ABSTRACT

CHRISTIAN, LEA ANNE. Metaphors in Decision Science: An Analysis of an Argument. (Under the direction of Steven B. Katz.)

This research examines how computational metaphors function in building a scientific theory. Herbert A. Simon's The New Science of Management Decision was chosen for study. Two methods of analysis were used: a metaphor analysis, which focuses on the metaphors and determines how they are functioning, and an argument analysis, which focuses on the way the scientist builds an argument using grounds, warrants, and claims. The metaphor analysis revealed the transference of one system (a computer system) to an abstract system (human thinking) through rhetoric. The argument analysis revealed that the metaphors act as warrants, grounds and claims within the argument, resulting in a complex theory based on computational metaphors. The argument analysis also includes Toulminian diagrams to illustrate Simon's argument. This study discusses the social nature of the scientific method and illustrates the role of metaphor in science, concluding with recommendations for future research.

METAPHORS IN DECISION SCIENCE: AN ANALYSIS OF AN ARGUMENT

by

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For Daniel,
my wonderful brother.

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Chapter 1: Introduction

Although many people do not view science as rhetorical, in recent years several scholars have examined the role that rhetoric does play in science (e.g., Bazerman, Fahnestock, Gross, Halloran and Bradford). As a part of this research, many have focused their work not only on the role of persuasion in science, but more specifically on the way metaphors function in scientific theory (Boyd, Black, Kuhn, MacCormac). According to Max Black, metaphors should be reserved for "just those cases where there can be no question as yet of the precision of scientific statements." This perspective, while acknowledging that metaphors exist in scientific rhetoric, still asserts that metaphors do not define an objective "truth" or discovery; rather, metaphors merely guide scientists heuristically toward "precise truth."

But while many agree with this view, other scholars contend that metaphors are not only heuristic but "theory-constitutive"; as Richard Boyd says, "there exists an important class of metaphors which play a role in the development and articulation of theories." Further, not only do metaphors define these developing theories, but they provide what Boyd calls "epistemic access," or ways of revealing areas of knowledge that explain causal relationships in science. However, metaphors may not only reference reality. As Kuhn points out, they may also define our perception of what is real. Because the idea that metaphors not only provide "epistemic access" but also could construct "reality" through other metaphors, it becomes important to examine how metaphors are functioning in scientific theory.

To investigate this issue I will draw from two areas of research: one, past and present theories on the functions of metaphor, and two, current views on the nature of scientific arguments. By using two types of analyses I will investigate this fundamental question: how do metaphors function in building scientific arguments? In answer to that question, I hypothesize that scientists' arguments are built through the metaphors that they choose, either consciously or subconsciously. These metaphors not only provide "epistemic access," but also create bases for scientific paradigms (sets of assumptions or models of reality). Within argumentation, as Toulmin, Rieke, and Janik note, there are assumptions (called warrants) that build a bridge between the grounds (data) and claims (hypotheses) of theories; when analyzed and examined, they tend to reveal something about scientists' paradigms. Thus, if metaphors can act as warrants for a theory, they invoke or imply a relationship that is accepted as real (Turbayne).

Method

To explore my hypothesis, I use two methods of analysis: one, a metaphor analysis, focusing on the metaphors used (both explicitly and implicitly) in scientific theory and what they reveal about a scientist's paradigm, and two, a Toulminian analysis, which reveals the argumentative method.

A metaphor analysis seeks to determine how metaphors function within scientific theory. While metaphors may reference other areas of knowledge, Boyd asserts that metaphors also "cut the world at its joints," and by doing so, define underlying causal relationships. Further, even if metaphors do not cut the world at its joints, they can provide bases for scientific paradigms. To support the notion that metaphors create scientific paradigms, it is important to examine a scientific theory to see how the metaphors are functioning. In this analysis I focus on several metaphors that Simon uses to explain his theory, and define and discuss these metaphors outside the context of his theory, also considering the implications of their use.

An argument analysis, according to Stephen Toulmin, focuses on how scientific arguments are logically constructed. In the case of science, this point becomes crucial as many, in accordance with the empirical view of science, believe that scientific theory explains causal relationships. In this analysis I examine, through Toulminian diagrams, the location of the same metaphors analyzed in the metaphor analysis. Further, while discussing the implications of using these metaphors within his argument I also note how, in some cases, the metaphors cycle among the grounds, warrants, and claims.

Description of Project

To investigate how metaphors can act as warrants, I analyze the first edition of Herbert A. Simon's <u>The New Science of Management Decision</u>. Because Simon's work continues to influence many in organizational theory and is widely cited in management texts, it is important to study the metaphors that he uses. A well known professor and computer scientist, Simon uses much computer terminology to present his ideas. Just as cognitive psychologists have built a paradigm of thought about the mind by using terms such as "feedback," "information processing," and "programming," Simon too has built a paradigm of thought about managerial decision making through his computational metaphors. Through these analyses I plan to show how the warrants of his theory are based on these metaphors, and as Boyd would say, ultimately cut the organizational world at it joints. By examining his metaphors and discussing their role in scientific arguments, this thesis contributes to a growing awareness of the role of rhetoric not only in decision science, but in management literature as well.

Thesis Organization

This thesis is organized into five chapters: the introduction, the review of literature, the metaphor analysis, the argumentative analysis, and the conclusion. Chapter two surveys relevant literature on the role of metaphors in scientific theory, and argumentative method. Chapter three analyses several crucial metaphors within Simon's <u>The New Science of Management Decision</u>, and chapter four discusses and illustrates Simon's argument using Toulminian diagrams. Chapter five summarizes and discusses the results of my analyses, concluding with the implications not only for these types of analyses but also implications for rhetoric, science, and organizational theory, noting recommendations for future research.

Chapter 2: Review of Literature

Many scholars have devoted much time to studying not only the role of rhetoric in science, but also how metaphors function in the development of scientific theory. Because their work is diverse and sometimes contradictory, this chapter reviews some of this relevant literature, briefly noting the social nature of science, the traditional literary view of metaphor, and most importantly, the role that metaphors can play in scientific theory. Current research on the computational metaphor and its influence in cognitive psychology and related disciplines is also included, as Simon often uses the computational metaphor to express his ideas. Additionally, because I assert that metaphors can function as the warrant for a scientist's argument, this chapter contains a brief look at argumentation in science.

The Social Nature of Science

While many in the scientific community argue that science is, by the nature of the scientific process, objective, and thus should be explained in the most "unbiased" terminology, there are those who contend that science is social by nature, and as such is necessarily rhetorical (e.g., Gross, Holton, Kuhn). These scholars assert that while science proclaims to have an "objective" scientific method, an element of subjectivity exists which cannot be overcome. This subjectivity is usually disguised in the choices that scientists make and the methods used, either consciously or subconsciously. While science functions under the pretext of being detached from experiments, the instruments, type of experiment, and process of observation invariably contribute to the subjectivity of the results (Heisenberg 53). And this subjectivity is then carried over as the scientist discusses results with other scientists, who agree or disagree with findings, emphasize one point over another, and eventually affirm or disregard the observed result.

Other scholars also support this perspective by emphasizing the role of rhetoric in science. Charles Bazerman notes that scientific writing is a "social act," limited by "human motivations, intentions, and actions" that hold many mysteries, rather than precise truths. As he notes, because a scientist cannot separate himself from his social conditioning to write an impartial account of observation, his perceptions will color the final text. Halloran argues that scientific communities can be bound together by the specific beliefs that they hold (ethos), and, more importantly, by the manner in which they express these beliefs through rhetoric (71). Thomas Kuhn notes that in the development of scientific theories, paradigms become crucial as they determine from what perspective the scientists are approaching their work, thus influencing not only what they are looking for but also what they finds. In other words, one must be predisposed to "see" something in order to "see" it. The increasing awareness of rhetoric, especially its role in defining what knowledge is, therefore makes the metaphor important.

The Metaphor: Fact or Figure?

The study of metaphor begins with Aristotle, who considered the general relationship between metaphors in language and their purpose in communication. He believed in what is now called the comparison theory of metaphors (based on the principles of analogy) which assumes understanding of one concept in terms of another. (For example, the sentence "Your words seem *hollow*" implies understanding "words" in terms of things that are hollow.) While the comparison view takes the literal paraphrase to be a statement of similarity, usually evidenced in analogies (Black 28), the substitution view of metaphor (as its name implies) regards the metaphor as replacing some type of literal explanation. These views are very similar in that one term is substituted for another (for example, "your eyes are the *windows* of your soul").

Aristotle believed that metaphors were ornamental in nature, and were essentially a device of the poetic imagination. During the Renaissance metaphors continued to be regarded as mere ornamentation in language, and any language which employed metaphors was considered "rhetorical." Thus, it became desirable to eliminate all figures and tropes from "objective" or "straightforward" language, leaving rhetoric to the world of poetry. The Baconian tradition is grounded in this idea: "one must free one's mind and one's language from the idols that inhabit them, so that reality may be impartially observed and accurately reported in a language that is transparent and unproblematic" (Bazerman 157).

Today there are many who still agree with the Baconian view of metaphors; as an example, while Black breaks out of the two "traditional" definitions of metaphor by introducing a third view of metaphor, he still basically agrees that a metaphor's role in theory is somewhat limited. In lieu of accepting either the traditional "comparison view" or "substitution view," Black proposes the "interaction view" of metaphor. Black explains this view by asserting that metaphors "project onto the primary subject a set of associated implications. . . that are predicable of the secondary subject" (28). As an example, Black considers "Marriage is a zero-sum game." He explains the interaction between "marriage" and "zero-sum game" this way:

> (G1) A game is a contest;
>
> (G2) between two opponents;
>
> (G3) in which one player can win only at the expense of the other. (30)

The interpretation of these statements "depends critically upon the interpretation given to "contest," "opponents," and "winning." Here the *context* of the association becomes important, as the metaphor forces the listener or reader to select properties and construct parallels that fit the primary subject; through these interactions the listener gains new insight. As he notes, "I think of a metaphorical statement (even a weak one) as a verbal action essentially demanding *uptake,* a creative response from a competent reader [or listener]" (29). Black also says that creative metaphors, especially in the cognitive disciplines, can give valuable insight into what is unknown, if the metaphors are "strong enough" to survive criticism. But as to their role in scientific theories, Black notes that these metaphors have a somewhat limited use: "we need the metaphors in just those cases where there can be no question as yet of the precision of scientific statements" (Boyd 357). So while we see the metaphor being acknowledged within the scientific environment, its role is restricted to comparing ideas rather than defining ideas. However, as Boyd also notes in his discussion of ostension (or reference-fixing), metaphors can provide a way of referencing natural things or phenomena. Therefore, they can provide an open-endedness that allow scientists to create new boundaries within a discipline: they can "cut the world at its joints" (Boyd 358).

