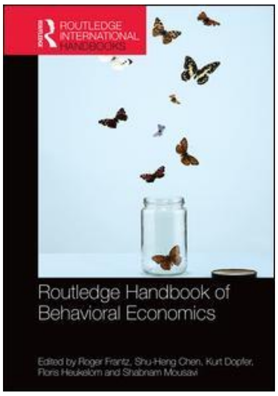

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HERBERT SIMON'S BEHAVIORAL ECONOMICS

Esther-Mirjam Sent

Introduction

Behavioral economics and its focus on the interrelations between economics and psychology are attracting increasing attention and recognition (Heukelom, 2014; Sent, 2004b). Bounded rationality has made its way into the work of, for example, rational expectations economists such as Thomas Sargent and game theorists such as Robert Aumann (Sent, 1997; 2004b). Yet, in 1992 Herbert Simon noted that "[r]eaders would not be deceived by the claim that economists flocked to the banner of satisficing man with his bounded rationality. The 'flocking' was for a long time a trickle that is now swelling into a respectable stream" (Simon, 1992b: 266).

Bounded rationality, in all likelihood, first appeared in print in *Models of Man* (Simon, 1957: 198; see Klaes and Sent, 2005). In his mature work, Simon used the concept to "designate rational choice that takes into account the cognitive limitations of the decision-maker—limitations of both knowledge and computational capacity" (Simon, 1987b: 266). Through the use of bounded rationality, Simon sought to criticize neoclassical economists for their lack of interest in the formal foundations of rationality. As Simon (1999: 23) reflected on this act of conceptual innovation, he began to use this concept after a while:

> You have to realize about the bounded rationality terminology that I began to use this as a label for the things that economists needed to pay attention to— and were not. It was never intended as a theory in any sense.

This is reminiscent of Harvey Leibenstein's introduction of X-efficiency theory (Frantz, 2007; Perelman, 2011).

Described by his colleague and friend Richard Cyert as a "true Renaissance man" Simon is the master of scientific border crossing. This chapter argues that "complexity" is the central theme of Simon's contributions to the various disciplinary domains (also see Frantz, 2003). Before turning to Simon's research in the third section, a brief second section will offer a biographical prolog. The section on the central theme of Simon's contributions is subsequently followed by one that highlights certain discontinuities. The fifth section next situates Simon's contributions within economics, while the last section concludes.

Biographical prolog

Born on June 15, 1916 in Milwaukee, Wisconsin, Simon was the second son of Arthur Simon, an immigrant German who was an electrical engineer and inventor, and Edna Merkel Simon, a third-generation American who was an accomplished pianist. Determined to become a mathematical social scientist, he bid farewell to Milwaukee at age seventeen to enter the halls of academe in Chicago, where he obtained his BA in 1936 and his graduate degree in 1943, both in political science. During his professional career, he was affiliated with the University of California at Berkeley, the Illinois Institute of Technology, the Cowles Commission, the RAND Corporation, and Carnegie Mellon University, which was still known as the Carnegie Institute of Technology when Simon moved there in 1949. At the time of his death in 2001, he was the Richard King Mellon Professor of Computer Science and Psychology at Carnegie.

In 1978, Simon received the Nobel Prize in economics for what the Nobel committee called "his pioneering research into the decision making process within economic organizations." Bounded rationality has received renewed attention in recent years from, among others, behavioral economists, game theorists, and rational expectations economists (Heukelom, 2014; Sent, 2004b). Yet, whereas Simon saw bounded rationality as an alternative to mainstream economics, many contemporary theorists attempt to use his ideas to solve some of the problems in their neoclassical program.

Starting off in political science and then moving through several disciplinary domains, such as management theory, economics, cognitive psychology, and artificial intelligence, Simon's entire academic career was focused on understanding human decision making and problem solving processes, and their implications for social institutions.

