Simon and the Sirens: A Commentary

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Abstract: Even in its extended usage, the concept of bounded rationality bears the birthmark of its origins in economics. First and most obviously, it is about seeking the most efficient (not necessarily the best) means toward a given end, whether that is curing patients or proving theorems. Second, the means are whittled down to the most parsimonious possible, not only acknowledging cognitive limitations but actually imposing them, whether in the form of Morgan's canon, Methodist agnosticism about causes, or *Entscheidungsproblem*-like restrictions on the acceptable formulation of mathematical proofs. Third, these parsimonious restrictions all tend to minimize the role of reasonable deliberation in rationality, albeit in different ways. As an object of inquiry *for* the history of science, bounded rationality has great promise. But as a model *of* the history of science, as one long exercise in bounded rationality, its utility may apply more to future than past science.

"Bounded rationality" is one of those terms that seems to wear its meaning on its sleeve: we strive to be rational; but being mere mortals, we succeed only within limits. Yet plunge into these apparently transparent waters, and the depths soon become murky indeed—and the bottom disappears from sight altogether. The authors of the essays in this Focus section have taken the plunge, and their soundings from various centuries and disciplines—from Methodist medicine in Greco-Roman antiquity (Colin Webster) to financial bubbles in the eighteenth century (William Deringer) to "trial and error" inquiry in the nineteenth (Henry Cowles) to computer proofs of logical theorems in the late twentieth (Stephanie Dick)—provide rich material for a history of bounded rationality, both the concept and the thing. Drawing on the four essays, I'll start with the concept, proceed to the thing, and conclude with some thoughts about the implications of these case studies for a history of rationality—and also about why and to what degree the history of rationality is part of the history of science (as opposed to, say, the history of philosophy or even the history of theology).

So, first, what exactly is "bounded rationality"? The term was coined by the American social scientist Herbert Simon in his book *Models of Man* (1957) as a critique of the optimizing theories of rationality in economics. However, as Simon himself later pointed out, the idea was already present *avant la lettre* in his revised University of Chicago dissertation, *Administrative Behavior* (1947), and became the red thread woven through his remarkable career in economics, psychology, decision theory, public policy, and Artificial Intelligence.[1]

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[1] Herbert A. Simon, *Models of Man, Social and Rational: Mathematical Essays on Rational Human Behavior in a Social Setting*

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Simon pointed out that optimization theory, which dictates that rational actors should be able to compute the probabilities and outcome values of all rival courses of action, is not descriptively accurate with respect to how human beings actually make decisions. Nor is this situation corrigible: optimization as envisioned by neoclassical economics or even rational expectation theory is impossible in principle, since it ignores intrinsic limits to information about the future and computational abilities as well as the costs of increasing both resources. According to Simon, *Homo economicus* was as mythical as the centaur:

> Traditional economic theory postulates an "Economic Man," who in the course of being "economic" is also "rational." This man is assumed to have knowledge of the relevant aspects of his environment which, if not absolutely complete, is at least impressively clear and voluminous. He is assumed also to have a well-organized and stable system of preferences and a skill in computation that enables him to calculate, for the alternative courses of action that are available to him, which of these will permit him to reach the highest attainable point on his preference scale. . . . Broadly stated, the task is to replace the global rationality of Economic Man with a kind of rational behavior that is compatible with the access to information and the computational capacities that are actually possessed by organisms, including man, in the kinds of environments in which such organisms exist.[2]

Instead, Simon proposed, the economic rationality of optimization should be replaced at both the descriptive and normative levels with a rationality of "satisficing": finding solutions that were good enough without making extravagant or even impossible demands on resources such as information search costs and computational power. Some researchers following in Simon's footsteps have gone so far as to claim that, at least in some domains, simple satisficing heuristics produce not just good enough but better results than much more complicated models that aim at optimization.[3] Simon's own version of bounded rationality was less ambitious, placing the accent squarely on "bounded": to fall short of the strenuous demands of economic optimization was perhaps to admit imperfection, but not irrationality.