The Metaphor in Science

However, current thinking challenges these ideas about the role of metaphors in scientific theory. While the scientific method may appear to merely observe facts, the theories stemming from these observations actually represent a very complex structure of information, created to persuade the listener logically. For example, Halloran and Bradford claim that: "Scrutinized closely, a theory more often than not turns out to be a figure of both thought and speech, pressed hard and elaborated in great detail" (180). Thus, these figures may become the foundation for the theory's structure, or model. While they note that often scientists work to eliminate ambiguity ("we must convey only <u>one</u> meaning"), embellishment ("the term must be straightforward and plain"), and especially an author's style ("scientific writing should have <u>no</u> personality"), in reality scientists are actually relying upon other established models to structure their observed information. As they say,

> Science, contrary to its own contentions, is not just the presentation of objective information gleaned from observation. No synthesis could ever be achieved, no models postulated, no paradigms established if science relied wholly upon "careful observation" for its theories. Model-building

> requires an inductive leap; carefully recorded examples must be synthesized into a logical premise, and then be further verified and expanded by traditional scientific method. For this, science must exploit the power of metaphor; it must shape its expectations, choose its experiments, and interpret its data in a realm of thought outside the literal world. (183)

Thus, while science claims to condemn figures and tropes of language, in actuality science must rely upon these figures to build arguments and persuade listeners.

Pylyshyn notes that the scientific metaphor is most useful in research, specifically in the "top-down" method. This method focuses on reducing a phenomenon step by step in order to gain a deeper, more general, and therefore more complete explanation of a phenomenon. For example, in order to explain how the brain "works," one could begin with a general theory, such as "the brain is similar to a computer," and then piece together the separate "parts" which contribute to this theory. Pylyshyn argues that this method operates in artificial intelligence and cognitive psychology theory, and thus creates a way for scientists to continue to search for precise truth, rather than creating categories of data (used in a bottom-up strategy) which often must be reconstructed or abandoned. He also distinguishes the extent to which metaphors invite certain kinds of further explication. Some metaphors act within a context in which no explicit definition is necessary. Others, however, are open to interpretation; "they make predictions possible without affording explanation." (In other words, these metaphors provide new analogies for consideration, and in doing so are open to interpretation.) It is the latter category, Pylyshyn believes, to which cognitive metaphors belong, noting the following:

> The difference between literal and metaphorical description lies primarily in such pragmatic considerations as (a) the stability, referential specificity, and general acceptance of terms; and (b) the perception, shared by those who use the terms, that the resulting description characterizes the world as it really is, rather than being a convenient way of talking about it, or a way

of capturing superficial resemblances. (434)

So while metaphors are primarily useful in research and may be perceived as a heuristic tool, Pylyshyn shows that within the cognitive disciplines they may also be an indication, or perception, of what is real.

Taking this view one step further is the work of Richard Boyd, who argues that metaphors function as a catachresis (i.e., using a wrong word within a context) in the development of mature sciences; in other words, they introduce terminology where none previously existed (357). In this way metaphors are not merely heuristic, but theory-constitutive. Further, "their success does not depend on their conveying quite specific respects of similarity or analogy. Indeed, their users are typically unable to precisely specify the relevant respect of similarity or analogy, and the utility of these metaphors in theory change crucially depends upon this open-endedness" (357). Boyd goes on to note that their use is one of many devices available to scientists to accommodate language to the causal structure of the world. "Cutting the world at its joints" is the metaphoric phrase Boyd uses to show how language represents the structure of reality, while coming closer and closer to the "truth" by introducing new terminology or categorizations.

Boyd also discusses the role of metaphor in ostension (reference-fixing). In theoretical terms, metaphors access already established knowledge in order to increase understanding of a particular thing or phenomenon. Boyd calls this referencing process "epistemic access," which shows the connection between a metaphor and a previously established "truth." As he notes, "the issue of reference for a general term is the issue of its role in making possible socially coordinated *epistemic access* to a particular sort of thing or natural phenomenon" (358). Through these socially coordinated, or accepted, references, scientists can create metaphors which allow new insight into a particular field. The idea of ostension becomes particularly important as this reference-fixing quality can be projected from a metaphor.

Colin Turbayne contributes another theory on the role of metaphors in science.

He notes, in tracing the scientific method, that "Descartes and Newton were victimized by their metaphors, victimized because they presented the facts of one sort as if they belonged to another, but without awareness. They were engaged in sort-crossing" (46). Turbayne isolates three types of sort-crossing in metaphors in his research: (1) the connections between principles and theorems assumed to be true because they had been passed down by their teachers; (2) the identification of physical explanation with causal explanation; and (3) the definition of science through measurable demonstration. These three cases represent sort-crossing through metaphors because each involves accepting "facts" in new situations as the "facts" applied in old situations without questioning or examining their relevance or application. As Turbayne argues, while the scientific method is successful, awareness of sort-crossing activity is also important. "Becoming aware of the presence of hidden metaphors in science, it dawns on us that there are other ways of viewing the world besides those that we inherit from the great sort-crossers of the past who, by their genius, hold us enthralled in just those attitudes that appealed to them" (56). Further, we must realize that we cannot replace metaphors with the literal truth; we can never become wholly aware of reality because we cannot get "outside" language to look.

A Metaphor's Paradigm

Thomas Kuhn discusses the role of metaphors in constructing models of reality, or paradigms. While he agrees (in some respects) with Boyd, Kuhn believes that metaphors can constitute paradigms, rather than merely categorize new developments. While Kuhn also notes that "metaphor plays an essential role in establishing links between scientific language and the world," (416) his basic premise is different. Boyd's work assumes that nature has but one set of joints to which evolving scientific terminology comes closer and closer with time. But Kuhn argues that the metaphors we use in describing reality can actually be truth: "What is the world, I ask, if it does not include most of the sorts of things to which the *actual* language spoken at a given time refers?" (418). Further, if our understanding of reality is essentially based upon metaphors referencing other metaphors, then our reality could be perpetually circular as we constantly define one thing in terms of another.

George Lakoff and Mark Johnson agree with this view, noting that while many would prefer to eliminate metaphor, in reality metaphor is very common in everyday life, not only in our language but also in our thoughts and actions. To support their idea they examine the metaphor "argument is war." While there are obvious expressions of this metaphor ("It's me *against* you" . . . "I'm *right on target*" . . . "He *shot down* my argument"), underlying this statement is an understanding of "argument" in terms of "war." On the contrary, a culture that understands argument in other terms (as Lakoff and Johnson say, in terms of dance) would have an entirely different concept of argument. Further, once a metaphor is accepted, it tends to unconsciously predispose us to use certain words and to think of things in certain ways. Lakoff and Johnson essentially argue that human thought processes are largely metaphorical; if this is true, the metaphors that operate in scientific theory represent a perceived conceptual reality, and therefore construct or constitute paradigms.

The Computational Metaphor

Because this study focuses on the use of computational metaphors in scientific theory, it is important to define these metaphors and discuss where and how they are used. Computational metaphors are generally found in the rhetoric of cognitive psychology and generally explain the nature of human thought; Richard Boyd notes the following examples:

1. the claim that thought is a kind of "information processing," and that the brain is a sort of "computer";
2. the suggestion that certain motoric or cognitive processes are

"preprogrammed";

3. disputes over the issue of the existence of an internal "brain-language" in which "computations" are carried out;
4. the suggestion that certain information is "encoded" or "indexed" in "memory store" by "labeling," whereas other information is "stored" in "images";
5. disputes about the extent to which developmental "stages" are produced by the maturation of new "programmed" "subroutines," as opposed to the acquisition of learned "heuristic routines," or the development of greater "memory storage capacities" or better "information retrieval procedures";
6. the view that learning is an adaptive response of a "self-organizing machine";
7. the view that consciousness is a "feedback" phenomenon. (360)

As Boyd notes, the prevalence of these metaphors "shows an important feature of contemporary theoretical psychology: a concern with exploring analogies, or similarities, between men and computational devices has been the most important single factor influencing postbehaviorist cognitive psychology" (360). Further, "computer metaphors have an indispensable role in the formulation and articulation of theoretical positions. These metaphors have provided much of the basic theoretical vocabulary of contemporary psychology" (361). Because these metaphors are used in this way, numerous scholars have examined computational metaphors to determine their function and influence in related disciplines (Boyd, Kuhn, MacCormac, Pylyshyn, Turbayne).

In looking at particular metaphors that simulate the human thought process, Pylyshyn argues that computational metaphors can be taken literally: "[they] apply just as literally to mental activity as [they] do to digital computers" (435). While this may be perceived as a radical approach, he notes (as does Boyd) that theory-constitutive metaphors are those for which no literal paraphrase is known. Therefore, because we have no other way of perceiving the workings of the human mind, this metaphor adequately explains what we cannot examine. However, while he acknowledges that these imprecise metaphors are essential to the top-down research strategy, in cases such as cognitive psychology acceptance of these computational metaphors can impose burdens for those in the field. As he notes, committing to these descriptions of mental activity implies a responsibility of awareness and constant pursuit of "ultimate explanatory terms" of what does occur in the human brain. However, Pylyshyn essentially sees no problem with accepting the computer metaphor for simulating the human thought process.

Contrary to Pylyshyn's opinion but also contributing to the study of the computational metaphor is the work of Earl MacCormac. He provides examples of the substitutive view of metaphor by examining the way humans are represented. He notes that the interpretation of the human mind and brain as a computer has simply replaced the 18th century view of "man as machine." Human beings, he says, have long compared themselves with technology, as evidenced by our admiration for clear, rational thinking unclouded by emotions. However, there is a danger in accepting the computational metaphor for our thought process; as MacCormac argues, accepting this metaphor literally (as Pylyshyn advocates) can enchant us into thinking that what these metaphors suggest really does exist, or lead us to assume that the attributes normally possessed by either referent are possessed in the same way by the other. He provides the example of computers "thinking" to show his point; the issue of whether or not computers "think" rests on our interpretation of what thinking really is, either linear (or computer-like) or haphazard. Further, not only do we accept these machines as models of human thought, but we also personify computers, perhaps evidencing again our admiration and acceptance of technology. This becomes especially important as we recognize the widespread familiarity of the computational metaphor symbolizing human thought. MacCormac concludes by advocating awareness of the computational metaphor for what it really is, rather than as a literal expression. "Forgetting the differences between men and machines dehumanizes man and personifies machines, thereby distorting both" (215). So MacCormac's implied theory of metaphor agrees with Kuhn's notion of metaphors creating paradigms, or ways of thinking: by viewing man as a machine, and concurrently personifying computers, we have defined ourselves and our reality.

Argumentation in Science

Although the role of the metaphor is the primary concern of this thesis, the method of argument also is important in order to see how Simon uses these metaphors. Scientific theories are not merely objective presentations of accumulated knowledge; they are arguments for or against particular ideas. As Perelman and Olbrechts-Tyteca note, "all argumentation aims at gaining the adherence of minds . . ." (14). These arguments are evidenced, in this case, in the scientific community. Further, and important to this discussion, "every social circle or milieu is distinguishable in terms of its dominant opinions and unquestioned beliefs, of the premises that it takes for granted without hesitation" (20). In the scientific community, established knowledge exists as unarguable fact or truth: "Facts are withdrawn, at least for the time being, from argumentation, that is to say, there is no need to increase the intensity of the adherence or to generalize it, and it requires no justification" (67).

However, most important is the social acceptance of "facts;" essentially, there are no facts other than socially accepted ones. Further, as long as "facts" are universally accepted, then there is no problem. But if doubts are raised within the audience to which it was presented, or if new members who carry different but equally sound facts enter the group, then the fact can lose its status. Hence, argumentative style becomes important as Perelman and Olbrechts-Tyteca note that a "considerable mass of elements that is compelling to the hearer or which the speaker strives to make compelling" (68) is necessary to convince the audience of validity.

