

Economic Choice Theory: An Experimental Analysis of Animal Behavior, John H. Kagel, Raymond C. Battalio, and Leonard Green. Cambridge University Press, 1995, xii + 230 pages.

Do animals comply with economic choice theory? Kagel, Battalio, and Green argue that they do. Their experiments, they claim, show that economic choice theory provides a better account of animal behavior than rival principles of animal psychology. They think that their studies extend economic choice theory's scope and, moreover, validate the theory with controlled experiments impossible to run with human subjects. They imagine a day when the interspecies validity of economic choice theory is widely recognized, and social planners try out novel ideas in the animal kingdom before implementing them in human society, just as drug companies test new medications on animals before marketing them for people.

Obviously, the authors do not attempt to apply all of economic choice theory to animals. They pass over the parts calling for uniquely human behavior and institutions, and test only the parts of the theory applicable to animal behavior. In particular, they study individual choice between goods. For example, they consider a rat's choice between two nonessential liquids when it must pay in lever presses to obtain them. They ask whether a change in prices produces results in conformity with consumer choice theory, and find that it does. In their experiments each rat had unrestricted access to essential food and water, and restricted access to the nonessential liquids root beer and Tom Collins mix. During a day, the rat had a limited number of lever presses to spend on soda, and generally spent them quickly with more going for root beer than for Tom Collins mix. Next, the authors doubled the price of root beer by halving the volume a lever press yields, and halved the price of Toms Collins mix by doubling the volume a lever press yields. They also increased the rat's income in terms of lever presses so that the originally consumed amounts of root beer and Tom Collins mix were purchasable at the new prices. In the new circumstances the rat typically reduced its consumption of root beer and increased its consumption of Tom Collins mix, as predicted by consumer choice theory (12–13).

The book reports tests on animals of theories of commodity-choice behavior, labor-supply behavior, choice over uncertain outcomes, and intertemporal choice. In general, the tests show that animals such as rats and pigeons exhibit the behavior the theories attribute to humans. In fact, in exceptional cases where humans depart from classical theories of choice, as they depart from expected utility theory in Allais's paradox, so do animals (154–5). The similarity of animal and human choice behavior is the main conclusion of the experimental studies.

The book's style is admirable. It is clear, forthright, and accessible to readers from many fields. Chapters review the economic principles to be tested before reporting experimental results. They also start with introductions and end with summaries that keep attention focused on the main points. The authors set high standards for their experiments, which always treat animals humanely. Their experiments are well grounded in the relevant literature. Results are carefully interpreted.

To defend their explanations of animal behavior, the authors consider rival explanations and cleverly design new experiments to discriminate between their explanations and their rivals. For example, they consider the matching law of animal psychology, which holds that behavior matches reinforcement schedules. This law is a quantification of the law of effect, the law that greater reinforcement produces greater strength of response. According to the matching law, if an animal has two choices, then $C_1/C_2 = R_1/R_2$, where the C's are the choice frequencies and the R's are the rates of reinforcement for these choices (51–2). The authors show that rats choosing between two goods conform to consumer choice theory rather than the matching law. They find anti-matching behavior when two goods are not substitutes for each other. For example, if one lever yields food and another lever yields water, then the choice ratio for the levers changes inversely to the reinforcement ratio. The greater the amount the food lever provides, the less frequently it is pressed, and the more frequently the water lever is pressed (57–8). They also find departures from the matching law in rats' choices between a normal good and an inferior good, as in choices between root beer and quinine water. Since rats dislike the taste of quinine, they purchase this inferior good more when its price is low and they are thirsty. At

low levels of income, rats spend more on low-priced quinine water than on high-priced root beer. But at higher levels of income, they spend less on low-priced quinine water and more on high-priced root beer. These results conform to consumer choice theory but depart from the matching law, which makes no provision for income effects (60–61). The problem with the matching law is that it addresses primarily choices between two behaviors both of which yield the same good, and, when two behaviors yield two different goods, fails to consider the extent to which the goods may substitute for each other.

The authors' extension of economic choice theory to animals raises interesting questions about the theory's interpretation. Some economists think of the theory as a normative theory prescribing principles of rational choice. Others think of it as a descriptive theory that begins by treating people as fully rational agents but then makes modifications to take account of their systematic departures from standards of rationality. The extension of economic choice theory to animals plainly takes the theory as descriptive. Animals do not have the sort of mental life that makes standards of rationality applicable to them. We would not accuse rats of irrationality if they failed to conform with the theory.

