THE SCIENCES OF RISK[1]

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Decision-making under uncertainty (risk) is a problem germane to a vast range of human enquiry and practices. In finance and economics, experts wish to understand how decisions to invest (by individuals and companies) are determined by the variance of returns. Biologists wish to understand how organisms time life-history events (such as the time of flowering or the age of adolescence) or moment-to-moment foraging decisions according to unpredictable circumstances. Legal professionals wish to understand how a jury decides to take the risk of releasing a potentially violent person back onto the streets. Governments and the medical profession wish to understand how people respond to information communicating risk (e.g. risks of unprotected sex).

The themes discussed at the Wiko workshop on "The Sciences of Risk" encompassed theories of and experimental investigation into human and animal choice that can contribute to our understanding of all the above questions. The thematic issues that dominated the workshop included:

1) Models of human and animal choice and their interrelationships (e.g. normative vs. descriptive, process vs. outcome, empirical vs. theoretical, human vs. animal).
2 Measurement and level of analysis issues (e.g. genes, organisms/individuals/groups; risk attitude and behavioural measurement; stability of risk measures across multiple modalities).
3) Comparative issues (e.g. interspecies/inter-group comparison; anthropological analysis of the construction of risk as a shared notion; singularity vs. multiplicity of evolutionarily stable strategies for dealing with risk).

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4) Time-scale issues (e.g. risk as an internal trait rather than expressed in momentary decisions; discounting future rewards and costs; genetic vs. learned strategies and responses for dealing with risk).
5) Real world applicability of theories (e.g. crime, financial and market behaviour, industrial performance).

Perhaps most significantly, the research program of the focus group with the same title was subjected to external analysis, input, and validation, a role of the workshop that several of the focus group's members reported as extremely useful. The opportunity of the invitees to hear of the Wiko focus group's activity and to relate it to their own areas was similarly important, as well as the mixing of the "norms" and "risk" groups.

A major theme of the workshop was the comparison of three major theories of choice under uncertainty, notably prospect theory, risk sensitivity theory, and scalar utility theory. Members of the workshop who were co-originators and known proponents of these theories were asked to place the emphasis on current weaknesses and empirical difficulties of their own pet constructs, an approach that resulted in a constructive and thorough examination of the state of the art.

Attendees

Members of "The Sciences of Risk" Focus Group:

- Robert Boyd (University of California, Los Angeles USA and Fellow, Wissenschaftskolleg zu Berlin)
- Martin Daly (McMaster University, Hamilton, Canada and Fellow, Wissenschaftskolleg zu Berlin)
- Cathy Eckel (Virginia Polytechnic Institute and State University, Blacksburg, USA and Fellow, Wissenschaftskolleg zu Berlin)
- Gesine Hofinger (Otto-Friedrich-Universität Bamberg, Germany and Fellow, Wissenschaftskolleg zu Berlin)
- Eric Johnson (Columbia University, New York, USA)
- Alex Kacelnik (University of Oxford, UK and Fellow, Wissenschaftskolleg zu Berlin)
- John McNamara (University of Bristol, UK and Fellow, Wissenschaftskolleg zu Berlin)
- Miguel Rodriguez-Gironés (Estación Experimental de Zonas Aridas, Almeria and Fellow, Wissenschaftskolleg zu Berlin)

– Elke Weber (Columbia University, New York, USA and Fellow, Wissenschaftskolleg zu Berlin)
– Margo Wilson (McMaster University, Hamilton, Canada and Fellow, Wissenschaftskolleg zu Berlin)

Members of "The Origins and Effects of Social Norms" Focus Group:
– Cristina Bicchieri (Carnegie Mellon University, Pittsburgh, USA and Fellow, Wissenschaftskolleg zu Berlin)
– Ernst Fehr (Universität Zürich, Switzerland and Fellow, Wissenschaftskolleg zu Berlin)
– Michael Kosfeld (Universität Zürich, Switzerland and Fellow, Wissenschaftskolleg zu Berlin)
– Nathalie Smith (University of California, Los Angeles, USA)