They also note that presumptions that are established prior to argumentation play an important role in "setting up" the argument; presumptions are connected with what is "normal and likely," and without proof to the contrary, there is no question of their validity. But because they are often intertwined, distinguishing fact from presupposition often becomes difficult: "Agreement based on the presumption of the normal is supposed to have the same order of validity for the universal audience as agreement upon established facts and upon truths so that agreement on presumptions is often not easily distinguishable from agreement on facts" (73).

Given this research, which considers the importance of persuasion in argumentation, it becomes important to analyze specific arguments to see how scientists persuade their audience. Toulmin, Rieke, and Janik provide a method of analysis that involves distinguishing among grounds, warrants (and/or backing), and claims of an argument. Grounds are the already established information or knowledge gathered from scientific reports. As Perelman would say, the grounds are the "facts," accepted without further argumentation. Claims are the new hypotheses, ideas, or facts advocated by the theorist. The method used to leap from ground (A) to claim (B) is the warrant; they are "proven, valid" formulas or laws that authorize the connection between the (previously accepted) facts and the (new) conclusion. These warrants may be substantiated by what is called "backing" (or authority) and, once accepted, the warrant's reliability is usually no longer questioned (251).

Toulmin, Rieke, and Janik also make a distinction between "regular" and "critical" scientific arguments. A "regular scientific argument" is one in which "the goal of reasoning is to establish a factual conclusion by appealing to currently accepted scientific ideas" (249). A "critical scientific argument" is one that examines the "ways of arguing about our regular scientific ways of arguing" (256). In other words, scientists must constantly criticize and improve their own methods of arguing. As they say,

> The subject matter of critical scientific arguments, therefore, is not simply

> the objects, systems, and/or processes of the natural world, so much as *our theories about* those objects, systems, and processes. The immediate questions at issue in such arguments have to do not so much with nature itself as with the adequacy of our current ideas about nature. (256)

Thus, critical arguments examine the method by which scientists argue, which might question the validity of their facts, either by themselves or within a particular context. Further, presumptions acting as warrants can be critically examined for their own validity. This thesis, by examining Simon's metaphors and argument, represents a critical examination of theory.

As previously mentioned, Toulmin notes that agreement within the scientific community is crucial to a new theory's acceptance or dismissal; the "refereeing process" that new articles must go through, even to the point of their defense by others at conventions, shows that a scientist cannot simply propose a radical change in theory and expect acceptance of the idea. Instead, scientists rely greatly on systematic procedures to evaluate, question, and test new theories. And the role that facts or other presumptions play as warrants becomes a critical part of this process. As Rottenberg notes, "all our claims, both formal and informal, are grounded in warrants or assumptions that the audience must share with us if our claims are to prove acceptable" (142).

Implications of this research essentially call for examinations of how metaphors are functioning in scientific theory. More specifically, because of the influence of computational metaphors in disciplines other than cognitive psychology, it becomes important to analyze how these metaphors are used in explaining human thought. The following chapter provides a metaphor analysis of decision science, a science which was developed to aid organizational managers in understanding daily decision-making. Following the chapter on metaphor analysis is a chapter presenting Toulminian diagrams of Simon's argument, which highlight his metaphors and discuss how they are used.

Chapter 3: Metaphor Analysis

Herbert A. Simon's The New Science of Management Decision provides a good example of computational metaphors at work in building a scientific theory. Although it was published in 1960, and is only one of many articles and books published by Simon, his continual influence in public administration, organizations, and the classroom justifies a close look at his theory's language and argumentative method.

Essentially, The New Science of Management Decision illustrates Simon's justification for using the computer to simulate the human thought process. As Thomas L. Norton acknowledges in the book's introduction, Simon has been conducting research on the processes of decision-making, using electronic computers to simulate human thinking. He cites business problems that can be handled successfully by automated processes, and describes possibilities of automating nonrepetitive types of decisions. He also explores, in terms of organizational structure, employment opportunities, work satisfaction, and creativity, what the nature of business will be as changes in business decision-making take place. This thesis, however, concentrates on the metaphors used to explain fundamental aspects of his theory, rather than the general application of his work to organizational structure. Therefore, the reader will note that most analyses come from chapters one, two, and three of The New Science of Management Decision.

Simon acknowledges using explicit computational metaphors within his argument, as the reader will see in chapter four. By examining the metaphors that are used within his argument, this analysis seeks to demonstrate that the computational metaphors Simon uses constitute the basis or warrant of Simon's argument by transferring aspects of one system (computer technology) to another system (human decision-making).

Analyzing the Metaphors

"In accepting an analogy," Perelman says, "one subscribes to a certain choice of aspects which it is important to emphasize in the description of a phenomenon. At the same time, in criticizing an author, one is often led to oppose the analogies he uses" (119). While I do not claim to oppose Simon's proposed vision of the human mind (as it may be very well be the best that we have), I assert that it is important to discuss the implications of using mechanistic or computational metaphors to describe the brain's activity. Because it is impossible to examine every sentence or paragraph from The New Science of Management Decision, I have chosen several fundamental metaphors which are repeatedly used in his work, namely:

- Human Thought is a "Process"
- Decisions are "Programmed" or "Nonprogrammed"
- Decision Making is a "Skill" or "Technique"
- The Mind consists of "Mechanisms"
- Human Problem Solving is a "Search Activity Process"
- The Mind is a "Program."

The goal of this analysis is to define these metaphors and discuss the implications of using these metaphors to describe human thinking. The metaphors are presented within the context of Simon's presentation, citing specific examples of his terminology.

The reader will also notice a pattern while progressing through the analysis. As I will explore in chapter four, one metaphor often provides the foundation for building (or introducing) related metaphors, resulting in Simon's portrayal of the mind as a computer. At a fundamental level, his metaphors provide examples of Black's interaction view, in which the metaphors interact through a particular context. Simon does not merely compare likenesses between two systems; instead, one system is defined in terms of another. Hence the analogy has become an interchangeable description of two very different systems. Simon builds a system of human thought based on a metaphor (Lakoff and Johnson).

Human Thought is a "Process"

Central to Simon's argument is the perception of human thought as a "process": numerous times Simon refers to this metaphor as he describes various decision-making activities. As we see in his opening paragraphs, Simon provides common images of the decision-maker poised at the critical moment of making a decision: a gray-haired executive ready to vote "aye" or "nay" at a business meeting; a referee about to toss a coin; and an officer on horseback about to issue an order. However, Simon is not interested in this critical moment; rather, Simon is concerned with what he terms "the whole lengthy, complex *process* of alerting, exploring, and analysing" that precedes the final moment of decision [italics added].

Strictly defined, "process" means a series of actions, changes, or functions that bring about an end or result; additionally, and relevant to this discussion, within computer science terminology the word "process" means "performing operations on data." In terms of human thinking, Simon is viewing thinking as a mechanistic operation, in which humans "process" reality as data. Metaphorically, this term provides the foundation for Simon's theory; using the word "process" to describe what occurs in decision making implies some type of mechanistic pattern or sequence.

Exploring this metaphor further, we can examine the implications of the mechanistic sequence. Two types of sequence rapidly come to mind. In one case, the sequence or pattern could be understandably complex, with many different levels connected in various ways. Or in the second case, the sequence could be linear, in which one activity follows and is dependent upon another. Many would argue that the human brain is indeed very complex. But in order for a theory to logically explain how the brain functions, the theory must categorize (and therefore eliminate) many of the complexities for ease of understanding. Therefore, I would assert that implying that human thought is some type of linear "process" better fits Simon's needs.

Once Simon establishes the "process" metaphor, he calls this process "lengthy" and "complex"; here Simon transfers aspects of time or space (length) and degree of simplicity (complex) to an abstract system, that of decision making. On an even deeper level, using these terms to describe this "process" actually emphasizes the linear nature of this "process"; thus, Simon has reinforced the "process" aspects of one system (that of a lengthy, complex series) to an abstraction (what really occurs in decision-making).

Contributing to this metaphor, Simon introduces some of the "parts" that make up this "process:" Simon asserts that decision making includes three principal "phases." These include (1) finding occasions for making a decision, (2) finding possible courses of action, and (3) choosing among courses of action. He introduces metaphors for each of these "phases":

> The first phase of the decision making process — searching the environment for conditions calling for decision — I shall call *intelligence* activity (borrowing the military meaning of intelligence.) The second phase — inventing, developing, and analysing possible courses of action — I shall call *design* activity. The third phase - selecting a particular course of action from those available — I shall call *choice* activity. (2)

Within this excerpt there are numerous metaphors; on one level, isolating "phases" within decision-making again implies notions of time and linear structure (there are "phases" that decision makers pass through, as opposed to recursion). Further, applying the metaphors "intelligence activity," "design activity," and "choice activity" encourages the reader to accept more definitions relating to this "process." In the military, intelligence is synonymous with information; hence, if Simon borrows the military meaning of intelligence, then he is equating human intelligence with information processing. Using the metaphor "design" again implies a type of structure (possibly architectural) which could be changed or redesigned as necessary. And finally, the idea of choice between alternatives implies boundaries that would necessarily limit (and simplify) options. Even his arrangement of phases connotes and supports his notion of decision-making as a "process": in the initial phase, *information* is processed; in the second phase, solutions are *designed;* in the final phase, an alternative is *chosen.* Hence, if managers can identify these phases and, as needed, adjust them to fit their particular decision, then the percentages of successful decisions should increase, if success is defined in terms of this type of efficiency.

Simon also addresses the "structure" of information, thus contributing to his argument that the brain "processes" this information (or "data") as would a computer:

> Nowadays, with the advent of computers, we can think of information as something almost *tangible*; *strings of symbols* which, like strips of steel or plastic ribbons, can be *processed* — changed from one form to another. We can think of white-collar organizations as factories for *processing information* [italics added]. (5)

In this excerpt we can see Simon directly applying the computer metaphor to the idea of information; information is suddenly material and able to be manipulated. Thus information, from whatever previous medium it is received (sensory or otherwise) has been redefined in terms of how a computer manipulates and processes symbols. Also implied are the benefits of computer technology, evidenced in Simon's analogy between white-collar organizations and mechanical factories that "process" information.

Influencing Simon's ideas about human thought are experiments which attempted to examine what occurs in the brain during problem-solving. At the time this book was published, subjects within a laboratory were given problems to solve and asked to think aloud. Although these types of procedures are now somewhat questionable, the sessions were taped and from this information researchers hoped to gain insight about what the mind does during problem-solving. Simon explains this process in the excerpt below:

> From the tape-recording, we observe that the subject compares the theorem to be proved with some theorems he knows — he looks for similarities and differences. These suggest *subproblems* . . . Subproblems may,

> in turn, *generate* new subproblems, until he comes to a problem he can solve directly. Then he climbs back up to the next level of problems above. He gradually begins to *assemble* results that look as though they will contribute to the solution of the whole problem [italics added]. (23)

In this example Simon implies that problems are essentially structures which contain sets of subproblems. Further, these subsets are considered infinite, as they "generate" new sets of problems. Choosing the verbs "generate" and "assemble" also can imply computer-like activity; within computer science, "generate" refers to producing (or printing) a program by instructing a computer to follow given parameters which act as a skeleton structure. The verb "assemble" implies mechanically putting together individual or groups of parts to complete a whole structure. By using these terms as a description of how problem-solving actually "works," Simon has constructed a structural pattern which, while infinite and still partially unexplained, is also computer-like.

