people fail to be alarmed about a risk or hazard, they do not take precautions. Recent personal experience strongly influences the evaluation of a risky option. Low-probability events generate less concern than their probability warrants on average, but more concern than they deserve in those rare instances when they do occur. Personal experience with noticeable and serious consequences of global warming is still rare in many regions of the world. When people base their decisions on statistical descriptions about a hazard provided by others, characteristics of the hazard identified as psychological risk dimensions predict differences in alarm or worry across different classes of risk. The time-delayed, abstract, and often statistical nature of the risks of global warming does not evoke strong visceral reactions. These results suggest that we should find ways to evoke visceral reactions towards the risk of global warming, perhaps by simulations of its concrete future consequences for people's home or other regions they visit or value. Increased concern about global warming needs to solicited carefully, however, to prevent a decrease in concern about other relevant risks. The generation of worry or concern about global warming may be a necessary but not sufficient condition for desirable or appropriate protective or mitigating behavior on part of the general public.

1. Introduction

There appears to be growing consensus among climate scientists worldwide about the seriousness of potential risks posed by global warming (IPCC, 2001; Arctic Climate Impact Assessment, 2004). Some hold this belief so passionately that they go to great length to alert the public and politicians to the magnitude of the risks, stepping outside of their typical scientific venues to provide congressional testimony or popular press accounts to trigger action (e.g., Hansen, 2004). With some notable exceptions, the concern shown by citizens and governmental officials is smaller and less emphatic than that of climate scientists (Dunlap and Saad, 2001). The absence of a visceral response on part of the public to the risks posed by global warming may be responsible for the arguably less than optimal allocation of personal and collective resources to deal with this issue. Behavioral decision research over the past 30 years provides some answers as to why members of the general public and

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their public officials show so much less concern about global warming than climate scientists.

This paper makes three claims and provides supporting evidence for them. (1) The first claim concerns the causal importance of visceral reactions towards risk. To paraphrase Peters and Slovic (2000), affect – and, in particular, negative affect – is the wellspring of action. Emotions like fear or worry motivate us to remove ourselves from a dangerous situation or to change the environment in ways that reduce our feeling of being at risk. While the affective system is only one of two processing systems available to homo sapiens, it has much greater influence over decisions under risk and uncertainty (including actions to address global warming) than the analytical processing system. Visceral reactions like fear or anxiety serve as early warning to indicate that some risk management action is in order and motivate us to execute that action.

The next two claims provide an explanation for the absence of (visceral) concern about global warming on part of the general public, which can be puzzling to climate scientists. (2) The second claim is that there are two pathways to establish concern, or the feeling of being at risk, that are differentially effective. The first, more effective path is through personal exposure to (adverse) consequences, typically repeatedly and over time. The second, less effective path is through the consideration and possibly mental simulation of adverse consequences based on a statistical summary of the hazard, typically provided by domain experts. (3) The last claim concerns that fact that people's visceral reactions to risky situations often have little correspondence to more objective measures of risk that quantify either the statistical unpredictability of outcomes or the magnitude or likelihood of adverse consequences. Instead, visceral judgments of risk (which fuel self-protective action) are determined by other situational characteristics that elicit affective reactions as part of our evolutionary heritage.

The next sections provide support for these three claims. In combination, they suggest that, without intervention, the risks of global warming will fail to evoke visceral reactions, thus predicting that we will fail to allocate attentional and material resources to these risks. The final section of the paper introduces two other behavioral regularities that further complicate policy recommendations on how to motivate nonscientists to take more appropriate preventative, protective, or mitigating action against global warming. The paper ends with a more positive set of implications and recommendations.

2. Affect as the Wellspring of Action

2.1. RISK AS FEELINGS

Evidence from cognitive, social, and clinical psychology has been converging on the observation that risk perceptions are influenced by association- and affect-driven

processes as much or more than by analytic processes (see Loewenstein et al., 2001, for a review). People have been shown to process information in two distinct ways, mediated by different neural substrates when making judgments or arriving at decisions (Chaiken and Trope, 1999; Epstein, 1994; Sloman, 1996; Slovic et al., 2002). The first system, which is evolutionarily older and thus shared with other animals (not just mammals but birds and insects as well) works on the basis of temporal and spatial association and similarity. It teaches us, for example, to dislike food eaten just prior to symptoms of food poisoning and to avoid foods of similar taste or smell in the future. The associative system is intuitive, automatic, and fast. It maps uncertain and adverse aspects of the environment into affective responses (e.g., fear, dread, anxiety) and thus represents *risk* as a *feeling* (Loewenstein et al., 2001). This system requires real world experience as input (i.e., experienced decision makers make better decisions using it than novices), but its basic mechanisms are hard-wired.