Invited Guests:
– Raghavendra Gadagkar (Indian Institute of Science, Bangalore, India and Non-Resident Permanent Fellow, Wissenschaftskolleg zu Berlin)
– Peter Hammerstein (Humboldt-Universität zu Berlin)
– Daniel Kahneman (Princeton University, Princeton, USA)
– Edward Mitchell (University of Oxford, UK)
– Larry Samuelson (University of Wisconsin, Madison, USA)

Summary of Presentations

Samuelson examined the difference between "real" utility functions and those prescribed by classical economics, with emphasis on biased preferences and unchosen, salient alternatives (choice set dependence). Evolutionary psychology suggests viewing utility functions in terms of the incentives they provide for evolutionarily successful decisions, while information economics suggests looking at these incentives in a setting where there is information (the output of cognition) accessible to the agent (the organism) but not directly to Nature in her role as "designer" of the utility function. Thus Nature, in her solution to what is a problem of asymmetric information, does not prescribe a direct utility function for decisions in which cognition may play an important role (e.g. knowing when to go and hunt through a cognitive compilation of probabilities and valuation of outcome alterna-

tives); however, in situations in which our cognition is of little importance (e.g. choosing between an energetically valuable and a poor food), Nature prescribes a direct utility function (sensory pleasures of eating a sizzling steak).

Weber presented an exposition of statistical determinants of risk preference in humans and other animals by comparing a meta-analysis of human risk preference in lotteries (for fixed/variable options) with a similar analysis of risky choice for other animals. The best predictor of the proportion of risky choices by lower animals across a wide range of situations was found to be the coefficient of variation (CV) – a measure of risk per unit of return (as opposed to the standard deviation or variance). The relevance of Weber's law and scalar utility theory to such choices was examined (in which the subjective perception of outcome variance is germane to the choice, such perceptions of variance increasing in proportion to the absolute magnitude of amounts of choice and delay); CV, through representing a relative measure of variability, should therefore provide a better predictor of risk sensitivity than unstandardised measures such as variance or standard deviation.

CV was not, however, a useful predictor of real or hypothetical human financial choices. Weber presented empirical evidence accounting for these findings by the manner in which information concerning the consequences of the two types of decisions is gathered; many human decisions use information derived from third parties rather than first-hand experience, the case being more or less the reverse for other animals. CV accounted for the proportion of risky choices in a card selection task when the properties of different decks were established by experiential sampling, but not when the same properties were awarded to the subject numerically and pictorially. Information acquisition through associative learning (e.g. fractional adjustment model) will produce choice behaviour correlating more strongly with CV than with variance. The benefits of CV lie in its psychophysical plausibility, its predictive ability, and its utility in comparisons of risk sensitivity across choice situations that differ in range or outcome dimension.

Eckel reviewed a range of measures of risk attitude in humans and the correlation between such measures, with implications for any putative stable personality trait of risk taking. While researchers such as Zuckerman have proposed such a construct (and validated a multi-domain sensation-seeking scale), Eckel found modest to minimal correlation between measures of risk attitude using diverse tasks and instruments such as valuation (e.g. lowest gamble-selling price), choice tasks (e.g. between gamble and certainty equivalent or two gambles), auction data, and survey instruments (which tend to be criticized by economists due to the incentive for truthful responses). While robust results are obtained, such

as general risk averseness and the general risk proneness of men compared with women, correlations among tasks and measures are low. Eckel further discussed trust as a risky decision (as indexed by an allocation game in which money could be "lent" to another subject, but with a risk that it wouldn't be paid back) and social-psychological findings of such tasks (e.g. "implicit racism" in which white subjects allocate lower amounts to black subjects than to other "in-group" subjects).