Taken as a descriptive theory, what does economic choice theory say when extended to animals? Some authors argue that it says only that choices are consistent or coherent. According to revealed preference theory, choices indicate preferences that in turn yield other choices, choices consistent with the choices revealing the preferences. In fact, some economists hold that preferences are dispensable intermediaries between choices. Agents choose as if guided by preferences, but they need not actually be guided by preferences. According to these economists, economic choice theory does not assume mental states guiding choices. It may even be applied to a thermostat. Imagining that a thermostat chooses whether to run the heating or cooling system, it chooses as if it had a preference for a certain room temperature. Its choices are consistent in the relevant sense.

This conception of economic choice theory makes it widely applicable. According to it, an application of the theory to rats need not suppose that rats have a mental life. The rats in the

authors' experiments behave as if they preferred root beer to Tom Collins mix. But the theory's application to them does not require that the rats actually have preferences. The rats' compliance with the theory may be mindless.

Some economists give economic choice theory an even leaner interpretation. According to them, not only it is independent of mental states, it is, in fact, a purely mathematical theory. They consider it mathematically demonstrable that behavior conforms with the theory. The authors quote a commentator with this view. In response their work he says, "I am a 'true believer' in microeconomic theory, and as a result I am perfectly willing to accept mathematical proofs without experimental verification" (7, n. 1). This critic thinks microeconomics is not empirical and so does not need experimental verification. The critic's interpretation of economic choice theory has some drawbacks, however. Under it, the theory does not contribute to the explanatory and predictive goals of economics. Consequently, I favor the authors' empirical interpretation of the theory, and their assessment of the role of experiments in the theory's confirmation. Even if the theory is shorn of assumptions about mental states and presented merely as a theory of consistent behavior, to verify the theory's application to animals, one must show observationally that animals behave in a consistent way, as if guided by preferences.

Although economic choice theory has empirical content, its application to animals may assume a weakening that boosts the theory's likelihood of success. For example, the tests of rats' conformity with consumer choice theory assume that the price of an amount of a commodity is a number of lever presses (12). Also, the tests of rats' conformity to labor-supply theory assume that a rat's wage is an amount of a commodity obtained by a number of lever presses (92). The role of lever presses in defining both wages and prices simplifies economic choice theory's application to rats. Since rats are not paid money for labor and do not use money to purchase commodities, they cannot waste their wages but must spend them on one of the two commodities available in the tests. Furthermore, the definitions of prices and wages guarantee that a rat is willing to work more for one commodity than for another if and only if it is willing to pay a higher price for the first commodity. This consistency is not an empirical finding, but a

consequence of operational definitions. As economic distinctions are conflated to make economic choice theory applicable to animals, the theory becomes less demanding and more easily satisfied, even if not purely mathematical.

The authors do not fully explain how they conceive of economic choice theory's application to animals. How seriously should one take the vocabulary of consumer choice theory when it is applied to animals? Do indifference curves apply to rats, or do rats simply behave as if they applied? When rats alter their consumption of root beer and Tom Collins mix in the face of price changes, is it because prices influence their preferences? Or are they responding to price changes in a way that bacteria could duplicate? In some studies the authors seem to attribute mental states to animals. For example, they investigate preference shifts in pigeons, shifts induced by unearned income (104–5). However, it is not clear how the pigeons' preferences are to be understood. Perhaps they have only behavioral significance. A thorough test of economic choice theory should start with a specification of the theory's content. If it is taken to make claims about animal psychology, those claims should be confirmed. Although the authors carefully explore the behavioral implications of economic choice theory's application to animals, they do not give equal attention to the theory's psychological implications.

Let us turn to another topic, the relevance of animal behavior to theories of human behavior. The authors observe some similarities between animal and human behavior and then reach the general conclusion that animals and humans behave similarly. Reasoning from the thesis of behavioral similarity, they hold that animals' compliance with economic choice theory confirms the theory for humans. In fact, they think that their experiments with animals provide the first real confirmation of consumer-demand theory for humans (2). Conversely, if an economic principle fails for animals, the authors infer that it fails for humans. Reasoning in this way, they use animal studies to criticize negative income tax programs (101–3), supply side economics (106), expected utility theory (154), and the cycle-of-poverty hypothesis (182–8). This is bold extrapolation from animals to humans.