The second processing system works by analytic algorithms and rules, including those specified by normative models of judgment and decision making (e.g., the probability calculus, Bayesian updating, formal logic, and utility maximization). It is slower and requires conscious awareness and control. Its algorithms need to be taught explicitly and its appropriateness of use for a given situation needs to be obvious, i.e., it does not get triggered automatically.

The two processing systems typically operate in parallel and interact with each other. Analytic reasoning cannot be effective unless it is guided and assisted by emotion and affect (Damasio, 1994). In cases where the outputs from the two processing systems disagree, however, the affective, association-based system usually prevails, as in the case of phobic reactions, where people know perfectly well that their avoidance behavior is at best ineffective and possible harmful to them, but cannot suspend it. Global warming, on the other hand, is an example where a dissociation between the output of the analytic and the affective system may result in less concern than advisable, with analytic consideration suggesting that global warming is a serious concern, but the affective system failing to send an early warning signal.

Even in seemingly objective contexts such as financial investment decisions, subjective and largely affective factors been shown to influence perceptions of risk. Holtgrave and Weber (1993) show that both affective reactions (e.g., dread) and cognitive-consequentialist considerations (e.g., choice outcomes and their probabilities) were necessary to predict perceptions of risk by University of Chicago MBA students in financial as well as health and safety decisions. As discussed below, women have been shown to worry more than men about a host of risks, including financial risks. Consistent with this difference in concern, women enroll in voluntary pension plans in greater numbers and make larger contributions than men (Sethi-Iyengar et al., 2004). Hersch and Viscusi (this volume) provide survey data that suggest that national differences in worry about global warming are associated with willingness to pay more for gasoline, if such price increases would result in less harm to the environment.

If risk perceptions were driven mostly or exclusively by cognitive-consequentialist variables, they would not be influenced by the way a particular hazard is labeled. Yet, reports about incidences of "mad cow disease" elicit greater fear than reports about incidences of bovine spongiform encephalitis (BSE) or Creutzfeld-Jacob disease, a more abstract, scientific label for the same disorder (Sinaceur and Heath, 2004). Aware of the affective power of labels, the Bush White House has instructed its departments and agencies to use the more neutral term "climate change" instead of "global warming." It is worth noting however that even the more emotionally-charged label "global warming" does not carry particularly negative or scary associations.

3. Two Pathways to Feeling at Risk: Personal Experience vs. Statistical Description

Consider the decision of whether to vaccinate a child against diphtheria, tetanus, and pertussis (DTaP). Parents who research the side effects of the DTaP vaccine by consulting the National Immunization Program Web site or a brochure provided by their pediatrician will learn that up to 1 child out of 1,000 will suffer from high fever (over 105°F) and about 1 child out of 14,000 will suffer from seizures as a result of immunization. An increasing number of parents, after reading such information, decide not to immunize their child. Although doctors have the same statistics at their disposal, they also have access to information not available to parents–namely, personal experience gathered across many patients. This information tells them that vaccination is very unlikely to result in side effects. Few doctors will have encountered one of the rare cases of high fever or seizures. If they have encountered one, the experience is dwarfed by thousands of memories of side-effect free immunizations. Doctors and public health officials thus tend to be strong advocates of immunization. Disagreement between doctors and parents on the question of whether vaccination is advised seems to be related to differences in the weight given to rare events (like the likelihood of a seizure) as a function of *how* they learn about this likelihood, either through *personal experience* or from a *statistical description*.[1]

The distinction between risky decisions made from personal experience and those made from statistical description has gotten a lot of recent attention because the ostensibly same information can lead to different choices depending on how the information is acquired (Hertwig et al., 2004, 2006). Decisions from experience rely on (repeated) personal encounters with risky choice options, the way animals make risky foraging decisions (Weber et al., 2004). While the outcomes of choice options may initially be completely unknown, repeated choices provide the decision maker with feedback about possible outcomes and their likelihood. Decisions from description, on the other hand, are made based on outcome and probability information provided in some numeric or statistical summary form. This method of

