# Why the Beliefs, Preferences, and Constraints Model?

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## 1 Introduction

Psychologists, sociologists, and anthropologists are fond of arguing that the rational actor model is a poor basis for modeling human decision making and strategic interaction. They are incorrect. The bottom line is that the demonstrable success of biology and economics in generating powerful and cumulative models of behavior is based on the rational actor model, and none of the other behavioral sciences even remotely approaches these disciplines in explanatory power.

Why is this the case? In these notes I want to present evolutionary and neuroscientific evidence in favor of the rational actor model. Because of the many misleading connotations of the term "rational," and following Henrich, Boyd, Bowles, Camerer, Fehr and Gintis (2005), I will use the term *beliefs, preferences, and constraints* (BPC) model, as this term more accurately expresses the nature of the model. I argue that (a) the brain evolved as fitness enhancing decision making organ; (b) evolution selects for brains that exhibit transitive preferences; (c) transitive preferences entail the BPC model; (d) neuroscientific evidence increasingly confirms the BPC model.

These notes come from Gintis (2005b).

## 2 The Brain as a Decision Making Organ

The fitness of an organism depends on how effectively it make choices in an uncertain and varying environment. Effective choice must be a function of the organism's state of knowledge, which consists of the information supplied by the sensory inputs that monitor the organism's internal states and its external environment. In relatively simple organisms, the choice environment is primitive and distributed in a decentralized manner over sensory inputs. But, in three separate groups of animals, the craniates (vertebrates and related creatures), arthropods (including insects, spiders, and crustaceans) and cephalopods (squid, octopuses, and other mollusks) a central nervous system with a brain (a centrally located decision making and control apparatus) evolved. The phylogenetic tree of vertebrates exhibits increasing complexity through time, and increasing metabolic and morphological costs of maintaining brain activity. There is thus no doubt but that *the brain* *evolved because larger and more complex brains, despite their costs, enhanced the fitness of their carriers*. Brains therefore are ineluctably structured to make on balance fitness-enhancing decisions in the face of the various constellations of sensory inputs their bearers commonly experience.

The human brain shares most of its functions with that of other vertebrate species, including the coordination of movement, maintenance of homeostatic bodily functions, memory, attention, processing of sensory inputs, and elementary learning mechanisms. The distinguishing characteristic of the human brain, however, lies in its power as a *decision making* mechanism.

Surprisingly, this basic insight is missing from psychology, which has two main branches: behavioral and cognitive. The former is preoccupied with learning mechanisms that humans share with virtually all metazoans (stimulus response and operant conditioning), while the latter defines the brain as an "information-processing organ," and generally argues that humans are relatively poor, irrational, and inconsistent decision makers. For instance, a widely used text of graduate-level readings in cognitive psychology, (Sternberg and Wagner 1999) devotes the ninth of eleven chapters to "Reasoning, Judgment, and Decision Making," offering two papers, the first of which shows that human subjects generally fail simple logical inference tasks, and the second shows that human subjects are irrationally swayed by the way a problem is verbally "framed" by the experimenter. A leading undergraduate cognitive psychology text (Goldstein 2005) placed "Reasoning and Decision Making" the last of twelve chapters. This includes one paragraph describing the rational actor model, followed by many pages purporting to explain why it is wrong. Behavioral psychology generally avoids positing internal states, of which preferences and beliefs, and even some constraints (e.g. dietary restrictions), are examples. Not surprisingly, when the rational actor model is mentioned, it is summarily rejected (Kahneman, Slovic and Tversky 1982, Herrnstein, Laibson and Rachlin 1997). Similarly, in a leading behavioral psychology text (Mazur 2002), choice is covered in the last of fourteen chapters, and is limited to a review of the literature on choice between concurrent reinforcement schedules and the capacity to defer gratification. Summing up a quarter century of psychological research in 1995, Paul Slovic asserted, accurately I believe, that "it is now generally recognized among psychologists that utility maximization provides only limited insight into the processes by which decisions are made." (Slovic 1995):365 "People are not logical," psychologists are fond of saying, "they are *psycho*logical." In these notes I argue precisely the opposite position, *pace* the performance errors and other decision making weaknesses discovered by experimental psychologists.