Continuities in Simon's contributions

There is a persistent reappearance of the theme of "complexity" in Simon's work. Indeed, Simon (1996a: ix) has counted himself among the partisans of complexity. Although several defining moments in complexity research may be distinguished, current enthusiasts tend to deal in concepts such as computational complexity, adaptive systems, genetic algorithms, classifier systems, and cellular automata (pp. ix, 169). In some instances, Simon has been cautious in his evaluation of these developments, arguing that "[i]t will be some time before we can assess its potential" (p. 181). Yet, in others, he has been much more forthcoming about the fundamental differences between these versions of complexity and his own.[1] Instead, Simon's (1996a: ix) own, idiosyncratic interpretation stressed "the particular hierarchical form of complexity,"[2] because "nature loves hierarchies" (Simon, 1973b: 5).[3] The reason for this, according to Simon (1996a: 196–7) is that "complex systems will evolve from simple systems much more rapidly if there are stable intermediate forms than if there are not. The resulting complex forms in the former case will be hierarchic."[4] For Simon, then, complexity was intimately connected with hierarchy, which, in turn, was closely related to ideas such as near decomposability, linkages, and frequency.[5]

Simon's complex, hierarchical system has linkages of different strengths or intensities among its components. Since he has maintained that effective hierarchies are nearly decomposable,[6] a complex, hierarchical system can be analytically divided into subsystems containing components with linkages of similar connectivity. The higher the subsystems are in the hierarchy, the lower is the frequency of interaction among their components. In other words, the weaker are the linkages among their elements. According to Simon (1973b: 10), "[m]otions of the system determined by low-frequency modes will be so slow that we will not observe them—they will be replaced by constants." Similarly, the lower the subsystems are in the hierarchy, the higher is the frequency of interaction among their components. In other words, the stronger are the linkages among their elements. For Simon (1973b: 10), "[m]otions of the system determined by the high frequency modes . . . will be so rapid that the corresponding subsystems will appear always to be in equilibrium . . . . In their relations with each other, the several subsystems will behave like rigid bodies . . . ". That is, Simon recommended treating slow behaviors at the higher levels as constants and fast behaviors at the lower levels as averages or equilibrium values. Hence, the analyzable subsystems with which Simon ended up are those in the middle, leading him to advocate theories of the middle level. In Simon's (1973b: 10–11) words:

> The middle band of frequencies, which remains after we have eliminated the very high and very low frequencies, will determine the observable dynamics of the system under study . . . . [W]e can build a theory of the system at the level of dynamics that is observable, in ignorance of the detailed structure or dynamics at the next level down, and ignore the very slow interactions at the next level up.

According to Simon, subsystems in the middle can be analyzed without reference to the subsystems below, since these are virtually in equilibrium, and the subsystems above, since these are essentially constant.[7] This description of Simon's interpretation of a complex, hierarchical system helps to understand the continuities in Simon's contributions to the various disciplinary domains.

First, Simon conceived of the organizations that he encountered in his political science and management theory research as complex, hierarchical systems.[8] The characteristics of these systems, as outlined in the previous paragraphs, allowed him to focus mostly on the middle levels of management. According to Simon (1960: 47), "the new developments in decision making will tend to induce more centralized decision making activities at middle management levels."[9] Therefore, Simon was mainly interested in how managers who find themselves situated in the middle make decisions, or, in how these managers manage to manage in complex, hierarchical systems. Simon (1960: 43) further noted that "[h]ierarchy is the adaptive form for finite intelligence to assume in the face of complexity." Consequently, just like systems can be divided into subsystems, goals can be divided into subgoals. Once these (moveable) subgoals have been set, the managers look for alternatives with which these can be met in a satisfactory manner. Therefore, satisficing allows the managers to determine when they are ready to move to the next subgoal, and heuristics inform the managers which branches to pursue from one subgoal to the next. Hence, managers are boundedly rational entities confronting the decisions they make in the complex, hierarchical systems in which they find themselves. Moreover, as suggested by Simon's later research in cognitive psychology and artificial intelligence, the problem solving skills of middle managers could be simulated and automated.[10] However, let us first follow Simon into economics.

Not unexpectedly, Simon also viewed economic systems as complex, hierarchical systems, thereby resonating with the contributions of Hayek to early complexity theory (Fiori, 2010).[11] Like the managers in political and administrative organizations, agents in economic systems are boundedly rational in dividing goals into subgoals, employing heuristics, and satisficing. Their choices do not stem from an examination of all possible alternatives. Instead, they climb on only certain branches of the tree; they can only explore subsystems of the complex, hierarchical system. In contrast, neoclassical economics[12] assumed that economic agents made choices: (a) among a given, fixed set of alternatives; (b) with (subjectively) known probability distributions of outcomes for each; and (c) in such a way as to maximize the expected value of a utility function. Instead, Simon wanted to model economic agents as making choices: (a') through a process for generating alternatives; (b') with strategies such as heuristics for dealing with uncertainty; and (c') in such a way as to satisfice relative to their aspiration levels. Hence, the nascent ideas inherent in Simon's early vision of science later blossomed into concepts that were to form the core of his criticism of neoclassical economics.[13]