The authors realize that generalization across species may fail. They recognize occasional interspecies differences in behavior. For instance, they expect more risk aversion in large as opposed to small animals since large animals are better able to survive adversity and can afford more caution (149–50). Animals and humans may also differ in their patterns of risk aversion. Although both animals and humans are risk averse when possible outcomes are gains, but risk seeking when possible outcomes are losses (166–7), humans, being open to instruction, may correct for framing effects by recalculating outcomes in terms of net wealth.

The phenomenon called probability matching provides another interspecies difference. Psychologists find that people probability match, that is, choose options with frequencies that match their probabilities of success. For example, if two options offer probabilities .25 and .75 of success, respectively, people perform them 25% and 75% of the time, respectively. In contrast, the authors find that animals do not probability match. Pigeons and rats adopt almost exclusively the option with the greater probability of success (34–5, 136–7). Here animals seem to conform more closely than humans to principles of expected utility maximization.

Despite such failures of cross-species generalization, the authors maintain the transferability of results from one species to another by and large. When considering choice under uncertainty, for example, they use animal behavior to discriminate between some subtly different theories. They rule out Machina's explanation of Allais's paradox because their tests of animals disconfirm his fanning-out hypothesis for certain regions of the unit-probability triangle, which represents gambles involving three possible states of the world. Considering such tests, they favor Kahneman and Tversky's prospect theory, with its S-shaped value function and weights for probabilities, rather than Machina's version of expected utility theory without the independence axiom (156–62).

Such extrapolations from animal behavior to human behavior may easily overlook crucial differences. To illustrate, consider expected utility theory again. Although the authors take the theory as descriptive rather than normative, people find many of its principles normatively compelling. They attempt to eliminate systematic violations by taking courses on statistics and

economics. They try to comply with the theory once they know how to apply it to their decisions. Departures from the theory common to both animals and humans may not persist in humans after instruction and learning from experience.

Also, some apparent deviations from expected utility theory by humans may be dismissed once the theory's application acknowledges the subtleties of human psychology. For example, whether an apparent violation of the theory is genuine depends on whether the outcomes the theory's application assumes are comprehensive. Do they include only money? Do they also include emotional factors such as regret for missed opportunities? Consequences such as regret are not available to explain away animals' departures from the theory, but are available to explain away humans' departures from the theory. Consequently, although animals may systematically deviate from the theory, humans, all things considered, may not. The book's interspecies arguments need supplementary principles, principles that say when extrapolation is warranted and when it is not.

Finally, to assess the book from another angle, let us consider how its application of economic choice theory to animals compares with other applications of economic theory to animals. Evolutionary game theory, for instance, applies game theory to animals. It treats animals as carriers of strategies that propagate in a population according to fitness in competition with other strategies. The carriers of strategies need not reason. They may execute strategies mindlessly because of instincts their genes create. Psychological differences between animals and humans do not impede this application of game theory to animals. It is a precedent for the authors' applications of economic choice theory to animals, although game theory's applications to animals usually involve explanations rather than predictions of behavior, and rest on computer simulations rather than experimentation.

In evolutionary game theory equilibrium emerges by trial and error. Mutant invaders introduce new strategies that may take over a population or disappear. The replicator dynamics of evolutionary game theory is a crucial feature of that theory. Along with fitness, it determines

which strategies are evolutionarily stable. Changes in the dynamics may radically influence the strategies that emerge.

The authors' test results concern animal behavior after it stabilizes in repeated choice problems (12). By trial and error an animal's choices reach a pattern of consumption or labor consistent with economic choice theory. What process leads those choices in the direction of the theory? What steps bring conformity with the theory during repetitions of a decision situation? How do changes in the dynamics affect the behavior emerging?

In evolutionary game theory, some dynamics yield irrational strategies. With correlation of organism types, evolution may support dominated strategies. For example, given correlation of like with like instead of random pairing, cooperation in a one-shot Prisoner's Dilemma may take over a population. When irrationality is rewarded, evolution departs from rationality. It promotes fit strategies, not rational carriers of strategies. Irrational strategies may propagate in friendly environments. Do the dynamics of animal learning over repeated trials likewise cause systematic departures from economic choice theory in some contexts? There is much interesting research to do about the dynamics of the process leading animals to stable patterns of choice.

To summarize, this book is a well designed experimental study of animal behavior. It also raises several critical issues concerning economic choice theory. Is the theory descriptive or normative? Does it attribute to agents behavioral regularities only or also mental states governing choices? The book is significant not only because of its experimental results but also because of the attention it gives these interpretative issues. Economists and psychologists will find it stimulating, and may join the authors in elaborating and extending cross-species theories of behavior.

Paul Weirich

University of Missouri, Columbia

(2,869 words)