Evolution and risky decisions*

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Does the human mind possess domain-specific inference mechanisms for solving the sorts of problems that confronted our distant ancestors? In a recent paper, Rode *et al.*[1] argue that human decision-making was shaped by an evolutionary history of foraging to include procedures for reasoning adaptively about risk. The task of demonstrating the adaptiveness of human decision-making would appear to be a daunting one, given a large body of experimental research suggesting that people routinely deviate from the standard norms of probability theory and expected utility theory[2]. Far from viewing human decision-making as adaptive, psychologists have tended to view people as susceptible to an extensive catalog of deficits and biases[3].

Biologists observing similar non-normative behavior in animals have tended to accept the adaptiveness of the animals' choices and instead faulted the assumptions of their own normative theories. To account for the observed behavior, they have focused on devising stronger, more robust theories of decision-making. For example, biologists modeling the foraging decisions of non-human animals initially started with the same assumption as expected utility theory, namely, that animals should seek to maximize expected returns[4]. However, it soon became clear that animals sometimes alternate between certain gains and risky gambles in ways unpredicted by standard foraging theory[5]. Faced with Caraco *et al.*[5] observation that yellow-eyed juncos (*Junco phaeonotus*) were alternating between certain and risky foraging options, Stephens[6] proposed risk sensitive foraging theory (RSFT), which, unlike expected utility theory, does not assume that animals are trying to maximize expected utility. Instead, RSFT assumes that animals are trying to maximize the probability of reaching a goal – in this case, finding enough food to survive the night. With this starting assumption, Stephens showed that in addition to expected value, both the variability in returns from the different options and the animal's aspiration level are crucial factors determining whether one option or the other is more likely to satisfy an animal's needs.

Now a group of psychologists have turned to this biological literature in the hope of resolving some of the apparent irrationalities in human reasoning. Rode *et al.*[1] provide an example of the progress that can be made through this interdisciplinary approach. Rode *et al.* hypothesize that the human mind has been designed by natural selection to

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take all three factors (expected value, variability, and aspiration level) into account when deciding among risky choices, as predicted by RSFT. Potentially this could provide an explanation for one purportedly irrational bias in human decision-making – ambiguity avoidance – in which people avoid gambles with an unknown distribution of possible outcomes. According to expected utility theory, people should judge gambles by their long-term expected outcomes alone, but people sometimes appear to opt for gambles with a lower expected outcome in order to avoid an ambiguous option[7].

Rode *et al*. begin by conjecturing that subjects interpret ambiguous options as risky options (i.e. options with high outcome variance), and thus that the ambiguity avoidance effect is produced by risk aversion, not avoidance of ambiguity *per se*. If true, this would potentially bring the ambiguity avoidance effect within the explanatory domain of RSFT. In order to clarify whether people are avoiding the ambiguity or the risks involved in an ambiguous option, Rode *et al.* presented subjects with a choice between two lotteries. For one lottery the outcome probabilities were completely known but highly variable, while for the other lottery the outcome probabilities were ambiguous but of lower variance. In contrast to earlier studies, here subjects consistently preferred the ambiguous option. Thus the ambiguity avoidance effect is not a product of ambiguity, but of the risks inherent in that ambiguity.

Rode *et al.* further conjectured that the ambiguity avoidance effect should disappear in situations where risk seeking is predicted by RSFT, namely, situations in which a low-risk option is unlikely to return a payoff higher than a subject's aspiration level. The logic behind this is simple. One should prefer a low risk to a high risk option when the expected values of both exceed one's aspiration level because the low risk option provides greater certainty that the return will fall close to the expected value. However, one should avoid the low risk option when the expected values of both fall below one's aspiration level because the low risk option provides greater certainty that the return will fall close to the expected value, i.e., fail to meet one's aspiration level. To test whether subjects conform to this model, Rode *et al.* devised a lottery in which a certain number of balls of a single color had to be drawn from an urn containing balls of two colors in order for the subject to be eligible to win money. One option offered a known distribution of balls of each color, and the other (ambiguous) option offered an urn with the same total number of balls, but in which the proportion of balls of each color was unknown. As predicted, when the expected payoff of both options was above the aspiration level – the threshold necessary to receive payment – subjects played it safe and picked the known option. However, when the expected payoff of the options was below the aspiration level, subjects tended to choose the ambiguous option instead. Thus Rode *et al.* showed not only that ambiguity avoidance is really risk avoidance, but also that when subjects' aspiration levels are experimentally manipulated they can become risk-seeking and therefore ambiguity-seeking as well.