Using these verbs to describe human activity contributes to the one-dimensional model that Simon has created. From this description of actual observation Simon provides an example of metaphor sort-crossing, which has in turn affected his choice of verbs. Simon has chosen verbs to metaphorically describe thought processes from the realm of computer technology, and the connection which he assumes is not only metaphorical, but real, and thus not needing proof.

Decisions are "Programmed" or "Nonprogrammed"

Also crucial to Simon's position are the metaphors "programmed" and "nonprogrammed," which he uses to describe types of decisions. While he notes that these two types represent ends of a continuum, decisions still can be categorized according to these classifications. Decisions are "programmed," he says, "to the extent that they are repetitive and routine, to the extent that a definite procedure has been worked out for handling them so that they don't have to be treated *de novo* each time they occur" (6).

Decisions that are considered to be novel, unstructured, or consequential are considered "nonprogrammed." Simon offers the following explanation for his choice of terminology:

> I have borrowed the term *program* from the computer trade, and intend it in the sense in which it is used there. A *program* is a detailed prescription or strategy that governs the *sequence of responses* [thinking] of a *system* [mind] to a *complex task environment* [reality]. Most of the *programs* that govern organizational response are not as detailed or as precise as computer programs. However, they all have the same intent: to permit an *adaptive response* of the *system* to the situation [italics added]. (6)

While on one level Simon has acknowledged his use of computer terminology ("program," "sequence of responses," "system," "complex task environment," "adaptive response"), on a deeper level there are greater impliciations of these explicit metaphors. Fundamentally, Simon has identified decision-making with computer programs, drawing an analogy between an abstraction and an instruction procedure coded for a computer. As I noted above, thinking is a "sequence of responses" (stimulus - response, which could be linear), the mind is a "system," and reality is a "complex task environment." Exploring these terms even further, the word "complex" implies a conglomoration of different but discernable parts. "Task" brings to mind an objective, well-defined piece of work, which must be completed (usually within a sequence) to gain sucess. Also implied is a biological or ecological dimension -- that of the computer as an organism which responds to the environment. The substitutive metaphor "program" ties all of these characteristics to the abstract system of human thinking.

As Perelman says, "every analogy highlights certain relationships and leaves others in the shadows" (119). By emphasizing aspects of decision making with the computer metaphor, Simon imposes a linear system onto another system; programs, according to Simon, are a sequence of responses within a system, whose purpose is to adapt to a complex task environment. Because we logically know that decision-making seeks to improve and adjust to various situations, then to Simon it seems appropriate to apply computational metaphors to this abstraction. De-emphasized are issues regarding intuition, judgment, or coincidence. In this excerpt Simon has emphasized the nature of programming in order to justify using the metaphors "programmed" and "nonprogrammed" for decisions. As Turbayne would note, these substitutions represent sort-crossing, as the definitions of two different systems become unrecognizable when one is literally defined in terms of another.

Continuing to build upon his analogy, Simon introduces other metaphors as he describes "nonprogrammed" decisions. As he says, while nonprogrammed decisions have no specific "procedures" to deal with impending situations, they can fall back on a general "capacity" for intelligent, adaptive, problem-oriented action. Further, this general problem-solving "equipment" is not always effective, either within individuals or within organizations. All of these metaphors add to Simon's mechanical image, which is composed of "processes," "procedures," has "capacities," and is "equipment" of human thought. Although earlier he mentions that nonprogrammed decisions address novel, unstructured decisions, he de-emphasizes the unique aspect by asserting that these decisions can still fall back on "equipment" for aid. Other aspects (or metaphors) of decision-making, such as "imagination" or "creativity" could be substituted in place of "equipment," but they are not part of Simon's mechanistic model of human thought. Instead, Simon continues his computer analogy by his choice of terms, programmed or nonprogrammed, (either consciously or subconsciously), when discussing exceptions within his model of decision making.

Decision Making is a "Skill" or "Technique"

Because Simon has already established that decision making is a "process," and additionally one that is either "programmed" or "nonprogrammed," he logically builds upon this metaphor by saying that decision-making is a "skill" that can be learned and developed. As he says, "The *skills* involved in intelligence, design, and choosing activities are as learnable and trainable as the skills involved in driving, recovering, and putting a golf ball" (4). One could reasonably conclude from this sentence, then, that learning the skills of decision-making would not be difficult; it becomes a matter of mastering technique or, in this case, mastering the series of programmable instructions. Further, Simon also says that the skills needed to design and maintain the modern decision-making organization are less intuitive skills: "Hence, [these skills] are even more susceptible to training than the skills of personal decision making" (5). Thus, not only are these skills learnable, but they are relatively simple as well. Again we see Simon building an image of decision making as an operating structure, easily taken apart and mastered by improving simple skills.

To support this notion of "skill" that is involved in decision making, Simon briefly looks at the history of traditional decision-making methods, or "techniques," which handle the two types of decisions. As he says, "We shall consider, in turn, *techniques* for making programmed decisions and *techniques* for making nonprogrammed decisions [italics added]" (9). On a fundamental level, Simon's use of the term "techniques" implies a systematic, masterable procedure through which a task is accomplished. Also implied is the previously mentioned idea of skill; if decision making is composed of skills, then there must be ways to improve these skills through appropriate "techniques."

Simon notes that traditionally organizations have focused on established "techniques" for improving human performance in organizations: "Mankind has possessed for many centuries an impressive collection of *techniques* for developing and maintaining predictable programmed responses in an organization to those problems posed by its environment that are relatively repetitive and well-structured [italics added]" (10). In particular, Simon is referring to the scientific management movement, in which Frederick

Taylor precisely timed human movements (while performing one particular skill, such as shoveling dirt) in order to establish the quickest and most efficient manner of completing tasks. As we know, the scientific management method has since been criticized for its "mechanistic" approach to managing workers. However, its contributions are valuable for establishing performance standards within organizations. Noting this method supports Simon's terminology by showing that others have also recognized the value of streamlining routine aspects of work.

Simon also discusses traditional "techniques" for nonprogrammed decisions. As he notes, in the past managers have not been able to isolate how managers make these decisions; they usually "exercise judgment." But exercising judgment, in Simon's view, is not a sufficient aid for teaching another how to master this "technique;" it is not a tangible "process" which can be isolated and therefore improved. Hence, we need something that will enable others to learn to deal with nonprogrammed decisions. To fill this need, Simon breaks down the psychological thought "process":

> One thing we have known about nonprogrammed decision making is that it can be improved somewhat by training in *orderly thinking.* In addition to the very specific habits one can acquire for doing very specific things, one can acquire the habit — when confronted with a vague and difficult situation — of asking, "What is the problem?" We can even construct rather generalized *operating procedures* for decision making. The military "estimate of the situation" — a checklist of things to consider in analysing a military decision problem — is an example of such an operating procedure. [Further] there is nothing wrong with such aids except that they don't go far enough [italics added]. (12)

Within this excerpt is the underlying implication that while nonprogrammed decisions do not yet have specific "techniques" to address their uniqueness, there is a basic structure that can be used to initiate solutions. Again Simon has fallen back upon a methodical and systematic arrangement as an aid; training in orderly thinking implies that a linear, logical thinking pattern will be of greater use than a haphazard, creative, or some other approach. Further, developing "operating procedures" for nonprogrammed decisions implies a structural pattern which can effectively be duplicated and function as needed. So while nonprogrammed decisions do not have specific methods to aid in their solution, there are structured approaches that can be used to turn the nonprogrammed decisions into programmed ones.

Within the context of programmed decision-making, Simon also discusses the notion of "design," advising the reader to note various important aspects of what he considers good "operating procedures":

> Appropriate design of the organization is important for nonprogrammed, as it is for programmed, decision-making. An important principle of organization design that has emerged over the years has been called facetiously "Gresham's Law of Planning." It states that programmed activity tends to drive out nonprogrammed activity . . . The organizational implication of Gresham's Law is that special provision must be made for nonprogrammed decision-making by creating specific organizational responsibilities and organizational units to take care of it. (13)

Through these paragraphs the reader can see that Simon uses the idea of "design" (which can be defined as the invention and disposition of the forms, parts, or details of something according to a plan) to fit his one-dimensional view of decision-making. Further, using this law not only uses emphasizes the metaphors "programmed" and "nonprogrammed" in describing decisions, but also implies that routine, structured problems and solutions tend to "crowd out" novel or unique ones. This implies that, left to organizations, programmed solutions are preferred over nonprogrammed solutions. While I do not argue with the law itself, using this law supports Simon's underlying bias that structured decisions are somehow superior to unstructured decisions, and therefore we should strive to create (or design) some type of structure for nonprogrammed decisions. This is evidenced by the last sentence in this excerpt: "special provision must be made for nonprogrammed decision making by creating specific organizational responsibilities and organizational units to take care of it" (13).

The Mind is a "Mechanism"

Building upon the "process" metaphor is Simon's use of the metaphor "mechanisms" to describe the "operative parts" of decision making. As Simon notes, while much progress has been made in analyzing organizations, there is relatively little insight into how the thought "process" actually works: "the progress that was made did not enlarge the repertory of basic *mechanisms* to which I shall refer [italics added]" (9). With this metaphor of the mind as a "mechanism" Simon implies an arrangement of connected parts in the brain that operate like those of a machine. Further, because decision making can be broken down into parts or mechanisms, then they are similar to and could be duplicated by a computer.

As a specific example, Simon focuses on habits as one "mechanism" of human thought. As he says, "The only difference between habits and *standard operating procedures* is that the former have become internalized — *recorded* in the central nervous system — while the latter begin as formal, written, recorded *programs* [italics added]" (10). Through this analogy we not only note the surface distinction between habits and standard operating procedures (as noted by Simon), but we also see a bias in his description of habits (they are "recorded," as are symbols in computer memory) and standard operating procedures (they are "programs"). Hence, while Simon implies that substituting the phrase "standard operating procedures" for "habit" is relatively simple, it means that the reader should assume that habits are symbolic code (easily duplicated by a computer) and that standard operating procedures can be easily developed from this code.

This distinction becomes important as it contributes to his claims about organizational structure:

> Organization structure, over and above standard operating procedures, is itself a partial *specification* of decision-making *programs*. The organization *structure* establishes a common set of presuppositions and expectations as to which members of the organization are responsible for which classes of decisions; it establishes a structure of *subgoals* to serve as criteria of choice in various parts of the organization; and it establishes *intelligence responsibilities* in particular organization units for scrutinizing specific parts of the organization's environment and for communicating events requiring attention to appropriate *decision points* [italics added]. (10)

In unraveling the above description of the organizational structure, one sees that Simon essentially breaks down organizations, like the mind itself, into various "programs" (to borrow his metaphor), each establishing a sequence of instructional rules about decision-making. Further, these programs not only establish these rules, but they also survey the environment (much like a radar?) in order to detect problems that need correcting.