Though perhaps unintended, Simon's ardent defense of theories of the middle level actually tended to immunize the neoclassical orthodoxy from damage from part of his attack. In addition to the above differentiation among levels of hierarchy, Simon further introduced a distinction between inner and outer environments. Just like subsystems higher up in the hierarchy can be analyzed without detailed descriptions of subsystems that are located lower down, one can evaluate the "outer environment with only minimal assumptions about the inner environment" (Simon, 1996a: 8). According to Simon, "[e]conomics illustrates well how outer and inner environment interact" (p. 25). Nevertheless, Simon's criticism of neoclassical economics seems to encounter some difficulties when he subsequently equated the outer environment with substantive, or neoclassical, rationality and the inner environment with procedural, or psychological, rationality, which tends to be the version modeled by himself (Simon, 1976).[14] If neoclassical economists propounded the idea that the outer environment could be evaluated without regard for the inner environment, they would have been given an argument for focusing on their preferred substantive as opposed to Simon's procedural rationality. Surely, Simon had not intended to bequeath this rationale to neoclassical economists![15] Furthermore, neoclassical economists have also employed some of Simon's mathematical results to their advantage in their own version of rationality. Again, these contributions were intimately related to Simon's focus on complex, hierarchical systems.

Consider Simon's valuable insights on causality and econometric identifiability.[16] What connects them to his research on managerial decision making and economic bounded rationality is, again, his interpretation of nearly decomposable systems.[17] Specifically, systems of simultaneous equations and sets of variables appearing in these equations can themselves be approached as complex, hierarchical systems. As a result, such systems can be divided into subsets of equations and subsets of variables. In particular, near decomposability is what allows the partitioning of both the equations and the variables of the system into relatively disjunct subsets for certain statistical purposes. The resulting hierarchies express the asymmetrical relationship among individual equations and their constituent variables. As Simon showed, they facilitate making a distinction between cause and effect and between endogeneity and exogeneity. In other words, hierarchy is intimately connected with causal ordering, which was closely related to econometric identifiability.

Next, consider Simon's useful contributions to the analysis of aggregation.[18] His conclusion that the possibility of consistent aggregation gives an insight into the difference between short run and long run dynamics again relied on the concept of complex, hierarchical systems.[19] As with his research on causality and identifiability, Simon started out with a system of variables that is nearly decomposable into subsystems. For reasons outlined previously, the interactions among the variables within a subsystem can be analyzed to a first approximation as though the links among the subsystems did not exist. Furthermore, interactions can be confined to different hierarchical levels, with the links among the variables within a subsystem represented by an index and the interactions among the indices representing subsystems may be evaluated without regard to the links within each subsystem. Simon further established that in the short run each subsystem can be studied (approximately) independently of the other systems and that in the long run the system can be studied by aggregating the variables of each subsystem into indices.

Finally, the conceptual framework of complex, hierarchical systems was extended in Simon's serial symbol processing hypothesis to cognitive psychology and artificial intelligence. In cognitive psychology, Simon's earlier argument that analyses of intermediate subsystems could be carried out without reference to the lower subsystems is reflected in his focus on the architecture of the mind at the symbolic level.[20] Specifically, Simon constructed a theory of the architecture of the mind and the characteristics of that architecture at the symbolic level in the absence of any but a very incomplete and primitive theory of how these symbolic processes were implemented by neuronal structures. Recall that Simon had earlier postulated that boundedly rational agents who find themselves in a complex, hierarchical system divide goals into subgoals, employ heuristics, and satisfice. In artificial intelligence, these same ideas enabled the development of simple problem solving procedures for computers.[21] In particular, they suggested that machines could be programmed to solve problems without specifying the solution for every class of problem in detail and that tasks could be divided into independent, hierarchically ordered subtasks. The result was a step-by-step, serial search through a vast problem space of possibilities, with each step guided by a heuristic rule of thumb. Moreover, his embrace of theories of the middle level led Simon to promote the resulting computer programs as tools for simulation.[22]

Branching from political science to management theory to economics to cognitive psychology to artificial intelligence, Simon saw complex, hierarchical systems everywhere. For Simon, these can be partitioned into suborganizations, subgoals, subsets of equations and variables, and subtasks. The subsystems in the middle consist of middle management, short run dynamics, the architecture of the mind at the symbolic level, and computer simulations of problem solving.[23] Heuristic rules of thumb guide managers, organizations, economic agents, human problem solvers, and computers. Moreover, each of these members of Simon's loosely coupled systems employ a satisficing strategy.