Rode *et al.* present an intuitively appealing explanation for why people sometimes avoid and at other times prefer ambiguous gambles, and back this explanation up with compelling evidence. But an important question remains: Did the mechanism underlying these preferences evolve to solve a problem specific to foraging, or the more general problem of making decisions under risk? This question is important because, according to evolutionary theory, a mechanism that evolved to solve a particular adaptive problem should show evidence of special design for solving that problem – in this case, the problem of deciding between foraging options when one has a survival requirement. The evidence for special design for foraging is clearer in the biological literature, where most tests of RSFT on animals have attempted to manipulate the energy budgets of animals in order to observe the effects of this manipulation on choices between low and high variance food sources[8]. The method employed by Rode *et al.*, on the other hand, is quite different, and is not necessarily related to foraging at all. Indeed, the available human evidence would seem to indicate the decision-making principles invoked by Rode *et al.* operate over a variety of domains, not just foraging. Wang[9,10] for example, also using the aspiration-level logic of RSFT, was able to elicit risk seeking decisions on a task involving life and death decisions about family members – a context even further removed from foraging than Rode *et al.*'s task. More generally, human risk preference reversals have been demonstrated across a wide range of problem contexts in the framing effect literature[11]. Given that risk preference reversals have been observed across a range of task domains unrelated to foraging, how can we be certain that a foraging mechanism is generating them?

There are several possible explanations for the generality of the risk-sensitivity effect. One explanation is that there is a general-purpose risky decision mechanism, sensitive to the abstract, probabilistic structure of choice problems, and not to their content or ecological context *per se*. Another possibility is that these risk-sensitive principles are embodied in a collection of distinct mechanisms. Yet another possibility is that there exists a single mechanism that evolved to solve problems specific to foraging, but that can also be applied to problems that did not originally drive its evolution. Which of these possibilities is correct is not merely an academic matter, because a proper understanding of the adaptive problem that shaped a particular cognitive mechanism is crucial for generating hypotheses about that mechanism's structure. So far, the evidence obtained by Rode *et al.*[1], Wang[9,10], and others[11] does not allow us to decide between the possible explanations for the generality of the risk-sensitivity effect, leaving open the possibility that the ability to take expected value, outcome variance, and one's aspiration level into account in making decisions under risk may have been selected for in multiple ecological contexts, not just foraging. In other words, the question of the proper domain of the mechanism or mechanisms generating risk-sensitivity remains open.

Rode *et al.*'s study is an important step forward in the debate over human decision-making, in two ways. First, it shows that the ambiguity effect is not merely a systematic reasoning error, as had been previously assumed. People interpret ambiguous options as having high outcome variance, and can be induced to favor these options when doing so increases their probability of satisfying a need or goal. This tendency is indeed systematic, but it is adaptive rather than erroneous. Second, Rode *et al.*'s study may help to clarify what we should seek in theories of human decision-making. In the past, theorists established norms of optimal behavior against which to measure human performance, without asking why and when people might be expected to meet these norms given the purposes for which our decision-making mechanisms were designed. Work such as Rode *et al.*'s is a valuable step away from the mere cataloging of adherences to and departures from objective norms, and towards a cataloging of mechanisms designed by the causal, historical process of evolution. Moreover, their work is a good example of a case in which evolutionary theory led to the generation and testing of hypotheses about human decision-making that might not have been considered otherwise. The fact that certain questions remain about the exact structure of risk-sensitive choice mechanisms should motivate more specific hypotheses about their evolved function, leading in turn to more precise predictions about their design. If we are interested in answering questions about the evolved structure of the mind, this is the right direction in which to go.

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References

1 Rode, C. *et al.* (1999). When and why do people avoid unknown probabilities in decisions under uncertainty? Testing some predictions from optimal foraging theory. *Cognition* 72, 269-304

2 Kreps, D. M. (1990). *A course in microeconomic theory*, Princeton University Press

3 Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science* 211, 453-458

4 Charnov, E. (1976). Optimal foraging: The marginal value theorem. *Theor. Pop. Biol.* 9, 129-136

5 Caraco, T. *et al.* (1980). An empirical demonstration of risk-sensitive foraging preferences. *Anim. Behav.* 28, 820-830

6 Stephens, D. W. (1981). The logic of risk-sensitive foraging preferences. *Anim. Behav.* 29, 628-629

7 Ellsberg, D. (1961). Risk, ambiguity, and the Savage axioms. *Quart. J. Econ.* 75, 643-669

8 Bateson, M., & Kacelnik, A. (1998). Risk-sensitive foraging: Decision making in variable environments. in *Cognitive ecology: The evolutionary ecology of information processing and decision making* (Dukas, R., ed.), pp. 297-341, University of Chicago Press

9 Wang, X. T. (1996a). Framing effects: Dynamics and task domains. *Organ. Behav. Hum. Decis. Processes* 68, 145-157

10 Wang, X.T. (1996b). Domain-specific rationality in human choices: Violations of utility axioms and social contexts, *Cognition* 60, 31-63

11 Kühberger, A. (1998). The influence of framing on risky decisions: A meta-analysis, *Organ. Behav. Hum. Decis. Processes* 75, 23-55