McNamara's paper examined the predictions of evolutionary theory and natural selection, and thereby adaptive behaviour, on the risk sensitivity of animals. The notion that natural selection has designed appropriate physiological adaptations (e.g. wings for flying, fins for swimming) is familiar and is formally expressed as maximization of appropriate measures of fitness by the organism. A fitness-maximizing animal should show risk sensitivity in its preferences (e.g. differential choice of low-variance and high-variance options as a function of state relative to biological thresholds such as sufficient energy reserves to survive a winter's night). Two examples were contrasted in the paper: a small bird facing demographic stochasticity (within year variation – "good and bad luck") and an annual plant facing environmental stochasticity (between year variation affecting all members of the population). An individual following an evolutionarily stable choice strategy maximizes the geometric mean of its number of descendants; naïve models of laboratory procedures are likely to fail to accurately predict risk sensitive behaviour, because fitness not only depends on the mean, but is also discounted by the variance.

Mitchell presented a web-based program, derived from animal cognition experiments, designed to measure human risk proclivity. APES, Advanced Performance Evaluation Software, makes use of a "metamemory" task to examine risky decision making. Metamemory is a concept derived from human and animal cognition and refers to "knowing what you know" (the ability to examine one's own memory state). A typical metamemory experiment requires animals to remember a sample stimulus, after which they are given the option to choose a task, which makes a large reward contingent on discriminating the sample stimulus from a group of similar stimuli. Alternatively, they may decline that task for a smaller fixed reward. The ability to monitor memory trace is inferred from a greater proportion of correct discriminations in trials that the animal chooses to enter than in forced trials. In addition, the subject should take the safe option more frequently as the retention interval between stimulus and choice increases (because it is less likely to make a correct discrimination). APES uses a metamemory task to examine whether subjects monitor their performance at the task and choose the task (risky choice) or the fixed option (safe

choice) as a function of actual and perceived performance. The use of the task was discussed in relation to research on decision-making in the oil/gas industry.

Kahneman's presentation was devoted to the current status of prospect theory and theories of risk more generally, as well as to discussing a new research program on "experienced" utility in the form of psychological well-being. Caution was advised about the notion of PT as an all-encompassing theory of choice under uncertainty (e.g. PT makes no predictions about the price that an agent will pay to acquire a gamble). PT was originally presented as a theory of choice between risky prospects with at most two non-zero monetary outcomes (gains and losses). Any formal explicit theory of choice will have an unreasonably narrow domain of application if it is to be unambiguously interpretable and will be tested and refuted under unnatural or highly contrived experiments. The function of proposing theories of choice is to learn about potent variables that may influence choice under a broad range of situations, not to prescribe that these are the only factors that will be relevant in wider domains than those for which the theory was proposed. In the case of PT, these variables are: objects of evaluation are mental representations of outcomes (which are susceptible to effects of context, framing, editing, mental accounting, etc., unlike objective states of affairs); a neutral reference point specifies outcomes in terms of gains and losses; there is risk aversion to losses (steeper value function in the negative domain); and the underweighting and overweighting of high and low probabilities respectively. The terms "theory" and "theory testing" are thus overused terms suggesting that a) there is more competition between models than exists; and b) that empirical data will validate a theory rather than being more properly used to delineate the boundaries in which theoretical concepts are useful (or not). Regret theory, while having extremely limited empirical support, is a good intuitive theory, even if not successful beyond its narrow domain.

The second part of Kahneman's presentation espoused the revival of Benthamite notions of "experienced utility" (the quality and intensity of hedonic experience) that have been superseded as viable areas of study by the more familiar "decision utility" inferred from choices (and designed to explain choices). Economic arguments against experienced utility (that it can't be measured and it doesn't need to be measured) are not shared by psychologists, who deem constructs such as psychological well-being both useful and feasible to measure. A fledgling research program examining constructs of well-being and happiness was described, together with the implications of prospect theory for such a program.