Simon's subsequent work sought to articulate the nature of that rationality in detail and in many different domains, including scientific discovery. In his 1991 autobiography, Simon declared: "I would not object to having my whole scientific output described as largely a gloss—a rather elaborate gloss, to be sure—on the pages of *Administrative Behavior* where these ideas [on bounded rationality] were first set forth." He became increasingly critical of mainstream economics and what he considered to be its pie-in-the-sky assumptions about exhaustive knowledge of future eventualities, precise probabilities, well-defined choices, perfectly ordered utility preferences, and other fixtures of optimization models, for which he

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(New York: Wiley, 1957), pp. 196–201; and Simon, *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization* (New York: Wiley, 1947), pp. 39–41, 204–212, 240–244. On the development of Simon's ideas see Hunter Crowther-Heyck, *Herbert A. Simon: The Bounds of Reason in Modern America* (Baltimore: Johns Hopkins Univ. Press, 2005), esp. pp. 112–117.

[2] Herbert A. Simon, "A Behavioral Model of Rational Choice," *Quarterly Journal of Economics*, 1955, *69*:99–118, rpt. in Simon, *Models of Thought*, 2 vols. (New Haven, Conn.: Yale Univ. Press, 1979), Vol. 1, pp. 7–19, on p. 7 (subsequent citations will be to this reprint).

[3] For examples see Gerd Gigerenzer and Wolfgang Gaissmaier, "Heuristic Decision Making," *Annual Review of Psychology*, 2011, *62*:451–482.

claimed there was "a complete lack of evidence."[4] Yet Simon's own framework remained economical in at least one basic sense. Whether he was analyzing chess, learning theory, or inventory control in firms, proving logical theorems or discovering scientific laws, Simon focused on how to arrive at results that were "good enough" without extravagant expenditure in time, effort, money, computation, and other scarce resources. Moreover, he achieved this frugality by means that might also be described as economical in a practical sense: just as factories divided complex tasks into distinct subunits of production, Simon recommended dividing problems into "component processes" that were manageable by rules of thumb that he and his colleague Allen Newell called "heuristics."[5] It is this practical sense of "economical" that clings to Simon's heresy in economics, even when the concept of bounded rationality is more broadly construed and transplanted to other domains.

With one exception (Stephanie Dick's paper, which focuses on some of Simon's own work on computerized proofs), the contributors to this Focus section have, however, interpreted "bounded rationality" less boundedly than Simon himself. They have broadened the term's use to cover many kinds of cognitive limitations that force historical actors to rein in their ambitions to know perfectly but not to give up entirely on their aspirations to act rationally. It is, I think, significant that all four of the essays implicitly place the emphasis on rational *action* rather than rational deliberation: curing the sick, investing in the stock market, learning from experience, and programming computers. Even if their construals of bounded rationality deviate from the letter of Simon's computation-centered definition, the contributors all embrace its spirit: pure reason may luxuriate in the marble halls of idle abstraction, but rationality gets things done in the world, even at the cost of cutting corners.

The question that all four essays raise, in the most diverse and diverting ways, is whether bounded rationality is a useful concept for the history of science—either as an object of historical inquiry (e.g., the "trial and error" accounts of animal learning or machine-based accounts of mathematical proof) or as a description of science itself, as one long exercise in bounded rationality (e.g., the anticausal strictures of the ancient Methodists or the financial knowledge won in the hard-knocks school of the South Sea Bubble). The papers provide ample evidence of the enticements of both research programs. But bounded rationality as it emerges in these four papers is more than yet another theory about how fallible mortals somehow get by with their flawed faculties—the leitmotif of all epistemology since Plato (and also of a lot of postlapsarian Christian theology). It is more specifically a strategy of getting more for less, a kind of extreme parsimony of the mind—to the point where mind almost disappears entirely.

Let me explain what I mean with a few examples from the papers. When animal psychologists like Conwy Lloyd Morgan and Edward Thorndike banned easy recourse to reasoning processes as an explanation for dogs lifting latches or rats navigating mazes (as Henry Cowles tells us), or when the ancient Methodists banned inferences to the unseen causes of diseases (as described by Colin Webster), they were not simply making concessions to human limitations; they were, rather, imposing limits on the kind of reasoning deemed

[4] Herbert A. Simon, Patrick W. Langley, and Gary L. Bradshaw, "Scientific Discovery as Problem Solving," *Synthèse*, 1981, 47:1–27; Simon, *Models of My Life* (New York: Basic, 1991), p. 88; and Simon, "Behavioral Model of Rational Choice" (cit. n. 2), p. 10.