TABLE I
Choice pairs used in Experiments 1 and 2 of Weber, Shafir, and Blais (2004) and the observed proportions of respondents choosing the sure-thing option (p(ST)) under experience-based choice (Experiment1) and description-based choice (Experiment 2)

Choice pairs			*p* (Sure thing)	
ID#	Sure thing	Gamble	Expt. 1	Expt. 2
1	\$1	(\$0, .9; \$10, .1)	.68	.40
2	\$3	(\$0, .5; \$6, .5)	.39	.25
3	\$9	(\$0, .1; \$10, .9)	.24	.72
4	\$1	(\$0, .5; \$2, .5)	.58	.24
5	\$6	(\$0, .5; \$12, .5)	.42	.45

information acquisition is available only to humans, with their ability for abstract, symbolic representation.

People's choices can differ quite dramatically under the two information conditions, especially when the risky options include small probability events. Table I shows the proportion of respondents who chose the sure-thing option when choosing between two decks of cards in two studies by Weber et al. (2004). In Experiment 1, respondents were allowed to sample at their leisure (with replacement) from two decks of cards until they were confident they knew from which deck they would prefer to draw a card for a real monetary payoff. For choice pair #3, one deck contained 50 cards that all indicated a win of \$9, the other deck contained 5 cards that indicated that nothing was won or lost (\$0) and 45 cards that indicated a win of \$10. When decision makers discovered this information gradually by repeated sampling of cards (i.e., by personal experience), only 24% chose the "sure-thing" deck. In Experiment 2, respondents were provided with full information about the two decks, i.e., they were shown pie charts that summarized the amount(s) that could be won with each deck and their probabilities. In this description-based condition, 72% of respondents preferred to draw their real-payoff card from the sure-thing deck.

Weber et al. (2004) and Hertwig et al. (2006) describe the association- and affect-based learning mechanisms by which personal experience with low probability events leads to more apparent risk taking (and presumably lower risk perception) than that observed when the same options are presented by statistic summary descriptions. In a nutshell, people's evaluation of risky options under repeated sampling seem to follow classical reinforcement learning models where initial impressions are continuously updated in a way that gives recent events more weight than distant events.[2] Because rare events have a small(er) probability of having occurred recently, they (on average) tend to have a smaller impact on the decision than their objective likelihood of occurrence would warrant.[3] In those rare

instances where they do occur, recency weighting gives them a much larger impact on the decision than warranted by their probability, making decisions from experience more volatile across respondents and past outcome histories than decisions from description.[4] If people base their visceral reactions to the risks of global warming on personal experience, their perceptions of the risks will be low. The likelihood of seriously and noticeably adverse events as the result global warming is bound to be small for the foreseeable future for many regions of the world. As a result, ordinary continental Americans and even people whose economic livelihood depends on weather and climate events (e.g., farmers or fishermen) may not receive sufficient feedback from their daily or yearly personal experience to develop a reaction of alarm about global warming.[5] Climate scientists, on the other hand, whose research personally exposes them to observe the noticeable consequences of climate change in Arctic regions or Pacific Islands have a very different base of experience and thus experience-based reactions to the risks of global warming. They also have more and more reliable analytic information about global warming. Perhaps most importantly, climate scientists–by virtue of their education and training–can be expected to place far greater reliance than members of the general population on their analytical processing system and the statistical description and model output available to them, making them more likely on all three counts to consider global warming to be a more serious risk.

4. Feelings of Risk do not Agree with More Objective Measures of Risk

The observation that the feelings of members of the general public about such risks as global warming or nuclear power do not coincide with objective outcome information and the risk assessments provided by scientists and engineers has given rise to a number of attempts to describe and explain the discrepancy. A brief review of several paradigms that have examined subjective risk perception prior to the recent focus on the distinction between experience-based and description-based information processing will show that previous explanations are oftentimes related and make similar assumptions about the ways in which evolution provided homo sapiens (an information processor with finite attention and memory) with affective shortcuts to alert him or her to imminent danger and trigger quick evasive action. While these emotional reactions kick in quickly and automatically for the kinds of risks present in our early evolutionary history, they fail to occur for the more complex and time-delayed risks we face now. Our analytic processing system which allows us to address such complex risks and to use the vicarious experience of others in the form of statistical summary information is an evolutionary work-in-progress. Its operation is not (and perhaps cannot be) automatic and thus requires processing time and effort. Its algorithms are not hardwired but need to be learned and practiced. It is thus a processing system that we would expect to be in greater evidence in

segments of the population with greater education and technical sophistication and expertise.