Whereas Simon saw complex, hierarchical systems everywhere, he also simultaneously conceptualized his own science as such a system (Simon, 1989b; 1991a: 368–87). The supposed near decomposability of this system allowed him to branch out in many diverse directions. However, this also left him the victim of unintended consequences and subverted intentions, perhaps because the bounded rationality of his audience prevented it from comprehending his science as a complex, hierarchical system. Although Simon himself could see the continuity in his scientific career, those less prone to cross scientific borders were more likely to observe discontinuities, as will be elaborated in the next section.

Discontinuities in Simon's contributions

Simon started out his career criticizing the theoretical outlook in political science and management theory (Simon, 1997a). He initially sought to supply much-needed in-depth empirical studies to a field infatuated with theory. Yet, his resulting contribution eventually still lay within the classical tradition in organization theory of observation, experience, and reflection, as he himself acknowledged (Simon, 1991a: 59n). Despite his expressed conviction that systematic observation and experimentation were badly needed in order for organizational theory to become scientific, Simon admitted that he often relied on facts derived mostly from commonsense observation and experience (p. 73). To be sure, Simon did apologize for this, arguing that a satisfactory theoretical framework was needed before the direction of empirical studies could be determined. Instead of supplying such studies in political science, though, Simon moved on to another subsystem.

In economics, Simon eloquently chided the failures of neoclassical economics and game theory, as elaborated in the next section.[24] Instead, he would seek to develop a much-needed alternative in the form of bounded rationality (Simon, 1982a, b; 1997b). Yet, Simon gradually withdrew from boundedly rational decision making in economics and left the alternative at the mercy of mainstream economists, who have instead used it in an attempt to strengthen neoclassical economics (Sent, 1998d; 2004a). For instance, rational expectations economists sought to reinforce the rational expectations hypothesis by focusing on convergence to this equilibrium through boundedly rational "learning". They have also used bounded rationality to deal with some of the problems associated with rational expectations, such as multiple equilibria and the computation of equilibria (Sargent, 1993; Sent, 1997; 1998a, b). Similarly, game theorists have sought to save the rationality of the Nash equilibrium by incorporating limited versions of bounded rationality. In particular, they have used bounded rationality to select among multiple equilibria, rule out unintuitive equilibria in the prisoner's dilemma game, and circumvent no-trade theorems (Sent, 2004a).

Moreover, many of the specific mathematical results of the self-avowed critic of neoclassical economics have repeatedly been used in an effort to strengthen neoclassical economics. For instance, some have argued that the papers by Emile Grunberg and Franco Modigliani (1954) and Simon (1954a) on the harmlessness of self-fulfilling public prediction were precursors to the general concept of rational expectations (Hands, 1990). In fact, Simon (1982d: 608) himself has acknowledged the connection between his own work on public prediction and the subsequent rise of rational expectations economics. Similarly, Simon's (1956b) introduction of certainty equivalence[25] facilitated attempts by new classical economists to link linear prediction and linear optimal control techniques (Sent, 1998b). Also, Simon (1979c: 505) himself has noted a close connection between his work on certainty equivalence and new classical economics.

Finally, Simon was one of the pioneers of the serial symbol processing hypothesis in cognitive psychology and artificial intelligence (Newell and Simon, 1972). Specifically, Simon's general-purpose computer model of human cognition sought to capture much of what went on in human problem solving (McCorduck, 1979). Yet, gradually, this interpretation of artificial intelligence has come under increasing attack because of its controversial use of symbols with propositional content.[26] For example, where do the symbolic concepts themselves come from? And, how do they evolve and grow? Or, how are they molded by feedback from the environment? Instead of trying to answer such philosophical questions, a newer generation of artificial intelligence researchers has moved away from symbol processing towards adaptive computing systems that simulate intelligence through neural networks, genetic algorithms, or classifier systems.[27] In their focus on connectionism and parallelism, this research is generally set in opposition to the contribution by Simon.