[5] Allen Newell and Herbert A. Simon, "The Logic Theory Machine: A Complex Information Processing System," *IRE Transactions on Information Theory*, 1956, *1*:61–79. The word "heuristics" probably comes from the Stanford mathematician George Polya, with whom Newell had studied and who had explored such methods of mathematical discovery in his classic *How to Solve It: A New Aspect of Mathematical Method* (Princeton, N.J.: Princeton Univ. Press, 1945).

permissible. There is a difference between conceding that one has bad eyesight and deliberately donning a blindfold. In both cases, the motive for volunteering to be blindfolded seems to have been an odd combination of epistemological caution (don't leap to conclusions on the basis of insufficient evidence) and vaulting ambition (get the most mileage out of the fewest assumptions). The Methodists aimed to cure more patients with fewer inferences about the nature of disease (not for nothing were they called "champion doctors"); the animal psychologists aimed to explain as much complex behavior as possible by the simplest of mechanisms, trial and error. There is a comparable self-restraint at work in the efforts of early twentieth-century mathematicians to convert proofs into a finite sequence of rigidly rule-bound steps that forms the background to the theorem-proving computer programs of the 1950s (as recounted by Stephanie Dick). Well before Newell and Simon or Hao Wang attempted to mechanize proofs of logical theorems, many mathematicians had set about banning the intuition and insight that had since Euclid been the hallmark of rigor. The Turing Machine is a very stripped down version of a human mathematician, as Turing himself was the first to admit. Newell and Simon's first model of the Logic Theorist program makes the point even more dramatically: index cards were distributed to Simon's wife, children, and various graduate students so that "each person became, in effect, a component of the L[ogic] T[heorist] computer program" to prove the first twenty-five theorems of Bertrand Russell and Alfred North Whitehead's *Principia Mathematica*.[6] Computer subroutines were originally just an extension of the economic principle of the division of labor—and the intellectual deskilling that went with it.[7] And then there is economics red in tooth and claw, in the form of financial bubbles and crises. When economists like Eugene Fama (as cited by William Deringer) contend that markets are always rational—even markets gone mad, as in the 1720 South Sea Bubble—they are both flirting with tautology (markets *define* what is rational) and shifting the burden of being rational from individual actors (who may be addled or confused or deluded) to the market itself, which allegedly never errs.

What these examples show us is that bounded rationality even in its broadest sense is *intrinsically* economic—and in at least three senses. First and most obviously, it is about seeking the most efficient (not necessarily the best) means toward a given end, whether that means curing patients or proving theorems (in this managerial spirit, Hao Wang boasts that his programs prove more theorems in less time than Simon's does). Second, the means are whittled down to the most parsimonious possible, not only acknowledging cognitive limitations but actually imposing them, whether in the form of Morgan's canon, Methodist agnosticism about causes, or *Entscheidungsproblem*-like restrictions on the acceptable formulation of mathematical proofs.[8] These self-imposed restrictions exceed what would be required by epistemological modesty alone; they serve more-for-less principles of parsimony. Third, these parsimonious restrictions all tend to minimize the role of reasonable deliberation in

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[6] A. M. Turing, "Computing Machinery and Intelligence," *Mind*, 1950, 59:433–460, esp. p. 436; and Simon, *Models of My Life* (cit. n. 4), p. 207.

[7] These computer subroutines left tell-tale traces in the simulation models of the mind advanced in the 1980s in the cognitive sciences, where they became "known as program modules, perfect for the divide-and-conquer strategy programmers often use to tackle large problems. To the computer, however, it makes no difference whether subroutines are isolated or not": Gerd Gigerenzer and Daniel Goldstein, "Mind as Computer: The Social Origin of a Metaphor," in Gigerenzer, *Adaptive Thinking: Rationality in the Real World* (Oxford: Oxford Univ. Press, 2000), pp. 26–43, on p. 41.

[8] Alan M. Turing, "On Computable Numbers, with an Application to the *Entscheidungsproblem*," *Proceedings of the London Mathematical Society*, 1936–1937, 2nd Ser., 42:230–265. The *Entscheidungsproblem* (finding an algorithm to decide whether a given theorem in logic can be deduced from the axioms in a finite number of steps) was formulated in David Hilbert and Wilhelm Ackermann, *Grundzüge der theoretischen Logik* (Berlin: Springer, 1928), p. 77.

rationality, albeit in different ways. Sometimes the restrictions on deliberation are self-imposed on the inquirers themselves: the Methodists give up on trying to understand the etiology of diseases or even what diseases are; the mathematicians give up on all-at-once flashes of insight of the sort once thought to guarantee certainty. And sometimes they are imposed on the objects of inquiry: trial-and-error learning theorists deny animals and children the powers of judgment and inference; economists prefer the blind logic (sometimes known as the invisible hand) of the market to the intelligent design of individual actors and governments. Note that although such restrictions may tend toward formalization, as in the case of the Turing Machine and Newell and Simon's Logic Theorist, they need not do so. Long before computer algorithms and AI, bounded rationality seems to have been not just a *faute de mieux* alternative *to* but also an enemy *of* perfectly deliberative reason. To continue the economic metaphor: deliberative reason is a luxury that the parsimonious efficiency of rationality cannot afford.