Again, this leads one to believe that the organizational structure (like the mind), when functioning normally, is essentially a conglomeration of various programs, some routinely operating while others scan the horizon for difficulty. Again, through this analogy Simon has transferred the structure of computer programs to another phenomenon. Whether it be organizational structure, human thinking, or anything else, Simon understands these concepts in terms of their defining structure, or mechanisms. This understanding is presented to us through his metaphors.

Human Problem-Solving is a "Search Activity Process"

Supporting the idea of human thought as a "process," Simon addresses what he considers a major void left by programmed decision-making techniques; as he notes, while there have been great developments in techniques for programmed decision-making, they "still leave untouched a major part of managerial decision-making activity" (21). Hence, Simon sees a need for developing techniques to aid nonprogrammed decision-making. In order to develop these techniques, he returns to the basics; although he says that current research is far from complete, there have been fundamental discoveries made about the nature of human problem solving. Simon cites the following as examples:

> We know, for example, that problem solving involves a great deal of *search activity* of one sort or another, that it often uses abstraction and imagery, that small hints can have dramatic effects on the ease of solution of a problem, and so on. But all the *processes* observed in problem solving — particularly the *search activities* and the use of relatively obvious *perceptual clues* — appear so simple that we do not believe they can account for the impressive outcomes . . . Little wonder that we invent terms like "intuition," "insight," and "judgment," and invest them with the mystery of the whole process [italics added]. (23)

From this excerpt the reader will notice a couple of things. On a metaphorical level, Simon uses the terms "search activity" and "perceptual clues" to comprise the whole thought "process." Using the metaphor "search activity" implies some type of exploring mechanism which would thoroughly investigate decision alternatives. And the notion of the brain responding to "perceptual clues" indicates a system triggered by signals which would guide or direct the person toward a solution of the problem. Both imply parts of the overall system; one acting as a radar, and the other acting as a stimulus. Further, by comparing these metaphors with the "mysterious" connotations of the terms "intuition," "insight," and "judgment," Simon implies that the computer metaphors are more specific and therefore can more accurately describe what occurs in the human mind.

The Mind is a "Program"

One of Simon's most frequent metaphors, used both explicitly and implicitly, is that the human mind is a "program." It is implied in his distinction between "programmed" and "nonprogrammed" decisions and in his explanations about how particular "processes" in the human brain work. Because many people quickly object to the idea of a computer program as an accurate model for human thought, Simon addresses and eventually dismisses a common question: "But after all, how can a computer be insightful or creative? It can only do what you program it to do." His answer to this question justifies computer simulation and eventually leads to the central tenet of his theories: "In solving problems, human thinking is governed by *programs* that organize myriads of *simple information processes* -- or *symbol manipulating processes* if you like -- into *orderly, complex sequences* that are *responsive to* and *adaptive* to the task environment and the *clues* that are *extracted* from that environment as *sequences* unfold" [italics added] (26).

Noticeably, numerous computational metaphors are used to present his central hypothesis; fundamentally, "human thinking is governed by programs." This implies two things: one, that human thinking consists of an organized set of instructions which solve problems; and two, even if human thought is made of other mysterious "processes" (such as the aforementioned "intuition," "judgment," or "creativity"), the "programs" actually control the majority of human thought. Further, these programs operate like those of a computer; they organize symbol manipulating processes (like entering and deciphering computer code) into "orderly, complex sequences." In other words, the brain manipulates symbols and creates some type of linear or structural pattern with those symbols. Additionally, these sequences are adaptive and responsive to the environment and various other symbols that are extracted from the task environment. Hence, we see the programs as flexible and responsive to external code which may be "entered into" the system.

All of these metaphors represent a overall transference of one system (that of computer programs) and its particular functions onto another structure, that of the human brain. As previously mentioned, mysterious, unexplainable "processes" are left out; metaphors such as "imagination" or "originality" do not fit Simon's model. This provides a good example of Black's distinction between "strong" and "weak" metaphors. Strong metaphors are "markedly emphatic and resonant;" weak metaphors "might be compared to an unfunny joke . . . one understands the unsuccessful or failed verbal actions in the light of what would be funny (27). As Black would note, any metaphors relating to the model, such as "mechanisms," "data," etc. are "strong" metaphors, while those not relating to his model could be considered "weak" by Simon.

Simon's answer to the original question of whether or not programs are creative also shows his transference of one system to another; that of the "programming system" to the "human thinking system." Within his answer we again see explicit and implicit computational metaphors at work:

> A human being can think, learn, and create because the *program* his biological endowment gives him, together with the changes in that *program* produced by interaction with his environment after birth, enables him to think, learn, and create. If a computer thinks, learns, creates, it will be by virtue of a *program* that endows it with these capacities . . . It will be a *program* that makes the system's behavior highly conditional on the task environment — on the task goals and on the clues extracted from the environment that indicate whether progress is being made toward those goals. It will be a *program* that analyzes, by some means, its own performance, diagnoses its failures, and makes changes that enhance its future effectiveness. It is a simple question of fact whether a computer program can be written that will have these properties. And the answer to this question of fact is that such programs have been written. (25)

Through this excerpt we can see Simon emphasizing the similarities between computer programs and human thinking; a program is sensitive to the "task environment" and to clues extracted from that environment, as well as being able to monitor its performance and change when necessary. While we can acknowledge that the brain also responds to the environment and monitors/adapts when necessary, by emphasizing these similarities Simon can claim that a program can be written to duplicate these activities, empirically supported by those programs already in existence. Again, Simon has only selected those properties that can be simulated by a machine; other dissimilarities have been, as Perelman would say, left in the shadows.

Essentially, these metaphors represent the basic foundation of Simon's argument. After this analysis a question logically emerges: now that we know what the metaphors are, how are they functioning within Simon's theory? Chapter four answers this question by analyzing his argument, noting the location of these metaphors within the context of Simon's presentation. Following this discussion are results and implications of both analyses, concluding with areas for further research.

Chapter 4: Argument Analysis

After examining Simon's metaphors and discussing their implications, one now understandably asks how these metaphors function in building his theory. An important aspect of any theory's development, argument plays a criticial role in gaining readers' acceptance of ideas. As Toulmin, Rieke and Janik note, "the problems of science may seem to have an adversarial aspect, but on a deeper level they are directed toward a consensus, or rational agreement, between the parties concerned" (233). What grounds or empirical evidence scientists rely upon; what claims they make from grounds, and, most importantly for my hypothesis, what warrants they use to support their claims, all contribute to a theory's success within the scientific community.

Because I am hypothesizing that computational metaphors are acting as warrants for Simon's theory, it is also important to define the term "warrant" again. Toulmin, Rieke and Janik define warrant as the method by which a scientist justifies the intellectual step from data, evidence, or other grounds (G) to the original claim or conclusion (C) (249). In this analysis I take some of the computational metaphors noted in chapter three and show how they function within the context of Simon's argument, tracing their movement through parts of his theory and illustrating how the metaphors not only act as warrants, but also as grounds and even claims within his theory.

Analyzing the Argument

In the case of decision science, while Simon claims to base his conclusions on evidence gathered from observation, he essentially uses computational metaphors to develop his theory. In other words, Simon's fundamental metaphors, or terms, act not only as analogies but also as *definitions,* which classify one system (human thinking) in terms of a totally different system (computer technology).

This analysis is organized much like the metaphor analysis, highlighting the same metaphors analyzed previously. This chapter shows the location of these metaphors within his argument, and discusses how they contribute to Simon's theory of decision-making.

Because many metaphors establish fundamental aspects of his theory, I am particularly interested in how Simon sets up his argument initially; for this reason many diagrams come from earlier pages of his text. Samples of text which support each diagram are located in the Notes (pages 50 - 55) for reference.

Human Thought is a "Process"

After Simon sets up the definition of thought as a "process" he uses this metaphor to develop his theory. As discussed in chapter three, defining human thinking in terms of a "process" could also imply that thinking is linear.[1] The diagram below illustrates this idea:

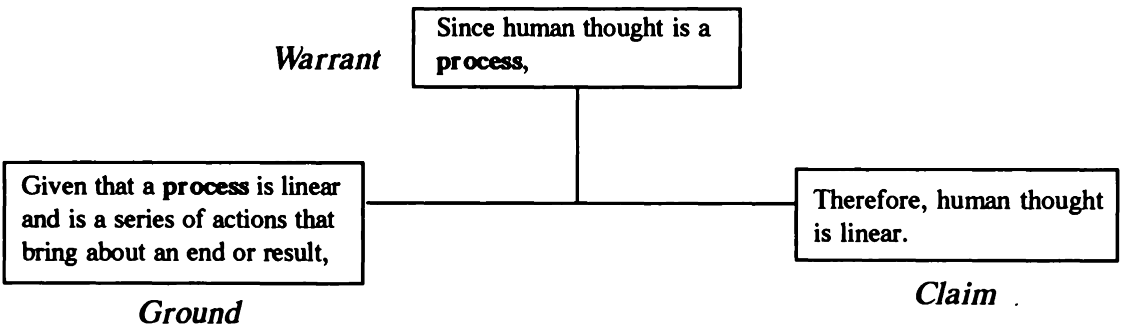

Figure 1. Human Thought is Linear.

In this diagram the "process" metaphor exists in the warrant and grounds of his argument. Using "process" in the grounds establishes the metaphor as an appropriate definition for human thought. "Process" used within the warrant shows Simon's assumptions about the audience, or scientific community, he is addressing. Important in this example is the implication, discussed in chapter three, of a process being linear. Once the reader accepts the prior definition of thinking as a "process," then implications of this term also filter into the model (e.g., that thinking is a sequence of phases, in which one follows another). So, if human thinking is a process, then the human thought process must be linear.

As a next step in this argument, if linear processes are describable (by steps, procedures, or phases), then there probably is a need for a methodology to describe that process, such as decision science. Thus Simon establishes that decision science is an appropriate way to describe executive activity, or thinking.[2] The diagram below illustrates this point:

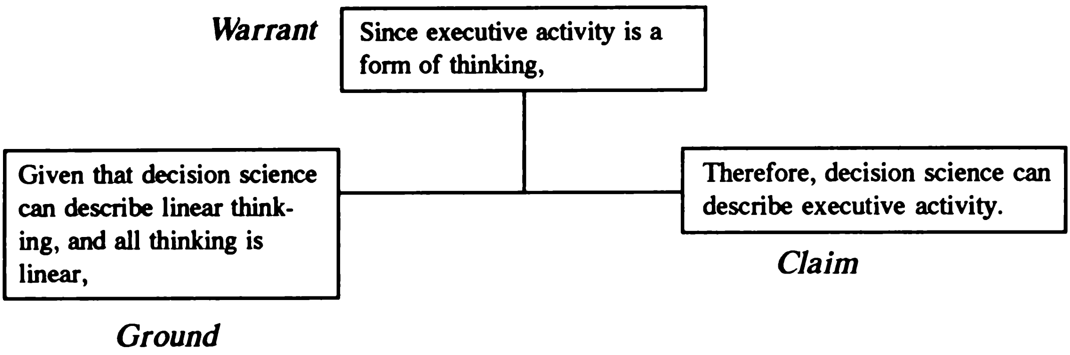

Figure 2. Decision Science can Describe Executive Activity.