4.1. AXIOMATIC MEASURES OF PERCEIVED RISK

Studies within the axiomatic measurement paradigm have focused on the way in which people seem to subjectively transform objective risk information (i.e., possible consequences of risky choice options such as mortality rates or financial returns and their likelihood of occurrence) in ways that reflect the impact that these events have on their lives (e.g., Weber, 2001a, 2001b; Palmer, 1996). The conjoint-expected risk model (Luce and Weber, 1986), for example, allows for the possibility that upside variability in financial returns has a different (and usually smaller) effect on perceived riskiness than downside variability. Partly because of their focus on higher-order moments of outcome distributions, empirical studies validating axiomatic measures of perceived risk have almost exclusively employed choice situations where the outcomes of risky choice options are (statistically) described (e.g., as an outcome distribution for a lottery or a past return distribution for an investment option) rather than personally experienced over time. The axiomatic measurement paradigm describes (more than explains) differences in the subjective perception of the risk of global warming by differences in values of parameters that determine the relative weight given to such situational components as upside vs. downside, or probability vs. outcome information.

Another explanation in the axiomatic measurement tradition is the distinction between exponential vs. hyperbolic discounting of future costs or benefits. While it is reasonable to discount future costs and benefits by a constant amount per period of time delay (e.g., by the current rate of interest offered by banks), a mechanism that can described mathematically by an exponential discount function, empirical research shows that people apply sharp discounts to costs or benefits that will occur at some point in the future (e.g., a year from now) relative to experiencing them immediately, but discount much less when both time points are in the future, with one occurring later than the other (e.g., six years into the future vs. five years into the future). Such behavior can be described mathematically by a hyperbolic discount function which shows its greatest decrement as we defer immediate consumption (Ainslie, 1975; Loewenstein and Elster, 1992). Actions to mitigate climate change are unattractive within this framework because they require immediate sacrifices in consumption that are compensated only by heavily-discounted and highly-uncertain benefits at a much later point in time. Hyperbolic discounting is mostly a restatement of the phenomenon, rather than an explanation. McClure et al. (2004) recently attributed hyperbolic discounting to the operation of two separate neural substrates (one responsible for tradeoffs involving immediate costs or benefits and the other responsible for all other tradeoffs differing in time). Other researchers have looked for more proximal mechanisms as discussed in the next section.

4.2. CONSTRUCTED PREFERENCE AND PERCEIVED RISK

The notion that people, in many choice situations, do not have firmly established preferences but instead construct them when they need to make a decision is one of the most robust insights of behavioral decision research (see Payne et al., 1993; Slovic, 1995). Two theories related to preference construction relate to intertemporal discounting. Trope and Liberman (2003) suggest that people construe future events differently from events in the present. In particular, events in the distant future (an invitation to give a paper at a conference two years from now, or the prospect of coastal flooding 30 or 50 years from now) are construed in abstract terms, whereas events close to us in time (the upcoming trip on Monday to attend the long-scheduled conference, or the prospect of a major hurricane passing through town tomorrow) are construed in very concrete terms. One difference between the abstract vs. concrete representation of the consequences of possible actions lies in their discrepancy in affective strength and impact. Abstract representations of consequences in the distant future lack the concrete associations that are connected to emotional reactions, essentially by definition. In contrast, concrete representations of choice alternatives in the present or the immediate future tend to be saturated with affective associations. This difference in the richness and concreteness of the representation of temporally close vs. distant consequences may well lie at the root of observed problems of self control, be they impatience and impulsivity in obtaining desirable outcomes (Mischel et al., 1969; Laibson, 1997) or procrastination with undesirable tasks (O'Donoghue and Rabin, 1999). Protective or mitigating actions against global warming require the sacrifice of concrete, immediate benefits for the sake of abstract, distant goals. The strong negative affect associated with the concrete, immediate costs and sacrifices and the absence of feelings of worry about possible abstract and distant consequences of global warming in the absence of such actions may well drive ecologically damaging consumption decisions and actions.