Why not? Bounded rationality differs from Occam's Razor in that it doesn't just whittle down the *number* of assumptions to a bare minimum but also systematically bans certain *kinds* of assumptions, namely those requiring what traditionally have been called the higher mental faculties: deliberation, design, inference, intelligence, insight. At the level of scientific explanation, it could be argued that this is a trend that has been going on since at least the mechanical philosophy of the seventeenth century. Since then, there has been a steady expansion of this explanatory strategy from the realm of matter to that of mind, most recently in the cognitive sciences. But at the level of *doing* science, bounded rationality, with its strong economic associations, is not only new but in conflict with many of the most fundamental aims of science (and, before science, natural philosophy): namely, to understand the causes of things as comprehensively and coherently as possible.

Bounded rationality, whether it takes the form of AI or Big Data mining, speaks the economic language of efficiency rather than insight, of correlations rather than causes. When Simon and his collaborators attempted to program computers to make scientific discoveries (e.g., the chemical composition of water) from data sets—in essence, an AI reconstruction of the history of science, complete with references to Thomas S. Kuhn's categories of "normal" and "revolutionary" science—they hesitated to claim that the BACON.4 program had actually explained this finding by the atomic theory. "Does this result support the claim that BACON.4 has discovered the atomic theory of the formation of water vapor, hence has reductionist capabilities? We would say that it does not, although it is not easy to specify what is missing." In effect exercising second-order bounded rationality, they quickly left off "conjecturing about these difficult matters" and returned to the first-order version of formulating heuristic algorithms for computer simulations of scientific induction and deduction.[9]

Using the concept of bounded rationality to frame episodes within the history of science, as these four essays have so fruitfully done, is a different matter than equating the history of science *tout court* with bounded rationality. The latter formulation seems at once too broad and too narrow. Too broad, because it is trivially true: since humans are neither immortal nor omniscient, even their most rational attempts to know their world will inevitably be bounded in some fashion. In this broad construal, "bounded rationality" does indeed collapse into more familiar epistemological (and theological) diagnoses of the various forms of human frailty that obstruct progress to truth, running the gamut from deceptive sensations to unruly passions to overheated imagination. There certainly are moments in the history of science when these

[9] Simon *et al.*, "Scientific Discovery as Problem Solving" (cit. n. 4), p. 21.

doubts (and the discipline they impose) become acute, as in nineteenth-century positivist restrictions on allegedly "metaphysical" aspects of scientific theory of the sort preached by Auguste Comte or Ernst Mach. But the history of science is more than just a footnote to the history of epistemology or even that of epistemological modesty.

The narrow construal of bounded rationality—the history of science as Simon's AI reconstruction—seems an equally bad fit, this time tight and pinched rather than loose and baggy. Simon's BACON.4 and AM computer programs to simulate empirical and theoretical discoveries in science with the sort of procedural rationality he applied to the analysis of administrative decisions assume what they are supposed to discover. If, for example, Kepler had been provided with the selective and scrubbed data on planetary distances and periods fed to BACON.4, he would have had his work cut out for him. On this view of scientific discovery, a great deal of historical evidence (e.g., Kepler's own accounts of his stumble-blunder path to discovery set forth in his letters and the *Astronomia nova* [1609]) would be simply irrelevant. All that matters are the algorithms and the data, neither the conscious deliberations of the discoverer nor their context. However, although this may be an impoverished description of past science, it may come to be a more accurate portrayal of future science, albeit in the form of self-fulfilling prophecy, as data-mining algorithms modeled on machine learning and AI proliferate as research methods.