Decision science is therefore valuable, and should be further developed. While the supporting evidence for this argument acknowledges that decision-making is very complex, I think Simon still views human thinking as a linear process (cemented by the metaphor "phases"), and one that can be explained by his theory. As he says, "I shall feel justified in taking my pattern for decision making as a paradigm for most executive activity" (4).

Decisions are "Programmed" or "Nonprogrammed"

The next illustration shows how Simon introduces the metaphors "programmed" and "nonprogrammed" decisions. These metaphors represent a major idea in his theory, and he provides much explanation for his terminology.[3] Illustrated on the next page, this idea again uses a definition as grounds:

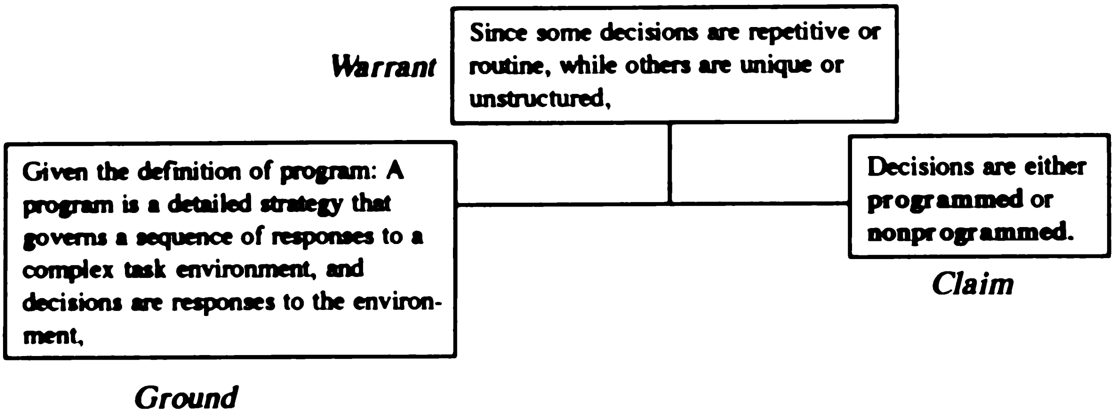

Figure 3. Decisions are either Programmed or Nonprogrammed.

In this diagram the reader can see that Simon relies on the definition of program as grounds for his argument. He has "cut the decisions at their joints" by defining them in terms of something else. The "process" metaphor is still implied as a warrant because a program is a "detailed strategy" which governs a "sequence of responses." This warrant is carried over from a prior argument (Figure 1), which shows how Simon builds on previously established ideas.

Another issue stemming from this particular argument could be an implied preference of programmed decisions over nonprogrammed ones. Programmed decisions are routine, easily sequenced and solvable, and therefore, probably linear. Hence, while all decisions are not programmed, there are a sufficient number to justify using decision science. In this way Simon can give credence to his theory while implicitly highlighting the linear aspect of routine decisions, rather than the uniqueness or unpredictability of other decisions.

Decision Making is a "Skill" or "Technique"

To further cement his image of human thought as a "process," Simon argues that decision making can be improved through appropriate skills and techniques.[4] As noted in chapter three, Simon initially cites the scientific management method as an indication that human skills and efficiency can be measured. By using similarity as a means of justifying his claim, he describes to the "nature" of decision making:

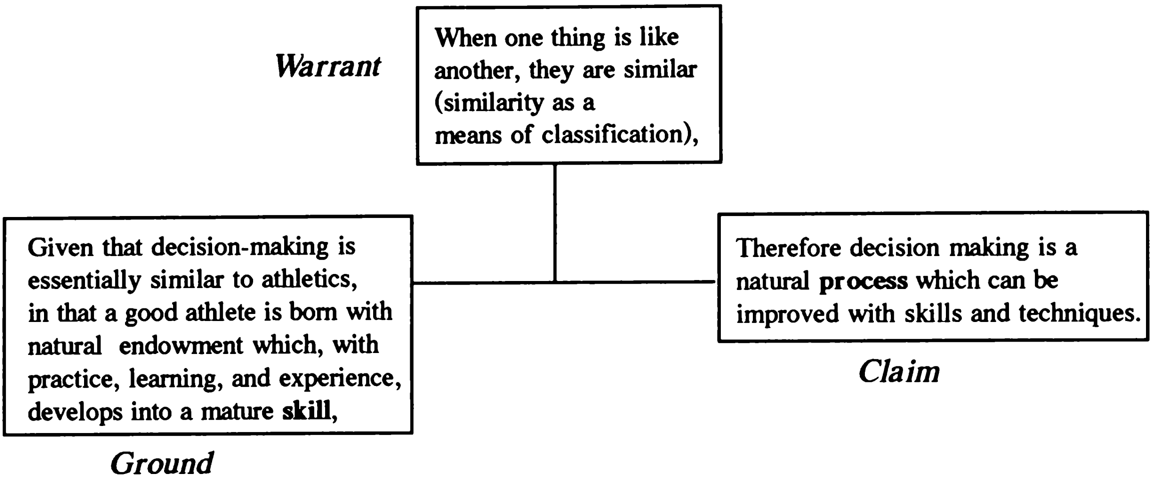

Figure 4. Decision-Making is a Natural Process.

In this diagram the process metaphor has moved and become part of Simon's claim. His warrant rests, once again, on the parameters established by a definition, or a way to cut the theory at another joint. As Corbett says, "the topic of definition can be used not only for clarifying the point at issue, but also for suggesting a line of argument" (99). He goes on to note that "whenever the predicate of a proposition put the subject into a general class of things, the subject is, in a sense, being defined, because limits are being fixed to the term. [Further] the rhetorical force of the topic of genus derives from the principle that what is true (or untrue) of the genus must be true (or untrue) of the species" (100). Hence, by defining improvement in decision-making as being similar to improvement in athletic ability (both through skills and techniques), he has highlighted another aspect of his one-dimensional model.[5] The diagram on the next page further explores this particular argument by solidifying the claim that decision-making can be improved through skill training.

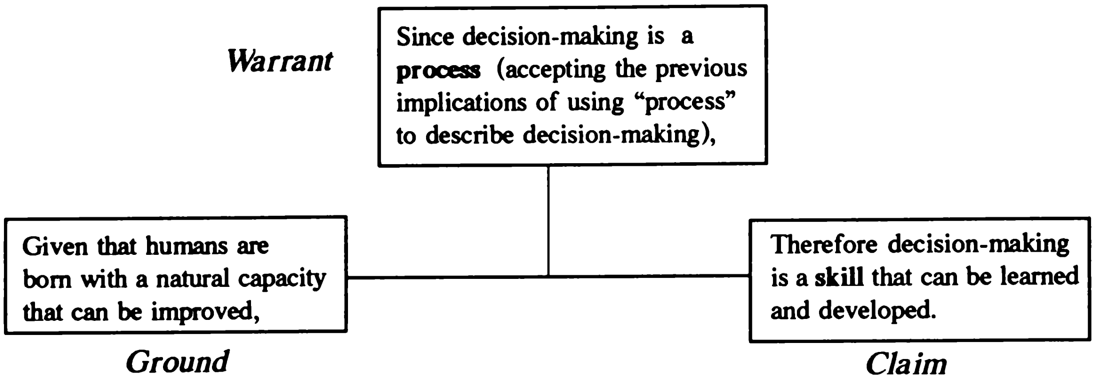

Figure 5. Decision-Making is a Skill that can be Learned and Developed.

In this diagram one can see that this argument uses previously established grounds, claims, and warrants. If one accepts that decision-making is a process, and as such is possibly linear and therefore programmable, then the capacity to improve that process through appropriate skills or techniques is understandable. Again, the reader sees how complex Simon's argument becomes as he provides a model using metaphors that highlight a particular dimension of a phenomenon, rather than including all possible explanations for an abstract system.

Also contributing to Simon's model is the idea that the mind is made of parts, or mechanisms. As he notes, in routine (or programmed) decisions the mind can fall back on a "program" to determine a response. But while there is no program to determine responses for nonprogrammed decisions, there still exists parts, or mechanisms, or (as shown below) equipment, which would aid the person in this "process":

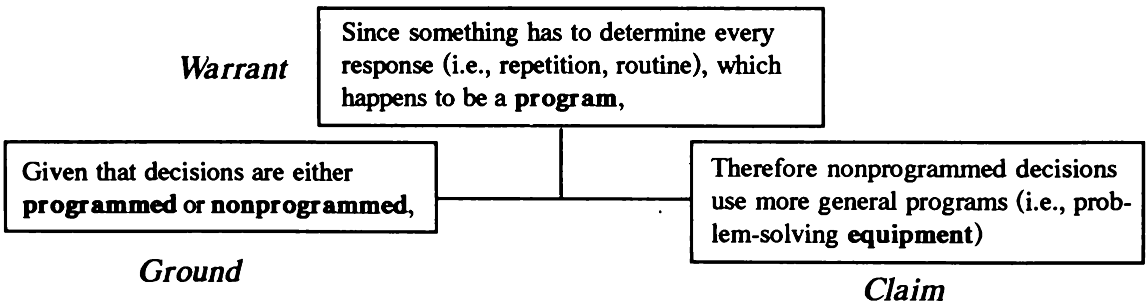

Figure 6. Nonprogrammed Decisions Rely on General Problem-Solving Equipment.

This argument contributes to Simon's model in that equipment could easily be a part of a "process." And because there are programs which govern programmed decision-making, Simon argues that both types can be aided by techniques, much like equipment (or hardware) can be upgraded.[7] There is an assumption that decision-making skills can be improved, thus making it appropriate and necessary to use techniques to improve these skills. This argument is illustrated below:

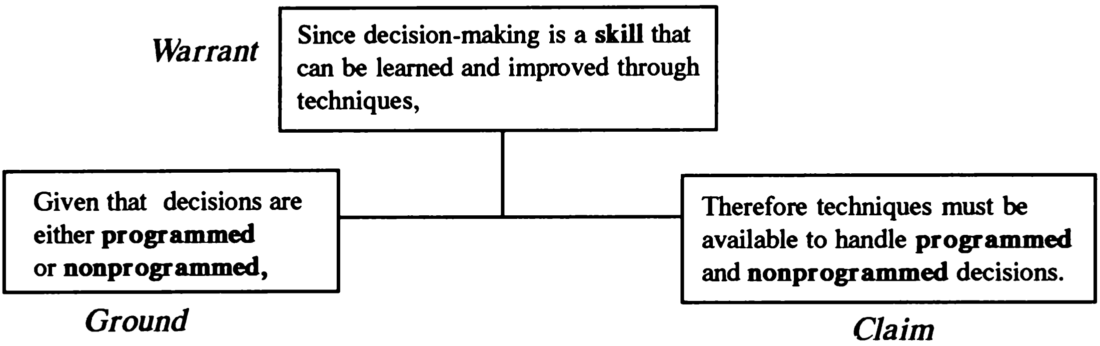

Figure 7. Techniques can handle Programmed and Nonprogrammed Decisions.