Psychology could be the centerpiece of the human behavioral sciences by providing a general model of decision making that the other behavioral disciplines use and elaborate for their various purposes. The field fails to hold this position because its core theories do not take the fitness-enhancing character of the human brain, its capacity to make effective decisions in complex environments, as central.[1]

## 3 The Foundations of the BPC Model

For every constellation of sensory inputs, each decision taken by an organism generates a probability distribution over fitness outcomes, the expected value of which is the *fitness* associated with that decision. Since fitness is a scalar variable, for each constellation of sensory inputs, each possible action the organism might take has a specific fitness value, and organisms whose decision mechanisms are optimized for this environment will choose the available action that maximizes this value.[2] It follows that, given the state of its sensory inputs, if an orgasm with an optimized brain chooses action A over action B when both are available, and chooses action B over action C when both are available, then it will also choose action A over action C when both are available. This is called *choice consistency*.

The so-called *rational actor model* was developed in the Twentieth century by John von Neumann, Leonard Savage and many others. The model appears *prima facie* to apply only when actors possess extremely strong information processing capacities. However, the model in fact depends only on choice consistency and the assumption that agents can trade off among outcomes in the sense that for any finite set of outcomes $A_1, \ldots, A_n$, if $A_1$ is the least preferred and $A_n$ the most preferred outcome, than for any $A_i$, $1 \leq i \leq n$ there is a probability $p_i$, $0 \leq p_i \leq 1$ such that the agent is indifferent between $A_i$ and a lottery that pays $A_1$ with probability $p_i$ and pays $A_n$ with probability $1 - p_i$ (Kreps 1990). Clearly, these assumptions are often extremely plausible. When applicable, the rational actor model's choice consistency assumption strongly enhances explanatory power, even in areas that have traditionally abjured the model (Coleman 1990, Kollock 1997, Hechter and Kanazawa 1997).

The rational actor model is the cornerstone of contemporary economic theory, and in the past few decades has become the cornerstone of the biological modeling

[1]The fact that psychology does not integrate the behavioral sciences is quite compatible, of course, with the fact that what psychologists do is of great scientific value.

[2]This argument was presented verbally by Darwin (1872) and is implicit in the standard notion of "survival of the fittest," but formal proof is recent (Grafen 1999, 2000, 2002). The case with frequency-dependent (non-additive genetic) fitness has yet to be formally demonstrated, but the informal arguments in this case are no less strong.

of animal behavior (Real 1991, Alcock 1993, Real and Caraco 1986). Economic and biological theory thus have a natural affinity: the choice consistency on which the rational actor model of economic theory depends is rendered plausible by biological evolutionary theory, and the optimization techniques pioneered by economic theorists are routinely applied and extended by biologists in modeling the behavior of a vast array of organisms.

For similar reasons, in a stochastic environment, natural selection will ensure that the brain make choices that, at least roughly, maximize expected fitness, and hence to satisfy the expected utility principle. To see this, suppose an organism must choose from action set $X$, where each $x \in X$ determines a lottery that pays $i$ offspring with probability $p_i(x)$, for $i = 0, 1, \ldots, n$. Then the expected number of offspring from this lottery is

$$\psi(x) = \sum_{j=1}^{n} j p_j(x).$$

Let $L$ be a lottery on $X$ that delivers $x_i \in X$ with probability $q_i$ for $i = 1, \ldots, k$. The probability of $j$ offspring given $L$ is then

$$\sum_{i=1}^{k} q_i p_j(x_i)$$

so the expected number of offspring given $L$ is

$$\begin{aligned}\sum_{j=1}^{n} j \sum_{i=1}^{k} q_i p_j(x_i) &= \sum_{i=1}^{k} q_i \sum_{i=1}^{k} j p_j(x_i) \\ &= \sum_{i=1}^{k} q_i \psi(x_i),\end{aligned}$$

which is the expected value theorem with utility function $\psi(\cdot)$. See also Cooper (1987).

There are no reported failures of the expected utility theorem in non-humans, and there are some compelling examples of its satisfaction (Real and Caraco 1986). The difference between humans and other animals is that the latter are tested in *real life*, or in elaborate simulations of real life, whereas humans are tested in the laboratory under conditions differing radically from real life. While it is important to know how humans choose in such situations (see section 4.7), there is certainly no guarantee they will make the same choices in the real-life situation and in the situation analytically generated to represent it. For instance, a heuristic that says "adopt choice behavior that appears to have benefitted others" may lead to expected fitness or utility maximization even when subjects agents are error-prone when evaluating stochastic alternatives in the laboratory.