There is yet a third possibility that emerges from the four essays about how bounded rationality might intersect with the history of science—or, rather, with the history of rationality, of which science would be just one example among several. This point of view is expressed most clearly in Deringer's essay, which suggests that the experience of the South Sea Bubble might be judged not as rational or irrational *in se* (the debate currently waged by economists over bubbles) but, rather, as a chapter in the history of what economic rationality means, both in precept and in practice. But the theme is at least implicit in the other essays as well. The self-imposed strictures on explanation among the Methodist physicians (Webster) and the trial-and-error psychologists (Cowles) set novel standards for rational explanations in their disciplines that were at odds with those of other practitioners. Dick's emphasis on the importance of the implementation of the rival theorem-proving computer programs also points to distinctions in what might appear at first glance to be identical forms of algorithmic rationality. Showing that rationality is not monolithic is of course not sufficient to prove that rationality has a history, but it is the necessary precondition for such a history. Without the bare possibility of variability, there can be no change over time.

What might such a history look like? For starters, it would *not* be a history of reason. Although the distinction between reason and rationality is clearer in some languages than others, and although there is a considerable overlap of semantic fields, the two branches of the Latin root "*ratio*" have diverged ever more sharply in the modern period. Economic theories in particular have detached rationality—formal, calculating, instrumental—from reason—a universal faculty that encompasses judgment, understanding, and insight.[10] Bounded rationality itself is an example of how rationality has pulled apart from traditional ideals of deliberative reason. Second, the history of rationality would be bound up with concrete practices—indeed, with squarely *practical* practices. It is perfectly possible to imagine a history of reason (and its representative discipline, philosophy) as a history of specific practices: the

[10] Paul Erickson, Judy L. Klein, Lorraine Daston, Rebecca Lemov, Thomas Sturm, and Michael D. Gordin, *How Reason Almost Lost Its Mind: The Strange Career of Cold War Rationality* (Chicago: Univ. Chicago Press, 2013), pp. 2–21.

agonistic dialogue, the demonstration from first principles, the spiritual exercise.[11] But the history of rationality would center on practices that aim first and foremost to do things in the world, rather than to understand it—sometimes even at the price of understanding it. Once again, bounded rationality is a case in point, as we have seen. Third, the history of science as conventionally defined intersects with the history of rationality but does not exhaust it. It is part of the historical and cultural specificity of various forms of rationality that they emerge in myriad contexts: in the laboratory, the observatory, and, for that matter, the library, but also in the offices of bureaucrats, on the battlefield, in the workshop, and at the market.

This last site returns us full circle to Simon's bounded rationality. I have suggested that this concept retains its economic birthmark even when broadly interpreted, as in the essays in this Focus section. Is this true of all forms of rationality? Much more research would be required to answer this question, but I suspect that the cross-historical, cross-cultural verdict would be "no": economic ends are only a subset of the practical ends that forms of rationality have been devised to realize. However, if we narrow our sights to the modern world, it is difficult to overlook the predominance of economic rationality[12]—to the point where the word "rationality" has become almost synonymous with "economic rationality." Already in 1964, the writing was on the wall. At a Berkeley conference on strategy in the age of nuclear conflict held that year, the economist Thomas Schelling chafed at the ambiguities of the word "rationality," especially its normative overtones: "It would be useful if rationality were not a loaded term which implies it's better to be rational, or that people who are rational are socially desirable, so they can't be eccentric or crazy. If we could Latinize the term so that one word means 'economic theory of rationality' and another means something else, we'd be better off." Instead of a new Latinate term, economic rationality (of several sorts) simply swallowed up rationality. By 1993 the philosopher Robert Nozick, in a book entitled *The Nature of Rationality*, wistfully conceded the future of his discipline to algorithms not unlike those used by Simon and his collaborators to model scientific discovery heuristically:

> In the study of reliable processes for arriving at belief, philosophers will become technologically obsolescent. They will be replaced by cognitive and computer scientists, workers in artificial intelligence, and others. . . . This will be useful to us—machines will be produced to do intricate tasks—but it will not be what philosophers earlier had hoped for: rules and procedures that we ourselves could apply to better our own beliefs, *surveyable* rules and procedures—I take the term from Ludwig Wittgenstein—that we can take in and understand as a whole and that give us a structurally revealing description of the nature of rationality.