Conceptualizing his own science as a complex, hierarchical system, Simon constantly moved from one disciplinary subsystem to the next. For example, he came to the University of Chicago with the intent to major in economics, but left with a political science degree. The hurdle here was Simon's unwillingness to satisfy the accounting requirement accompanying the economics major. Simon came to the Cowles Commission as a critic of the rationality postulate in neoclassical economics, but gradually withdrew from his interest in boundedly rational decision making as a result of frequent visits to the RAND Corporation. Simon had been invited to work on decision making in organizational theory at RAND, but slowly shifted to focus on problem solving mediated through cognitive science.

Situating Simon's contributions within economics

What connected Simon's ventures into the different disciplinary domains was a search for complex, hierarchical systems. From this perspective, Simon (1998) criticized the four basic assumptions of neoclassical economics: (1) the presupposition that each economic agent had a well-defined utility or profit function; (2) the idea that all alternative strategies were presumed to be known; (3) the assumption that all the consequences that follow upon each of these strategies could be determined with certainty; and (4) the presumption that the comparative evaluation of these sets of consequences was driven by a universal desire to maximize expected utility or expected profit. For Simon, these four assumptions clashed with insights from psychology that there were external, social constraints and internal, cognitive limitations to decision making, upon which he based the opposing assumptions of his bounded rationality program.

Simon argued that, first, the bounded rationality program assumed that decision-makers were confronted by the need to optimize several, sometimes competing, goals. Second, Simon's bounded rationality program postulated a process for generating alternatives. Third, Simon argued that individuals mostly applied approximate solutions to problems. Finally, Simon's bounded rationality theory proposed a satisficing strategy, which sought to identify, in theory and in actual behavior, procedures for choosing that were computationally simpler and argued that individuals picked the first choice that met a preset acceptance criterion.

Partly due to his explicit efforts to distance himself from the mainstream, Simon's insights never caught on in economics "proper." Disillusioned, he left the Graduate School of Industrial Administration at Carnegie Mellon University in the 1970s for the psychology department at the same institution, noting: "My economist friends have long since given up on me, consigning me to psychology or some other distant wasteland" (Simon, 1991a: 385). However, psychology is no longer considered a distant wasteland, partly because later contributions to behavioral economics situated themselves squarely within the mainstream (Sent, 2004b). Whereas Simon started from a conviction that neoclassical economists were not all that serious about describing the formal foundations of rationality while he was, the more recent contributions to behavioral economics rely on the insights from Kahneman and Tversky that use the rationality assumption of mainstream economics as a benchmark from which to consider deviations (Heukelom, 2014). In addition, the mathematical difficulties encountered by mainstream economics facilitated not only the incorporation of psychological insights, in general, but also encouraged efforts to integrate some bounded rationality, in particular, into mainstream models to deal with problems such as multiple equilibria, no-trade theorems, and so on (Sent, 2004b).

Concluding comments

This paper has explored the continuities and discontinuities in Simon's science. Yet, there is certainly room for improvement. For instance, it is noteworthy that Simon has collaborated very extensively throughout his scientific career. Furthermore, he has been affiliated with many powerful scientific institutions and societies. Although this paper has touched on some of this, following Simon in his focus on individuals has kept it from a thorough appreciation of the rich detail of Simon's social interactions. Moreover, in stressing the centrality of scientists for complex, hierarchical systems, this paper has, in effect, placed them in the middle of the hierarchy. For, if it had not done so, there would have been little reason within Simon's theory of complexity for the focus on them as objects of explanation. Hence, ironically, it has tended to put them on an equal footing with middle management, and not with the CEO or entrepreneur, or the assembly-line worker or the laboratory technician.

Simon himself has explicitly applied his views concerning science to his own science. Not too surprisingly, he found a fixed point in which his own predictions were self-fulfilling. In his autobiography, Simon (1991a: 386) described the application of his insights concerning simulations of science to his own science, as follows: "Not only does it predict (explain) my behavior successfully, but . . . it has provided me for fifty-three years with a reliable set for conducting research." At the same time, it does not seem to have helped much in gaining a lasting influence in the various disciplinary domains through which Simon traveled, including economics.