In addition to the explanatory success of theories based on the rational actor model, supporting evidence from contemporary neuroscience suggests that expected utility maximization is not simply an "as if" story. In fact, the brain's neural circuitry actually makes choices by internally representing the payoffs of various alternatives as neural firing rates, and choosing a maximal such rate (Glimcher 2003, Dorris and Glimcher 2003, Dorris and Bayer 2005). Neuroscientists increasingly find that an aggregate decision making process in the brain synthesizes all available information into a single, unitary value (Parker and Newsome 1998, Schall and Thompson 1999, Glimcher 2003). Indeed, when animals are tested in a repeated trial setting with variable reward, dopamine neurons appear to encode the difference between the reward that an animal expected to receive and the reward that an animal actually received on a particular trial (Schultz, Dayan and Montague 1997, Sutton and Barto 2000), an evaluation mechanism that enhances the environmental sensitivity of the animal's decision making system. This error-prediction mechanism has the drawback of only seeking local optima (Sugrue, Corrado and Newsome 2005). Montague and Berns (2002) address this problem, showing that the obitofrontal cortex and striatum contains a mechanism for more global predictions that include risk assessment and discounting of future rewards. Their data suggest a decision making model that is analogous to the famous Black-Scholes options pricing equation (Black and Scholes 1973).

The BPC model is the most powerful analytical tool of the behavioral sciences. For most of its existence this model has been justified in terms of "revealed preferences," rather than by the identification of neural processes that generate constrained optimal outcomes. The neuroscience evidence, for the first, suggests a firmer foundation for the rational actor model.

## 4 Some Misconceptions Concerning the BPC Model and Game Theory

Many behavioral scientists (including virtually all outside of economics, biology, and political science) reject the BPC model and game theory on the basis of one or more of the following arguments In each case, I shall indicate why the objection is not compelling.

### 4.1 Decision Makers are not Consistent

It is widely argued that in many situations of extreme importance choice consistency fails, so preferences are not maximized. These cases include time inconsistency, in which individuals have very high short-term discount rates and much lower long-term discount rates (Herrnstein 1961, Ainslie 1975, Laibson 1997). As a result, people lack the will-power to sacrifice present pleasures for future well-being. This leads to such well-known behavioral problems as unsafe sex, crime, substance abuse, procrastination, under-saving, and obesity. It is thus held that these phenomena of great public policy importance are irrational and cannot be treated with the BPC model.

When the choice space for time preference consists of pairs of the form (reward,delay until reward materializes), then preferences are indeed time inconsistent. The long-term discount rate can be estimated empirically at about 3% per year (Huang and Litzenberger 1988, Rogers 1994), but short-term discount rates are often an order of magnitude or more greater than this (Laibson 1997), and animal studies find rates are several orders of magnitude higher (Stephens, McLinn and Stevens 2002). Consonant with these findings, sociological theory stresses that *impulse control*—learning to favor long-term over short-term gains—is a major component in the socialization of youth (Power and Chapieski 1986, Grusec and Kuczynski 1997).

However, if the choice space is expanded to consist of triples of the form (reward,current time,time when reward accrues), then the observed behavior of individuals with discount rates that decline with the delay become choice consistent, and there are two simple models that are roughly consistent with the available evidence (and differ only marginally with one another): hyperbolic and quasi-hyperbolic discounting (Fishburn and Rubinstein 1982, Ainslie and Haslam 1992, Ahlbrecht and Weber 1995, Laibson 1997). The resulting BPC models allow for quite sophisticated and compelling economic analyses of policy alternatives (Laibson, Choi and Madrian 2004).

Other observed instances of *prima facie* choice inconsistency can be handled in a similar fashion. For instance, in experimental settings, individuals exhibit *status quo* bias, loss aversion, and regret, all of which imply inconsistent choices (Kahneman and Tversky 1979, Sugden 1993). In each case, however, choices become consistent by a simple redefinition of the appropriate choice space. Indeed, Kahneman and Tversky's "prospect theory," which models *status quo* bias and loss aversion, and for which Kahneman was awarded the Nobel prize in economics, is precisely of this form.