In other words, the rules and procedures that constitute rationality would be valid and efficacious but algorithmic—efficiently and reliably executed by a machine but opaque to human understanding.[13]

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[11] For examples see G. E. R. Lloyd, *Revolutions of Wisdom: Studies in the Claims and Practice of Ancient Greek Science* (Berkeley: Univ. California Press, 1987); Marcel Détienne, *Les maîtres de la verité dans la Grèce antique* (Paris: Découverte, 1990); Pierre Hadot, *Qu'est-ce que la philosophie antique?* (Paris: Gallimard, 1995); and Matthew L. Jones, *The Good Life in the Scientific Revolution: Descartes, Pascal, Leibniz, and the Cultivation of Virtue* (Chicago: Univ. Chicago Press, 2006).

[12] Economic rationality itself is by no means a unified concept; see Paul Weirich, "Economic Rationality," in *The Oxford Handbook of Rationality*, ed. Alfred R. Mele and Piers Rawling (Oxford: Oxford Univ. Press, 2004), pp. 380–398.

[13] Thomas C. Schelling, "Discussion: First Session: The Concept of Rationality," in *Strategic Interaction and Conflict*, ed. Kathleen Archibald (Berkeley: International Security Program, Institute of International Studies, Univ. California, 1966), pp.

Nozick's resignation in the face of bounded rationality extended to philosophy strangely inverts an episode in the *Odyssey* (Book 12). Odysseus, perhaps the most rational figure in all of Greek mythology, has himself bound to the mast of his ship so that he can hear the fatally enticing songs of the Sirens without succumbing to the temptation to steer into the rocks that have shipwrecked the Sirens' other victims. He has taken the precaution of plugging his crew's ears with wax and could of course have immunized himself against temptation by plugging his own as well. But he wants to hear the Sirens, to know their song, though he does not trust himself to resist its lure. Nozick was prepared, albeit with a touch of melancholy, to bind philosophy by the algorithms that would guarantee efficient and valid results but by that very token to relinquish the firsthand knowledge—or, rather, the firsthand experience of knowing—that Odysseus sought. *Mutatis mutandis*, the algorithmic exploitation of Big Data to mechanize scientific discovery has aroused analogous anxieties about "theory-free science."[14]

In his important book *Ulysses and the Sirens: Studies in Rationality and Irrationality* (1984), Jon Elster used this myth to characterize another kind of "imperfect rationality," less biologically tethered than Simon's bounded rationality. According to Elster, "Ulysses was not fully rational, for a rational creature would not have to resort to this device; nor was he simply the passive and irrational vehicle for his changing wants and desires, for he was capable of achieving by indirect means the same end as a rational person could have realised in a direct manner."[15] Despite significant differences in their views, Elster, like Simon, emphasized rationality's procedural side: how to achieve the desired end, not whether the end itself was rational. It was obviously rational to want to evade the Sirens' deadly trap for seafarers; was it also rational to want to hear their song? Economic rationality is mute on this topic: individual utility functions accommodate all manner of desires, no matter how strange, so long as preferences are consistently ordered. But if confronted with a choice among rationalities, as many philosophers and scientists now believe themselves to be, would it be more rational to prefer knowledge to knowing, efficient procedures over understanding? A history of rationality that took full account of the protean forms packed into that deceptively singular term cannot make that choice, but it could at least illuminate the options and their origins.

137–227, on p. 147; and Robert Nozick, *The Nature of Rationality* (Princeton, N.J.: Princeton Univ. Press, 1993), p. 76. Nozick's view of rationality as "reliable processes for arriving at [true] belief" conforms to the mainstream view among contemporary philosophers. See, e.g., Robert Audi, "Theoretical Rationality: Its Structure, Sources, and Scope," in *Oxford Handbook of Rationality*, ed. Mele and Rawling, pp. 17–44.

[14] Chris Anderson, "The End of Theory: The Data Deluge Makes the Scientific Method Obsolete," *Wired Magazine*, 23 June 2008, http://archive.wired.com/science/discoveries/magazine/16-07/pb_theory (accessed 11 Jan. 2015).

[15] Jon Elster, *Ulysses and the Sirens: Studies in Rationality and Irrationality*, rev. ed. (Cambridge: Cambridge Univ. Press, 1984), p. 36. Whereas Simon always regarded bounded rationality as rooted in Darwinian accounts of evolution, Elster contrasted "locally maximizing machines" (all other organisms except humans) with "globally maximizing machines" (humans): the latter are capable of "*waiting* and using *indirect* strategies" and of "surveying *all* alternatives, all possible futures." *Ibid.*, pp. 9, 16. See also Simon, *Models of My Life* (cit. n. 4), p. 166.