The other process-level theory of preference construction that has addressed intertemporal discounting is the preferences as memory framework of Weber and Johnson (2006). Its query theory assumes that people, when asked to delay consumption, first assess the evidence for immediate consumption and only then assess evidence that argues for delaying consumption. Query theory also postulates that, in order to help people reach a decision, evidence generated in favor of an action (e.g., immediate consumption) tends to interfere with the subsequent generation of evidence arguing against that action. Weber et al. (2006) not only find empirical support for both conjectures, but also succeed in drastically reducing the intertemporal discounting in people's choice by prompting them to first generate evidence in favor of deferring consumption, followed by a prompt to generate evidence in favor of immediate consumption. It is a question for future research whether the order of evidence generation also affects people's feelings of being at risk.

4.3. CULTURAL THEORY PREDICTIONS OF PERCEIVED RISK

While the axiomatic measurement tradition adheres to what some have described as the gambling metaphor of risky decision making, two other paradigms that have studied subjective perceptions of risk deviate from this metaphor in important ways. Many researchers have criticized the assumption that all risky decisions can be reduced to a probability distribution of possible outcomes that have a certain utility or disutility like that provided for monetary gambles, and that once such a distribution of the utilities of possible outcomes is established, no other characteristics of the decision (i.e., details of what the decision is about) are relevant (see Goldstein and Weber, 1995, for a review and critique of the gambling metaphor). Studies within the socio-cultural paradigm have examined the effect of group- and culture-level variables on risk perception, using typically participant-observation methodologies of anthropology (e.g., Douglas and Wildavsky, 1982). Risk perception is viewed as a collective phenomenon by which members of different cultures selectively attend to different categories of danger. Each culture selects some risks for attention and chooses to ignore others. Cultural differences in risk perceptions are explained in terms of their contribution to maintaining a particular way of life. The theory identifies five distinct cultures (labeled hierarchical, individualist, egalitarian, fatalist, and hermitic, respectively) that differ in their patterns of interpersonal relationships and argues that members of these cultures therefore differ in their perceptions of risk. Hierarchically arranged groups, for example, tend to perceive industrial and technological risks as opportunities and thus less risky, whereas more egalitarian groups tend to perceive them as threats to their social structure. The significance of this approach to understanding risk perception is that it provides a way of accounting for the effect of group- and culture-level variables on the behavior of individuals. It suggests that culture teaches individuals where their interests lie and what variables and events pose risks to those interests and ways of life.

Differences in prior experience or in general orienting disposition or worldview (Dake, 1991) seem to affect risk perceptions by moderating people's affective reactions. Familiarity with a risk (e.g., acquired by daily exposure) lowers perceptions of its riskiness, with the result that technical experts perceive the risk of such technologies as nuclear power generation to be much lower than members of the general public (Fischhoff et al., 1978). Numerous studies report differences in risk perception between men and women, with women judging health, safety, and recreational risks (Finucane et al., 2000; Flynn et al., 1994; Slovic, 1987) and also risks in the financial and ethical domain (Weber et al., 2002) to be larger and more problematic than men. This gender difference in perceived riskiness reverses only in the social domain, in which women arguably have greater familiarity (Weber et al., 2002).

Leiserowitz (this volume) has recently provided evidence for the value of this approach to understanding cultural differences in perceptions of the risks of global warming, following earlier work by O'Connor et al. (1998, 1999) that showed that differences in worldview affected perceptions of the risk of climate change.

4.4. PSYCHOLOGICAL RISK DIMENSIONS AS DETERMINANTS OF PERCEIVED RISK

Using psychophysical scaling and multivariate analysis techniques, the psychometric paradigm has identified the characteristics of hazards that affect people's subjective feelings of being at risk. This paradigm is the one that has more directly addressed people's emotional reactions to risky situations, showing that psychological/affective risk dimensions strongly influence judgments of the riskiness of physical, environmental, and material risks in ways that go beyond their objective consequences (Fischhoff et al., 1978; Slovic et al., 1986). Respondents are (implicitly) assumed to have some measure of personal familiarity with the risky stimuli used within these two paradigms, typically technologies or activities that pose some risk to health or safety (e.g., living within 20 miles of a nuclear power station). Descriptions of these risks rarely include explicit information about the severity or likelihood of adverse outcomes, which instead are (again implicitly) assumed to be generated by respondents from memory of personal experience or media coverage, possibly by using such heuristics as availability (see Sunstein, this volume). Peters and Slovic (1996) showed that differences in people's perceptions of technological or health and safety risk as a function of worldview or culture (Dake, 1991) can be captured and predicted by ratings of the affective valence of word or image associations generated by respondents to a label like "nuclear power."