### 4.2 Individuals Make Welfare-Reducing Choices

In many important cases, observed preferences are inconsistent with the well-being, happiness, or even the immediate pleasure of the decision makers. For instance, fatty foods and tobacco injure health yet are highly prized, addicts often they get no pleasure from consuming their drug of choice, but are driven by an inner compulsion to consume, and individuals with obsessive-compulsive disorders repeatedly perform actions that they know are irrational and harmful. More generally, behaviors resulting from excessively high short-term discount rates, discussed above, are likely to lead to a divergence of choice and welfare.

However, the BPC model is not based on the premise that choices are highly correlated with welfare. I have argued that we can expect the BPC to hold because, on an evolutionary time scale, brain characteristics will be selected according to their capacity to contribute to the fitness of their bearers. But, fitness cannot be equated with well-being in any creature, and in the case of humans, we live in an environment so dramatically different from that in which our preference predispositions evolved that it seems to be miraculous that we are as capable as we are of achieving high levels of individual well-being. For instance, in virtually all known cases, fertility increases with per capital material wealth in a society up to a certain point, and then decreases. This is known as the *demographic transition*, and accounts for our capacity to take out increased technological power in the form of consumption and leisure rather than increased numbers of offspring (Borgerhoff Mulder 1998). No other known creature behaves in this fashion. Thus, our preference predispositions have not "caught up" with our current environment and, especially given the demographic transition and our excessive present-orientation, they may never catch up (Elster 1979, Akerlof 1991, O'Donoghue and Rabin 2001).

### 4.3 Addiction Contradicts the BPC Model

Drug addiction, and substance abuse more generally, are both of great contemporary social importance and appear most clearly to violate the notion of rational behavior. Substance abusers are often exhibited as prime examples of time inconsistency and the discrepancy between choice and well-being, but as discussed above, these characteristics do not invalidate the use of the BPC model to analyze addictive behaviors. More telling, perhaps, is the fact that even draconian increases in the penalties for illicit substance use do not lead to the abandonment of illegal substances. In the United States, for instance, the "war on drugs" has continued for several decades and, despite the dramatic increase in the prison population, has not effectively curbed the illicit behavior. Since the hallmark of the rational actor model is that individuals trade off among desired goals, the lack of responsiveness of substance abuse to dramatically increased penalties has led many researchers to reject the BPC model out of hand.

The target of much of the criticism of the rational actor approach to substance abuse is the work of Nobel prize winning economist Gary Becker and his associates, and in particular, the seminal paper Becker and Murphy (1988). Many aspects of the Becker-Murphy "rational addiction" model are difficult to fault, however, and subsequent empirical research has strongly validated the notion that illicit drugs respond to market forces much as any marketed good or service. For instance Saffer and Chaloupka (1999) estimated the price elasticities of heroin and cocaine using a sample of 49,802 individuals from the National Household Survey of Drug Abuse. The price elasticity for heroin and cocaine were about 1.70 and 0.96, respectively, which are quite high. Using these figures, the authors estimate that the lower prices flowing from the legalization of these drugs would lead to an increase of about 100% and 50% increase in the quantities of heroin and cocaine consumed, respectively.

How does this square with the observation that draconian punishments do not squelch the demand altogether? Gruber and Koszegi (2001) explain this by showing that many drug users are hyperbolic discounters, for whom the possible future penalties have highly attenuated deterrent value. Nevertheless, allowing for this attenuated value, sophisticated economic analysis, of the sort developed by Becker, Murphy and Grossman (2004) can be deployed for policy purposes. By contrast, the rejection of the BPC model leads to a panopoly of incoherent and incompatible alternatives based on the irrationality of substance abuse, none of which has proved effective.

## 4.4 Positing Exotic Tastes Explains Nothing

Broadening the rational actor model beyond its traditional form in neoclassical economics runs the risk of developing unverifiable and *post hoc* theories, as our ability theorize outpaces our ability to test theories. Indeed, the folklore among economists dating back at least to Becker and Stigler (1977) is that "you can always explain any bizarre behavior by assuming sufficiently exotic preferences."