Earlier, in chapter three, I noted an implied superiority of programmed decisions over nonprogrammed decisions, evidenced in the idea that we should be able to turn nonprogrammed decisions (which are unique, novel, or unpredictable) into programmable decisions, and then be able to use techniques that have proven successful.[8] The following argument notes how these nonprogrammed decisions can be "improved" to fit this model:

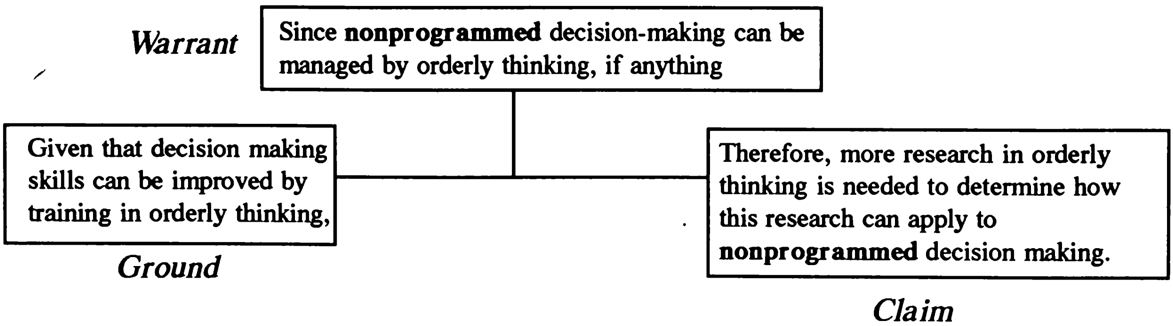

Figure 8. More Research is Needed for Improving Nonprogrammed Decision Making.

By claiming that more research about orderly thinking is needed to improve nonprogrammed-decision making, Simon is advocating that nonprogrammed decision-making is able to be explained. The creativity involved in nonprogrammed decision-making is implicitly excluded because it is often unexplainable; as mentioned in chapter three, intuition or judgment as a valid means of solving problems simply do not fit into Simon's model.

To summarize this set of arguments, the reader should note that initially Simon claims that decision-making is a skill that can be learned and developed. One way to do this is to train executives in orderly thinking, which is a skill. Further, if there is no skill or program to fall back on, then the general problem-solving equipment can be used. Therefore, nonprogrammed decisions, which have no program to stimulate a particular response, can be improved by training in orderly thinking. Within this brief summary the reader can see that Simon continues to imply a "process" of human thinking, which can be linear, can involve various steps or procedures, and, when this "equipment" breaks down, there are techniques or skills that can address and improve these weaknesses. While the model appeals to our logic, it still gives a very one-dimensional view of human thinking, one that excludes any unique solution that may affect how executives make decisions.

The Mind is a "Program"

As previously mentioned, Simon introduces the "program" metaphor initially as a ground. Building on these arguments, he explicitly argues that human thought is really a very complex program.[9] While this argument appears to be a large leap from his already established ideas that decisions are programmed or nonprogrammed and can be handled with various skills and techniques, in essence this claim is only one step from the prior claims. The following diagram illustrates this argument:

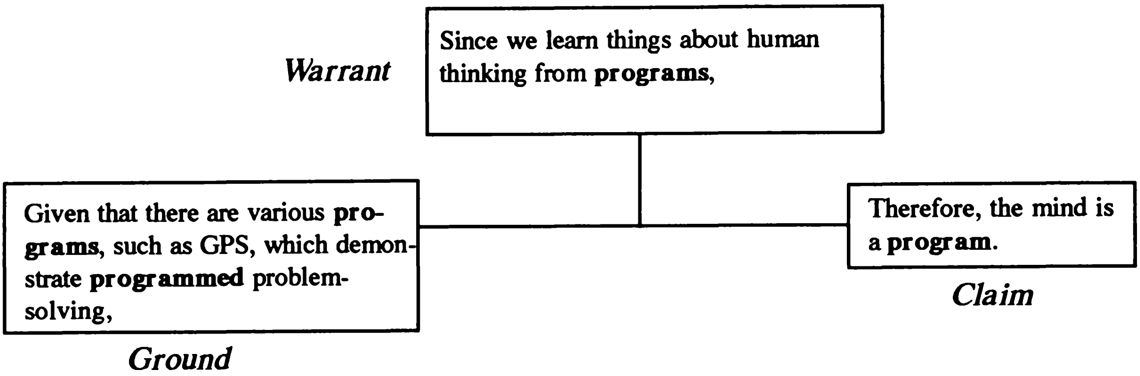

Figure 9. The Mind is a Program.

Within this argument Simon uses numerous established metaphors to support his claim. In his view, if decision-making can be handled like programmed decisions, proven by the the fact that other computer programs have been written which duplicate human thinking, then human thought must logically be a program. Once again we see Simon adding more layers to his model.

The Brain is a Computer

The model that Simon builds eventually leads up to this implicit major claim: the brain is a computer.[10] Although this is not explicitly stated within Simon's text, it is an inherent part of decision science (more on this later). All of the previous arguments, though beginning rather simply and rapidly becoming more complex, are building toward this model of the human brain. Using prior arguments as warrants to support this theory, Simon provides his implicit model, diagramed on the next page:

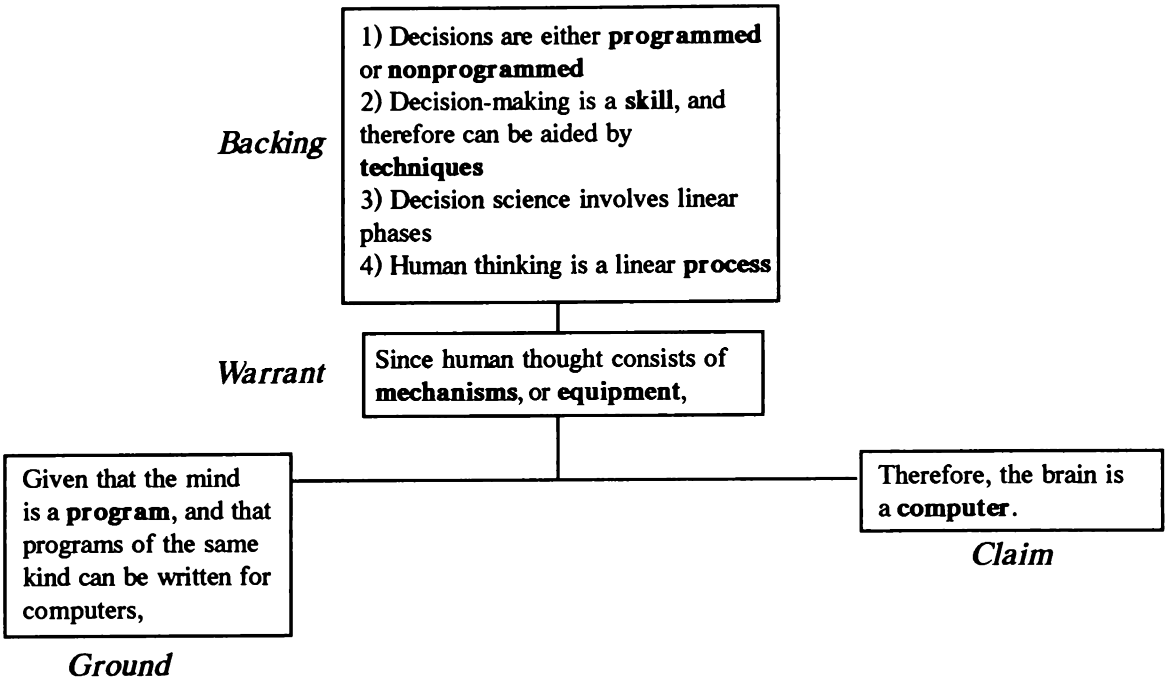

Figure 10. The Brain is a Computer.

As the reader can see, within these warrants are the metaphors that Simon has already logically presented; backing these warrants is the fundamental metaphor, based on the topoi of definition, that human thinking is a process, and presumably a linear one. Thus one can trace the movement of this particular metaphor through original grounds, to claims, and to warrants, repeatedly invading Simon's argument like (to use yet another metaphor) a computer virus. It appears that no matter how complex Simon's argument becomes, under the various arguments lie one fundamental metaphor: process. And returning to one of Simon's previous claims, decision science is an appropriate model to describe human thinking based on the prior claim that what is true of a computer is also true of human thought. Hence, Simon's model is metaphorically complete.

Chapter 5: Conclusions and Implications

Analyzing The New Science of Management Decision has proven interesting and thought-provoking. Based on the results of my analyses, I have categorized my conclusions into four major contexts: implications of the metaphor and argument analyses, implications for rhetoric and science, implications for organizational theory, and recommendations for future research.

Implications of the Metaphor and Argument Analyses

The goal of the metaphor analysis was to analyze Simon's computational metaphors and discuss their use, noting current research findings to encourage the reader to critically examine these metaphors. This analysis revealed that several metaphors, namely "process," "program," "programmed" and "nonprogrammed" decisions, "equipment" or "mechanisms, etc., have been expertly used to develop a paradigm for the human mind, providing a more specific and useful simplification of a complex system. Simon's discussions of programmed and nonprogrammed decisions imply that we are progressing toward a time when all decisions will follow some type of program. As cited within chapter three, although these metaphors make sense within Simon's argument, once they are taken out of context and analyzed for meaning and possible implications it becomes easier to understand and possibly question his model. Simon builds a rhetorical paradigm that emphasizes certain aspects of a phenomenon while de-emphasizing others; essentially, decision science is created in and based on computational metaphors. As mentioned previously, while this model may be the best that we have, nevertheless the audience must constantly be aware of the rhetoric used to express ideas.

The goal of the argument analysis was to analyze the function of the same metaphors within Simon's argument. The analysis revealed that metaphors not only act as warrants in some cases, but also as grounds and claims. This shifting of position may indicate that a well-developed argument, such as this one, intertwines its metaphors in order to more firmly establish its validity and persuade its audience. The metaphors found in the grounds of his arguments tend to define or set up his claim. The metaphors found in the claims may indicate an innovation within his model, which would be favorably viewed as "progress." The metaphors which emerged as warrants may indicate a motivational appeal by Simon; in other words, warrants that are based on the needs and values of an audience might invoke an emotional acceptance of his logic. Therefore, Simon's theory may be more persuasive because it uses as it warrants those metaphors which our culture recognizes as valuable. As Rottenberg notes, "one thing that makes the warrant different is that it is often unexpressed and therefore unexamined by both writer and reader because they take it for granted" (146). The metaphors found in Simon's warrants, I believe, fall into this category.

Implications for Rhetoric and Science

There are several implications for rhetoric and science based on this study. The metaphor analysis demonstrates how metaphors, taken out of context and analyzed, can illustrate a tendendency to highlight certain aspects of a system at the expense of others. But metaphors are still necessary, in cases such as the cognitive disciplines, in giving valuable insight about what is unknown. Although many believe that scientists try to eliminate "rhetoric" in their theoretical explanations (we must be clear and precise, and therefore eliminate tropes and figures from our scientific language), in reality rhetorical devices, such as metaphors, are necessary. Rhetoric, then, is not merely a fancy embellishment; rather, it is sometimes the only way ideas can be expressed. Therefore, rhetoric has an important place among scientific disciplines. The success of this paradigm is demonstrated wherever computational metaphors are used to describe human thinking (e.g., the field of artificial intelligence).