Notes

1 See Simon (1992e: 574, 576; 1993: 644-6).
2 Also see Boumans (1998: 77, 79), Mirowski (1998: 21–2), and Simon (1960: 40–3; 1973b: 5, 27; 1996a: 184).
3 Also see Simon (1996a: 184): "[C]omplexity frequently takes the form of hierarchy . . . "
4 Also see Cohen (1995: 185–6) and Simon (1973b: 27; 1996a: 7–8).
5 Also see Mirowski (1998: 18–22) and Simon (1973b; 1989b: 385–6; 1996a: 183–216).
6 See Simon (1996b: 83): "[W]hat is important about nearly decomposable systems is that we can analyze them at a particular level of aggregation without detailed knowledge of the structures at the level below." Also see Simon (1973b: 11–15; 1996a: 198, 216).
7 In addition, near decomposability applies to the horizontal relations among subsystems as well: "The loose horizontal coupling permits each subassembly to operate dynamically in independence of the detail of the others" (Simon, 1973b: 16).
8 See Simon (1960: 40): "An organization can be pictured as a three-layered cake. In the bottom layer, we have the basic work processes . . . . In the middle layer, we have the programmed decision-making processes . . . . In the top layer, we have nonprogrammed decision-making processes . . . "
9 As a result, Simon's (1996a: 28) insights "have been applied mainly to business decisions at the middle levels of management." Also see Simon (1973b: 3).
10 See Simon (1960: xi, 47; 1997: 21, 28, 167, 173–4).
11 See Simon (1998: 266): "Bounded rationality . . . is deeply concerned with the ways in which the actual decision-making process influences the decisions that are reached."
12 In contemporary economics, the mainstream approach is known as neoclassical economics.
13 See Sent (1998d, e) and Simon (1982a, b; 1997b).
14 See Simon (1996a: 25): "[A]n intelligent system's adjustment to its outer environment (its substantive rationality) is limited by its ability . . . to discover appropriate adaptive behavior (its procedural rationality)."
15 Please note that this argument is not related to the distinction between microeconomics and macroeconomics. As noted by Simon, the distinction here is between outer environment (or substantive rationality) and inner environment (or procedural rationality). Also see note 17.
16 See Simon (1953). Also see Boumans (1998: 82), Mirowski (1998: 20n), and Simon (1989b: 386).
17 According to Simon (1953: 66), one can "decompose the system into complete subsets of equations of various orders . . . "
18 See Simon and Ando (1961). Also see Boumans (1998: 83) and Simon (1996a: 198).
19 See Simon and Ando (1961: 111): "Such a system can be represented as a superposition . . . [that] separates short-run from long-run dynamics . . . "
20 Simon (1993: 644) wanted "to characterize most of the higher-level and complex cognitive phenomena at the symbol level, rather than attempting to describe it all solely in neuronal terms." Also see Simon (1991a: 328; 1996a: 80–3).
21 See Mirowski (1998: 17–19) and Simon (1960: 19; 1973b: 6; 1991a: 328; 1991b: 146; 1996a: 13–15). In fact, when Simon's first computer program did not employ heuristics, he designed a new program that did operate as a search system within heuristic search spaces.
22 See, for example., Simon (1996a): "Because of its abstract character and its symbol manipulating generality, the digital computer has greatly extended the range of systems whose behavior can be imitated. Generally we now call the imitation 'simulation' . . . " (p. 13). Simon continued: "Simulation can be of . . . help to us when we do not know very much initially about . . . the inner system" (p. 15).
23 Simon (1991a) further sometimes saw himself as a subsystem in the middle in his personal life: "It even occurred to me that the mediating role I had sometimes played as a boy, when misunderstandings arose between my mother and grandmother, was not wholly unlike the role of the foreman as 'man in the middle' between blue-collar workers and management" (p. 73).
24 Though initially developed as an alternative to neoclassical economics, game theory has become part of the mainstream. Interestingly, Simon and contemporary game theorists share much criticism of earlier incarnations of game theory (see Sent, 2004a).
25 Certainty equivalence, sometimes called the separation principle, permitted the separation of the maximum problem facing an agent into two parts, an optimization or control part and a forecasting part. It is applicable when the objective function is quadratic, the constraints are linear, and the noise is Gaussian.
26 See, for example, Churchland and Churchland (1990), Dreyfus (1972; 1992), Dreyfus and Dreyfus (1986), Flores and Winograd (1986), and Searle (1980, 1990).

27 See, for example, Anderson and Rosenfeld (1998), Crevier (1993), Nadel et al. (1989), Rumelhart et al. (1986), and Sent (1998c).

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