This critique was true before researchers had the capability of actually measuring preferences and testing the cogency of models with nonstandard preferences (i.e., preferences over things other than marketable commodities, forms of labor, and leisure). However, behavioral game theory now provides the methodological instruments for devising experimental techniques that allow us to estimate preferences with some degree of accuracy, (Gintis 2000, Camerer 2003). Moreover, we often find that the appropriate experimental design variations can generate novel data allowing us to distinguish among models that are equally powerful in explaining the existing data (Tversky and Kahneman 1981, Kiyonari, Tanida and Yamagishi 2000). Finally, since behavioral game-theoretic predictions can be systematically tested, the results can be replicated by different laboratories (Plott 1979, V. Smith 1982, Sally, 1995), and models with very few nonstandard preference parameters can be used to explain a variety of observed choice behavior (Gintis 2000, Camerer 2003).

### 4.5 Decisions are Sensitive to Framing Bias

The BPC model assumes that individuals have stable preferences and beliefs that are functions of the individual's personality and current needs. Yet, in many cases laboratory experiments show that individuals can be induced to make choices over payoffs based on subtle or obvious cues that ostensibly do not affect the value of the payoffs to the decision maker. For instance, if a subjects' partner in an experimental game is described as a "competitor" or an "opponent," or the game itself is described as a "bargaining game," subjects may make very different choices from a situation where the partner is described as a "teammate", or the game is described as a community participation game. Similarly, a subject in a bargaining game may reject an offer if made by his bargaining partner, but accept the same offer if made by the random draw of a computer (Blount 1995) on behalf of the proposer.

Sensitive to this critique, experimenters in the early years of behavioral game theory attempted to minimize the possibility of framing effects by rendering as abstract and unemotive as possible the language in which a decision problem or strategic interaction was described. It is now widely recognize that it is in fact impossible to avoid framing effects, because abstraction and lack of real-world reference is itself a frame rather than an absence thereof. A more productive way to deal with framing is to make the frame a part of the specification of the experiment itself, and vary the frame systematically to discover the effect of the frame on the choices of the subjects, and by inference, on their beliefs and preferences.

We do not have a complete model of framing, but we do know enough to know that its existence does not undermine the BPC model. If subjects care only about the "official" payoffs in a game, and if framing does not affect the beliefs of the subjects as to what other subjects will do, then framing could not affect behavior in the BPC framework. But, subjects generally do care about fairness, reciprocity, and justice as well as the game's official payoffs, and when confronted with a novel social setting in the laboratory, subjects must first decide what moral values to apply to the situation by *mapping the game onto some sphere of everyday life* to which they are accustomed. The verbal and other cues provided by experimenters are the clues that subjects use to "locate" the interaction in their social space, so that moral principles can be properly applied to the novel situation. Thus framing is in fact an ineluctable part of the BPC model, properly construed.

## 4.6 People are Faulty Logicians

The BPC model permits us to infer the beliefs and preferences of agents from their choices under varying constraints. Such inferences are valid, however, only if individuals can intelligently vary their behavior in response to novel conditions. While it is common for behavioral scientists who reject the BPC model to explain an observed behavior as due to error or confusion on the part of the agent, the BPC model is less tolerant of such explanations if agents are reasonably well-informed and the choice setting reasonable transparent and easily analyzable.

Evidence from experimental psychology over the past forty years has cast doubt on the capacity of individuals to reason sufficiently accurately to warrant the BPC presumption of subject intelligence. For instance, in one well-known experiment performed by Tversky and Kanheman (1983), a young woman Linda is described as politically active in college and highly intelligent, and the subject is asked which of the following two statements is more likely: "Linda is a bank teller" or "Linda is a bank teller and is active in the feminist movement." Many subjects rate the second statement more likely, despite the fact that elementary probability theory asserts that if p implies q, then p cannot be more likely than q. Since the second statement implies the first, it cannot be more likely than the first.