Figure 1 shows the two-dimensional factor space that has been replicated across numerous studies in which people judged diverse sets of hazards in multiple countries (Slovic, 1997). Factor 1, labeled "dread risk," captures those aspects of the described hazards that trigger our emotional early warning system. These are the situations that speed up our heart rate and make us anxious as we encounter them, probably as the result of natural selection: perceived lack of control over exposure to the risk and consequences that are catastrophic. At its high (right hand) end, we find such hazards as nuclear weapons fallout, nuclear reactor accidents, or nerve gas accidents or attacks. Factor 2, labeled "unknown risk," refers to the degree to which a risk is new: how much is known about the hazard and how easily are exposure and adverse consequences detectable? At its high (top) end, we find chemical hazards and radiation, which might kill exposed parties without their awareness, and DNA technology which has unforeseeable consequences not yet tested by time.

It is instructive to place the risks of global warming into the two-dimensional space of Figure 1. To the extent that people conceive of climate change as a simple and gradual change from current to future values on variables such as average temperatures and precipitation, or the frequency or intensity of specific events such as freezes, hurricanes, or tornadoes, the risks posed by climate change would appear to be well-known and, at least in principle, controllable ("move from Miami to Vancouver when things get too hot or dangerous in Florida"). While some of the perceived control may be illusory, the ability or inability

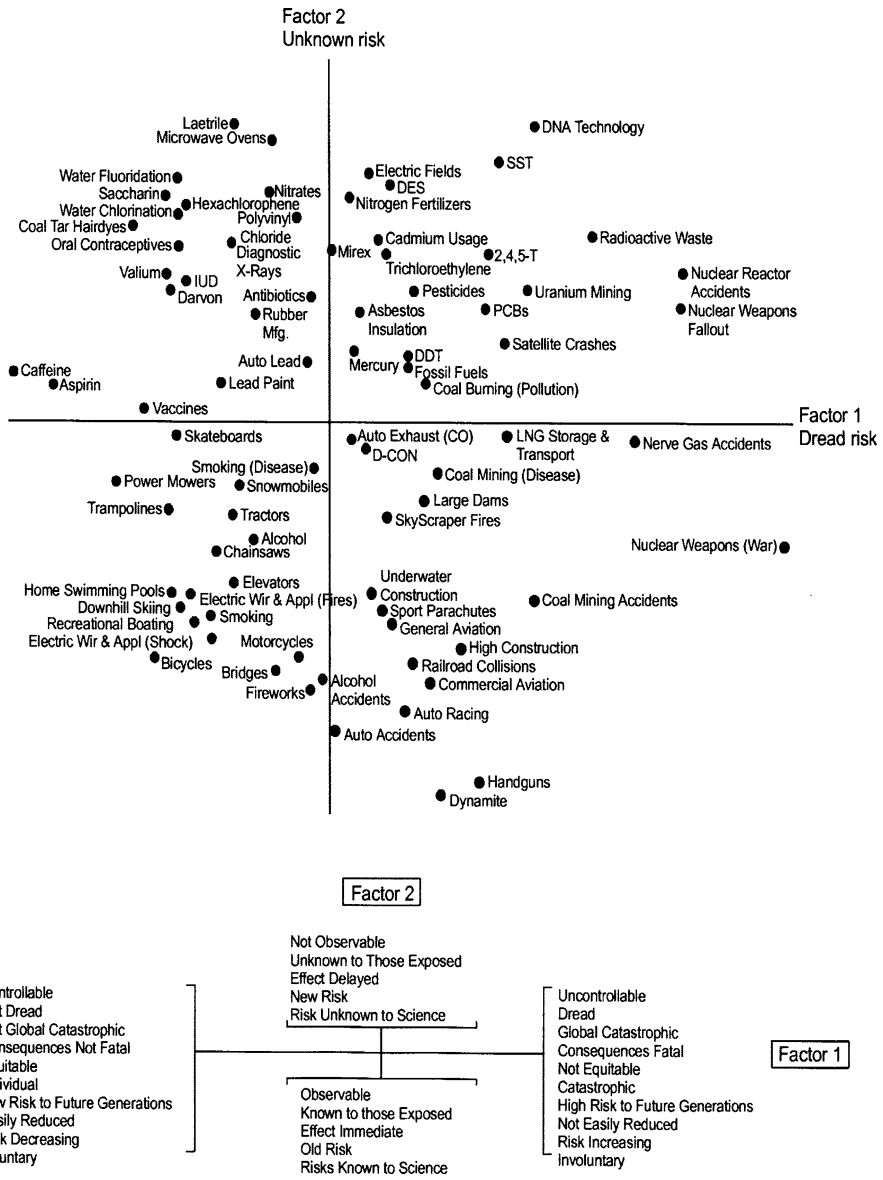

Figure 1. Location of 81 hazards in a two-dimensional space derived by factor analysis from the intercorrelations of 15 risk characteristics. Each factor is made up of a combination of characteristics, as indicated by the lower diagram. (Source: Slovic (1987)).