Kacelnik contrasted models of risky choice, drawing together the three theories presented at the workshop – prospect theory, risk sensitivity theory and scalar utility theory. Both

prospect theory and risk sensitivity theory prescribe nonlinearity between the objective payoff (e.g. money, food) and the maximized dimension (utility for PT, fitness for RST). This nonlinearity of the utility function conforms with and explains empirical observations that humans and animals are risk averse for gains (prefer low variance options) but risk prone for losses (prefer high variance options). SUT explains such observations without recourse to nonlinearity in the utility function by invoking the effect of Weber's Law on the perception of gains and losses; the expected utility of payoffs is encoded by the subject as bell-shaped probability density functions, the mean and standard deviation of which are proportional to their magnitude. These stored distributions (reference memory for multiple outcomes) are sampled when confronted with a choice set; the option with the lowest variance will generate the larger sample in a majority of paired comparisons, producing risk aversion for dimensions the subject wishes to be large (e.g. gains) and risk proneness for dimensions the subject wishes to minimize (e.g. delay to reward, losses). The competitive and complementary aspects of SUT, PT and RST were discussed. SUT is attractive as a theory of choice due to its strong grounding in psychophysics and its ability to explain and unify empirical observations in humans and animals. However, it is similar to RST and PT in its inability to explain loss aversion without changing the slope of the (linear) utility function.

Wilson and *Daly* discussed sex-differential risk assessment and risk taking by individuals in mating and parental effort with application to the epidemiology of homicide. They point out that social competition is most severe in unrelated males for access to females. Sexual selection theory thus makes predictions about dangerous interpersonal confrontations. Such confrontations, including homicide, may be cast as manifestations of competitive risk taking. Men die in accidents at higher rates than women, expose themselves to more risk in recreational activities, and are more risk prone than women in health choices (e.g. medical check-ups). Young men are the most risk-accepting demographic group, and empirical data shows that variation in homicide rates are predominantly variations in the rate at which young men kill each other in "status contests". Such lethal violence may be a result of steep discounting of the future by young males due to sensitivity to life expectancy. Indeed, neighbourhood data in Chicago shows life expectancy to have a –0.88 correlation with homicide rate (with the effect of homicide rate on life expectancy removed). Cross-national analyses of income inequality show that inequity strongly predicts homicide rates. Inequity of income is likely to contribute to competitive risk taking because those at the bottom of the resource distribution have little to lose in reckless behaviour or lethal

violence. The explanation of such observations by an adaptationist approach to risk in intrasexual competition stands in contrast to "traditional" explanations of lethal violence as by-products of unexplained cultural differences.

Boyd's presentation also examined the role of culture in decision-making, in particular the role of culturally acquired rules and beliefs in risky situations. Prior beliefs are more important when decisions are rare or difficult, and Boyd presented a model of the evolution of imitation and the population dynamics of beliefs. Such a model predicts conformism over a wide range of parameters. He referred to an analysis of risky choices in different ethnic groups in Chile (using relatively large stakes, e.g. 80% of a day's wage). The number of risky choices was best accounted for by group membership rather than wealth, land, income, age, sex, household size, etc. Such social conformism also explains behavioural patterns for risky choices, such as whether to plant barley or wheat, and also generalizes to beliefs (such as whether it is more profitable to have multiple kin rather than friends or whether misfortune is due to natural processes or sorcery). Informational conformism is favoured in more risky environments. Risky decisions may not in fact be "decisions" at all – instead representing socially prescribed/learned choices.

Participants of the symposium on The Sciences of Risk take a break in their deliberations in the garden of the Wissenschaftskolleg. From left to right: Miguel Rodriguez-Gironés, Ed Mitchell, Danny Kahneman, Michael Kosfeld, Elke Weber, Eric Johnson, Raghavendra Gadagkar, Larry Samuelson, Alex Kacelnik, Gesine Hofinger, Cathy Eckel, Margo Wilson, John McNamara, Martin Daly, Cristina Bicchieri, Robert Boyd, Peter Hammerstein