I personally know many people (though not scientists) who give this "incorrect" answer, and I never have observed these individuals making simple logical errors in daily life. Indeed, in the literature on the "Linda problem" several alternatives to faulty reasoning have been offered. One highly compelling alternative is based on the notion that in normal conversation, a listener assumes that any information provided by the speaker is relevant to the speaker's message (Grice 1975). Applied to this case, the norms of conversation lead the subject to believe that the experimenter wants Linda's politically active past to be taken adequately into account (Hilton 1995, Wetherick 1995). Moreover, the meaning of such terms as "more likely" or "higher probability" are vigorously disputed even in the theoretical literature, and hence are likely to have a different meaning for the average subject and for the expert. For instance, if I were given two piles of identity folders and ask to search through them to find the one belonging to Linda, and one of the piles was "all bank tellers" while the other was "all bank tellers who are active in the feminist movement," I would surely look through the second (doubtless much smaller) pile first, even though I am well aware that there is a "higher probability" that the folder is in the first pile rather than the second.

More generally, subjects may appear irrational because basic terms have different meanings in propositional logic and in everyday logical inference. For instance, "if p then q" is true in formal logic except when p is true and q is false. In everyday usage "if p then q" may be interpreted as a material implication, in which there is something about p that cause q to be the case. Thus, "if France is in Africa, then Paris is in Europe" is true in propositional logic, but false as a material implication. Part of the problem is also that individuals without extensive academic training simply lack the expertise to follow complex chains of logic, so psychology experiments often exhibit a high level of *performance error* (Cohen 1981). For instance, suppose Pat and Kim live in a certain town where all men have beards and all women wear dresses. Then the following can be shown to be true in propositional logic: "Either if Pat is a man then Kim wears a dress or if Kim is a woman, then Pat has a beard." It is quite hard to see why this is formally, true, and it is not true if the implications are material. Finally, the logical meaning of "if p then q" can be context dependent. For instance, "if you eat dinner (p), you may go out to play (q)" formally means "you may go out to play (q) only if you eat dinner (p)."

We may apply this insight to an important strand of experimental psychology that purports to have shown that subjects systematically deviate from simple principles of logical reasoning. In a widely replicated study, Wason (1966) showed subjects cards each of which had a "1" or "2" on one side and "A" or "B" on the other, and stated the following rule: a card with a vowel on one side must have an odd number on the other. The experimenter then showed each subject four cards, one showing "1", one showing "2", one showing "A", and one showing "B", and asked the subject which cards must be turned over to check whether the rule was followed. Typically, only about 15% of college students point out the correct cards ("A" and "2"). Subsequent research showed that when the problem is posed in more concrete terms, such as "any person drinking beer must over eighteen," the correct response rate increases considerably (Stanovich 1999, Shafir and LeBoeuf 2002). This accords with the observation that most individuals do not appear to have difficulty making and understanding logical arguments in everyday life.

### 4.7 People are Poor Statistical Decision Makers

Just as the rational actor model began to take hold in the mid-Twentieth century, vigorous empirical objections began to surface. The first was Allais (1953), who exhibited cases where subjects exhibited clear choice inconsistency in choosing among simple lotteries (a lottery is a probability distribution over a finite set of monetary outcomes). It has been shown that Allais' examples can be explained by regret theory (Bell 1982, Loomes and Sugden 1982), which can be represented by consistent choices over pairs of lotteries (Sugden 1993).

Close behind Allais came the famous Ellsberg Paradox (Ellsberg 1961), which can be shown to violate the most basic axioms of choice under uncertainty. Consider two urns. Urn A has 51 red balls and 49 white balls. Urn B also has 100 red and white balls, but the fraction of red balls is unknown. One ball is chosen from each urn but remains hidden from sight. Subjects are asked to choose in two situations. First, a subject can choose the ball from urn A or urn B, and if the ball is red, the subject wins $10. In the second situation, two new balls are drawn from the urns, with replacement, the subject can choose the ball from urn A or urn B, and if the ball is white, the subject wins $10. Many subjects choose the ball from urn A in both cases. This obviously violates the expected utility principle, no matter what probability the subject places on the probability the ball from urn B is white.

It is easy to see why unsophisticated subjects make this obvious error: urn B seems to be *riskier* than urn A, because we know the probabilities in A but not B. It takes a relatively sophisticated probabilistic argument—one that no human being ever made or could have made (to our knowledge) prior to the modern era—to see that in fact in this case uncertainty does not lead to increased risk. Indeed, most intelligent subjects who make the Ellsberg error will be convinced, when presented with the logical analysis, to modify their choices without modifying their preferences. In cases like this, we speak of *performance error*, whereas in cases such as the Allais Paradox, even the most highly sophisticated subject will need change his choice unless convinced to change his preference ordering.