to take corrective action is an important component of vulnerability. It is only the potentially catastrophic nature of (rapid) climate change (of the kind graphically depicted in the movie "The Day after Tomorrow") and the global dimension of adverse effects which may create hardships for future generations that

have the potential for raising a visceral reaction to the risk (see Leiserowitz, 2004).

4.5. AFFECT IN DESCRIPTION-BASED CHOICE

To bring the review of affect-driven phenomena in risk perception full-circle, psychological risk dimensions or, more generally, affective reactions to risky choice options seem to play a role even in description-based choice. Prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992) was developed to accurately capture observed choice regularities in description-based decisions. Its decision weight function predicts that people will overweight small probability events, in the sense that these event influence decisions more than their probability of occurrence would warrant. While the psychological reasons for this regularity have not been spelled out explicitly nor tested, it seems reasonable to attribute them to attentional processes. To the extent that people spend approximately the same amount of time to process information about a small-probability and a large-probability event when the two are presented in a pie chart or an outcome histogram, the decisions weights of all possible events can be expected to show some regression towards equal weighting, which would result in the overweighting of small and the underweighting of large probabilities, as specified by prospect theory and observed in many situations. On the other hand, there are situations where people seem to ignore small-probability risks altogether, e.g., when failing to buy subsidized flood-plain insurance. It would be interesting to investigate the hypothesis that the decision option's location in the psychological risk dimension space is responsible for either the overweighting or the editing out of rare events when they are communicated by statistical description. Evidence at least consistent with this conjecture has been provided by Rottenstreich and Hsee (2001).

5. Policy Recommendations and Caveats

It may be tempting to conclude that the research reviewed in the previous sections suggests that we should find ways to evoke stronger visceral reactions towards the risk of global warming in citizens, managers, or public officials, by making the possible consequences of global warming more vivid or concrete. Such a course of action may, however, have some unintended consequences. As worry increases about one type of risk, concern about other risks has been shown to go down, as if people had only so much capacity for worry (Linville and Fischer, 1991). Increased concern about global warming may result in decreased concern about other risks, suggesting that climate scientists and policy makers need to consider a portfolio of risks they would like to keep within the public's awareness.

5.1. FINITE POOL OF WORRY

Hansen et al. (2004) investigated the finite-pool-of-worry hypothesis in a climate context, testing whether increases in concern about climate variability on the part of Argentine farmers resulted in a decrease in concern about other risks. In two scenarios of a farm decision experiment, farmers rated the extent that they worried about (a) the political situation in Argentina and its effects on taxes, etc., (b) weather and climate, (c) prices of input variables, and (d) prices of crops at harvest, on a scale from 0 ("not at all worried") to 10 ("extremely worried"). The two scenarios involved the same crop-selection and cultivation decisions, but differed in the provision of a seasonal climate forecast which indicated unfavorable La Niña conditions for the upcoming growing season. Not surprisingly, stated concern about climate risks among the farmers significantly increased from the first to the second scenario, essentially providing a manipulation check for the provided climate information. At the same time, however, concern about political risk decreased from the first to the second scenario, even though the objective political risk had obviously not changed. There was some indication that concern and worry was a finite resource even *within* each scenario. In both climate scenarios, farmers who worried more about political risk tended to worry less about climate risk (the correlation between ratings of political risk and climate risk was -0.50 in Scenario 1 and -0.47 in Scenario 2). Judgments of worry or perceived risk were not inconsequential, in that differences in farmers' perceptions of the degree of risk posed by political, climate, input costs and crop price variables were associated with differences in their production and pricing decisions.

A real world illustration of the finite pool of worry effect is provided by the observation that increases in the concern of the U.S. public about terrorism post 9/11 seem to have resulted in decreased concern about other issues such as environmental degradation or restrictions of civil liberties.

5.2. SINGLE ACTION BIAS

Another class of suboptimal risk management responses is at least consistent with the role of affect as a motivator for action. Weber (1997) coined the phrase *single action bias* for the following phenomenon observed in contexts ranging from medical diagnosis to farmers' reactions to climate change. Decision makers are very likely to take one action to reduce a risk that they encounter and worry about, but are much less likely to take additional steps that would provide incremental protection or risk reduction. The single action taken is not necessarily the most effective one, nor is it the same for different decision makers. However, regardless of which single action is taken first, decision makers have a tendency to not take any further action, presumably because the first action suffices in reducing the feeling of worry or vulnerability. Thus Berbaum et al. (1991) found that radiologists looking for

abnormalities in x-rays often halt their search after finding one lesion, leaving additional lesions undetected. Weber (1997) found that farmers who showed concern about global warming in the early 1990s were likely to change either something in their production practice (e.g., irrigate), their pricing practice (e.g., ensure crop prices through the futures market), or lobbied for government interventions (e.g., ethanol taxes), but hardly ever engaged in more than one of those actions, even though a portfolio of protective actions might have been advisable. The fear of climate change seemed to set a "flag" that some action was required, but remained in place only until one such action was taken, i.e., any single protective action had the effect of taking down the "impending danger flag." While such behavior might have served us well in our evolutionary history where single actions generally sufficed to contain important risks, in more complex environments where a portfolio of risk management actions is advised, purely affect-driven, single-action biased responses may not be sufficient. Hansen et al. (2004) found evidence for the single-action bias in farm practices that can be interpreted as protective actions against climate change and/or climate variability. Thus farmers who indicated that they had the capacity to store grain on their farms were significantly less likely to indicate that they used irrigation ($r = -0.52$, $p < 0.01$) and that they had signed up for crop insurance ($r = -0.47$, $p < 0.02$).

In conclusion, behavioral decision research over the past 30 years strongly suggests that attention-catching and emotionally-engaging informational interventions may be required to engender the public concern necessary for individual or collective action in response to global warming. Such interventions would need to be conducted with full awareness about unintended side-effects (like reductions in concern about other important risks) and in ways designed to help people overcome cognitive and affective capacity limitations (e.g., the single action bias). To the extent that time-delayed consequences of our actions do not attract the attention or generate the concern ex-ante that they would seem to warrant ex-post, behavioral decision research provides some corrective actions. The concretization of future events and moving them closer in time and space seem to hold promise as interventions that will raise visceral concern. Guided protocols by which decision makers consider arguments for conservation and climate change mitigation before they are allowed to consider arguments against such actions may help to improve the balance between the desire for immediate gratification and the goal of sustainable development. Finally, for at least a subset of the public, better (environmental) science and statistics education can create the familiarity with the scientific presentation of information and mental habits that will create citizens who give greater weight to the output of their analytic processing system, moving the risk perception of the general public and its officials closer to that of climate scientists. Failing these efforts, the problem discussed in this paper is ultimately self-corrective. Increasing personal evidence of global warming and its potentially devastating consequences can be counted on to be an extremely effective teacher and motivator. Unfortunately, such lessons may arrive too late for corrective action.

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Notes

[1]There are other differences between the physician decision and the parental decisions (e.g., with a doctor considering public health and social welfare and the parent considering only the welfare of their child) which further contribute to the disagreement about best action. The example suggests, however, that the implicit and inarticulated feeling of the child being at risk (which is assumed to guide the decision) is different when equivalent probability information is acquired by personal experience vs. statistical description.

[2]This sort of updating and learning is adaptive in dynamic environments, where circumstances might change with the seasons or according to some other cycles or trends.

[3]An additional reason that rare events get underweighted is that with small samples, they often are not experienced at all and hence do not enter into the decision at all. The underweighting of small events, however, does not depend on just these cases, but follows from the iterative updating rule, where, after each trial, the impact of the most recent outcome is added to the evaluation of the choice option prior to experiencing the most recent outcome.

[4]For an interesting demonstration of this result in the context of domestic and foreign tourist reactions to terrorist activity in Israel see Yechiam et al. (2004).

[5]This would, of course, change according to the Weber et al. (2004) and Hertwig et al. (2005) model of experience-based decisions, if and when a small-probability catastrophic event (like a serious hurricane or coastal flooding) does occur, assuming that the event is causally connected to global warming in the public's mind.

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