Numerous experiments document clearly that many people have beliefs concerning probabilistic events that are without scientific foundation, and which will most likely lead them to sustain losses if acted upon. For instance, virtually every enthusiast believes that athletes in competitive sports run “hot and cold,” although this has never been substantiated empirically. In basketball, when a player has a “hot hand,” he is preferentially allowed to shoot again, and when he has a “cold hand,” he is often taken out of the game. I have yet to meet a basketball fan who does not believe in the phenomenon of the hot hand. Yet, Gilovich, Vallone and Tversky (1985) have shown on the basis of a thorough statistical analysis using professional basketball data, that the hot hand does not exist.[3] This is but one instance of the general rule that our brains often lead us to perceive a pattern when faced with purely random data. In the same vein, I have talked to professional stock traders who believe, on the basis of direct observation of stock volatility, that stocks follow certain laws of inertia and elasticity that simply cannot be found through a statistical analysis of the data. Another example of this type is the “gambler’s fallacy,” which is that in a fair game, after a run of exceptionally bad luck (e.g., a series of ten incorrect guesses in a row in a coin flip game), a run of good luck is likely to follow. Those who believe this cannot be dissuaded by scientific evidence. Many who believe in the “law of small numbers,” which says that a small sample from a large population will have the same distribution of characteristics as the population (Tversky and Kanheman 1971), simply cannot be dissuaded either by logical reasoning or presentation of empirical evidence.

We are indebted to Daniel Kahneman, Amos Tversky, and their colleagues for a long series of brilliant papers, beginning in the early 1970’s, documenting the various errors intelligent subjects commit in dealing with probabilistic decision making. Subjects systematically underweight base rate information in favor of salient and personal examples, they reverse lottery choices when the same lottery is described emphasizing probabilities rather than monetary payoffs, when described in term of losses from a high baseline as opposed to gains from a low baseline, they treat proactive decisions differently from passive decisions even when the outcomes are exactly the same, and when outcomes are described in terms of probabilities as opposed to frequencies (Kahneman et al. 1982, Kahneman and Tversky 2000).

Like many other behavioral scientists, I consider these findings of decisive

[3] I once presented this evidence to graduating seniors in economics and psychology at Columbia University, towards the end of a course that developed and used quite sophisticated probabilistic modeling. Many indicated in their essays that they did not believe the data.

importance for understanding human decision making and for formulating effective social policy mechanisms where complex statistical decisions must be made. Unlike many others, I do not consider these findings a threat to the BPC model (Gigerenzer and Selten 2001). They are simply performance errors in the form of incorrect beliefs as to how payoffs can be maximized.[4]

Statistical decision theory did not exist until this century. Before the contributions of Bernoulli, Savage, von Neumann and other experts, no creature on Earth knew how to value a lottery. It takes years of study to feel at home with the laws of probability. Moreover, it is costly, in terms of time and effort, to apply these laws even if we know them. Of course, if the stakes are high enough, it is worthwhile to go to the effort, or engage an expert who will do it for you. But generally, as Kahneman and Tversky suggest, we apply a set of heuristics that more or less get the job done (Gigerenzer and Selten 2001). Among the most prominent heuristics is simply *imitation*: decide what class of phenomenon is involved, find out what people "normally do" in that situation, and do it. If there is some mechanism leading to the survival and growth of relatively successful behaviors and if the problem in question recurs with sufficient regularity, the choice-theoretic solution will describe the winner of a dynamic social process of trial, error, and replication through imitation.

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[4]In a careful review of the field, Shafir and LeBoeuf (2002) reject the performance error interpretation of these results, calling this a "trivialization" of the findings. They come to this conclusion by asserting that performance errors must be randomly distributed, whereas the errors found in the literature are systematic and reproducible. These authors, however, are mistaken in believing that performance errors must be random. Ignoring base rates in evaluating probabilities or finding risk in the Ellsberg two urn problems are surely performance errors, but the errors are quite systematic. Similarly, folk intuitions concerning probability theory lead to highly reproducible results, although incorrect.

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