Additionally, using particular metaphors reveals something about the scientist's ideology, or the ideas that reflect the social needs and aspirations of an individual, group, class or culture. As Perelman notes, "not just any action is worth imitating; people imitate only those they admire, who have authority or social prestige because of the competence, their functions, and their place in society" (110). Simon's computational metaphors provide a good example of this phenomenon. The American culture places high value on technological advancement, and we continue to to try to develop a technology that will produce the most efficiently and most effectively as we compete with other cultures. While Simon acknowledged that he chose certain metaphors (such as "program") consciously, our values were still reflected in the implicit metaphors that he used.

Implications for Organizational Theory

The implications of Simon's rhetoric are evidenced in two ways: one, in the noted influence that Simon has in the field of organizational theory, and two, in the current relative success of the "brain as a computer" model. As noted by Klahr, Simon's influence is "manifested" in many ways: political science, administrative behavior, management science, operations research, psychology, computer science, philosphy of science, and economics. But although Simon is widely cited in management texts and in classrooms across the country, within current organizational theories today, there are several other models which aptly describe human activity within organizations. These contributions show that while Simon's model does provide a useful way to explain human thinking, many still believe that we have not discovered the "truth" about how the mind works. Scientists will continue to explore and provide explanations, using both old and new paradigms, for what occurs in the human brain.

In a era when we are concerned with managing huge amounts of information, we understandably look to those systems, computational or otherwise, which help us to do our jobs. Hence, Simon's contributions, in simplifying and isolating how we can improve a difficult process (to borrow his metaphor) of making decisions, is certainly welcome.

Over the years we have watched the computer develop into an "perfect" entity; we have "trained it" (to use a different metaphor) to do what we wish we could do, and then tried to make ourselves more like these machines. To use Simon's metaphors, "if we could just process data more efficiently and program ourselves to do the right thing" then we could get rid of those annoying "errors," or mistakes, that prevent us from making the correct decisions and completing our work.

Realizing the influence of the computer is one issue, but perceiving reality in terms of this metaphor is another; we must not only recognize our rhetoric but also our ideology. As my friend once said, in speaking of his memory, "I just can't seem to access pertinent information from my computer." This statement, I believe, accurately sums up the influence of computer technology on our thinking; we like to see ourselves as reflections of the machines we have created. While this may not be necessarily bad, it does tell us about what we are looking for in our research and what we value in our society.

Recommendations for Future Research

There are questions left unanswered by this study, listed here as possibilites for future research. Do scientific disciplines other than cognitive psychology also use metaphors in their arguments? If so, how are they used? What other metaphors, scientific or otherwise, reflect societal values?

As to Simon's rhetoric, because this study focuses on an earlier work, it would be useful to see if these metaphors continue to be developed in his more recent works. If he has shifted his paradigm, what metaphors have replaced those found in <u>The New Science of Management Decision</u>? If not, has he further "cut organizational theory at its joints" by introducing related metaphors? And if this particular paradigm is not as popular today, what is the current thinking about organizational theory and what and how are metaphors used in those theories?

Rhetorical analyses such as this one would continue to reveal a great deal of information about the way we persuade others through our rhetoric. There is no doubt that rhetoric within scientific disciplines is seriously considered by some as an important aspect of a well-developed theory, and future studies which would enable us to learn more about rhetoric and science are needed.

Notes

[1]Several passages contribute to this argument, and are listed as follows: "Decision making comprises three principal phases: finding occasions for making a decision; finding possible courses of action; and choosing among courses of action. . ." (1). "The first phase of the decision-making process — searching the environment for conditions calling for decision — I shall call *intelligence* activity (borrowing the military meaning of intelligence). The second phase — inventing, developing, and analysing possible courses of action — I shall call *design* activity. The third phase — selecting a particular course of action from those available — I shall call *choice* activity. . ." (2). "Generally speaking, intelligence activity precedes design, and design activity precedes choice" (3). While the diagram provided does not specifically address the phases of decision-making, the linear nature is implied through his organization.

[2]Simon acknowledges that the "phases" are very complex and therefore need a simplistic model for understanding: "Each phase in making a particular decision is itself a complex decision-making process. The design phase, for example, may call for new intelligence activities: problems at any given level generate subproblems that, in turn, have their intelligence, design, and choice phases, and so on . . ." (3). "It may be objected that I have ignored the task of carrying out decision. I shall merely observe by the way that seeing that decisions are executed is again decision-making activity. A broad policy decision creates a new condition for the organization's executives that calls for the design and choice of a course of action for executing the policy. Executing policy, then, is indistinguishable from making more detailed policy. For this reason, I shall feel justified in taking my pattern for decision making as a paradigm for most executive activity" (4).

[3]"In discussing how executives now make decisions, and how they will make

them in the future, let us distinguish two polar types of decisions. I shall call them *programmed decisions* and *nonprogrammed decisions,* respectively. Having christened them, I hasten to add that they are not really distinct types, but a whole continuum, with highly programmed decisions at one end of that continuum and highly unprogrammed decisions at the other end . . ." (5). "Decisions are programmed to the extent that they are repetitive and routine, to the extent that a definite procedure has been worked out for handling them so that they don't have to be treated *de novo* each time they occur. The obvious reason why programmed decisions tend to be repetitive, and vice versa, is that if a particular problem recurs often enough, a routine procedure will usually be worked out for solving it . . ." (6). "Decisions are nonprogrammed to the extent that they are novel, unstructured, and consequential. There is no cut-and-dried method for handing the problem because it hasn't arisen before, or because its precise nature and structure are elusive or complex, or because it is so important that it deserves a custom-tailored treatment . . ." (6). "I have borrowed the term program from the computer trade, and intend it in the sense in which it is used there. A *program* is a detailed prescription or strategy that governs the sequence of responses of a system to a complex task environment. Most of the programs that govern organizational response are not as detailed or as precise as computer programs. however, they all have the same intent: to permit an adaptive response of the system to the situation" (6).

[4]Here Simon defines another aspect of decision-making: "It is an obvious step from the premise that managing is decision making to the conclusion that the important skills for an executive are decision-making skills. It is generally believed that good decision makers, like good athletes, are born, not made. The belief is about as true in the one case as it is in the other. That human beings come into the world endowed unequally with biological potential for athletic prowess is undeniable. They also come endowed unequally with intelligence, cheerfulness, and many other characteristics and potentiali-

ties. To a limited extent, we can measure some aspects of that endowment — height, weight, perhaps intelligence. Whenever we make such measurements and compare them with adult performance, we obtain significant, but low, correlations. A man who is not a natural athlete is unlikely to run the four-minute mile; but many men who are natural athletes have never come close to that goal. A man who is not "naturally" intelligent is unlikely to star in science; but many intelligent scientists are not stars. A good athlete is born when a man with some natural endowment, by dint of practice, learning, and experience develops that natural endowment into a mature skill. A good executive is born when a man with some natural endowment (intelligence and some capacity for interacting with his fellow men) by dint of practice, learning, and experience develops his endowment into a mature skill" (4).

[5]Simplicity is implied here as Simon, based on his prior argument (see note 4), further supports the linear nature of the "process" metaphor: "The skills involved in intelligence, design, and choosing activities are as learnable and trainable as the skills involved in driving, recovering, and putting a golf ball. I hope to indicate some of the things a modern executive needs to learn about decision making" (4).

[6]Simon implies that while there are no procedures to follow in nonprogrammed decision-making, there is still equipment to handle these decisions: "In what sense, then, can we say that the response of a system to a situation is nonprogrammed? Sure something determines the response. That something, that collection of rules of procedure, is by definition a program. By nonprogrammed I mean a response where the system has no specific procedures to deal with situations like the one at hand, but must fall back on whatever general capacity, or problem-solving equipment, it has for intelligent, adaptive, problem-oriented action. Given almost any kind of situation, no matter how novel or perplexing, he can begin to reason about it in terms of ends and means" (6).

Supporting this notion of "problem-solving equipment", Simon explains the taped observations of humans thinking aloud while solving problems. His assessment is as follows: At one level, human problem solving does not seem complicated. "But still the feeling persists that we are seeing only the superficial parts of the process — that there is a vast iceberg underneath, concealed from our view and from the consciousness of the subject. Perhaps this feeling of mystery is an illusion. Perhaps the subconscious parts of the process are no different in kind from the parts we observe. Perhaps the complexity of the problem-solving process that makes its outcome so impressive is a complexity assembled out of relatively simple interactions among a large number of extremely simple basic elements."

"Even if we find such a hypothesis appealing, how would we go about testing it? If we could construct a synthetic thought process and show that, step by step, it matched every element in the verbalized part of the human thought process . . . we would be justified in concluding that we understood what was going on in the human process."

"The actual synthesis of thinking processes that parallel closely some thinking processes of human subjects has in fact been achieved within the past five years. The range of problem-solving tasks that has been studied in this way is still extremely narrow. However, little doubt remains that, in this range at least, we know what some of the principal processes of human thinking are, and how these processes are organized in problem-solving programs" (24).

[7]As Simon says, "my reason for distinguishing between programmed and nonprogrammed decisions is that different techniques are used for handling the programmed and the nonprogrammed aspects of our decision making. The distinction, then, will be a convenient one for classifying these techniques" (7).

[8]"One thing we have known about nonprogrammed decision making is that it can

be improved somewhat by training in orderly thinking. In addition to the very specific habits one can acquire for doing very specific things, one can acquire the habit — when confronted with a vague and difficult situation — of asking, "What is the problem?" We can even construct rather generalized operating procedures for decision making. The military 'estimate of the situation' — a checklist of things to consider in analysing a military decision problem — is an example of such an operating procedure" (11).

[9]Numerous citations support this fundamental argument. As cited in note 6, the sequence of responses that determines a programmed decision is defined as a program. "Computer programs have been written that enable computers to discover proofs for theorems in logic and geometry, to play chess, to design motors, to improve their skills at some of these tasks, to compose music. Some of these programs are aimed at detailed simulation of human processes — hence, at understanding problem solving — others are aimed at finding ways, humanoid or not, of doing the tasks well. From almost all of [these programs], whether intended as simulations or not, we learn something about human problem solving, thinking, and learning (26).

[10]Numerous citations lead to this major implicit argument. Some are as follows: "There is nothing about a computer that limits its symbol-manipulating capacities to numerical symbols; computers are quite as capable of manipulating words as numbers. In principle, the potentialities of a computer for flexible and adaptive cognitive response to a task environment are no narrower and no wider than the potentialities of a human. By in principle, I mean that the computer hardware contains these potentialities, although at present we know only imperfectly how to evoke them, and we do not yet know if they are equivalent to the human capacities in speed or memory size . . ." (24). A human being can think, learn, and create because the program his biological endowment gives him, together with the changes in that program produced by interaction with his environment after birth, enables him to think, learn, and create. If a computer thinks, learns,

creates, it will be by virtue of a program that endows it with these capacities. Clearly this will not be a program . . . that calls for highly stereotyped and repetitive behavior independent of the stimuli coming from the environment and the task to be completed. It will be a program that makes the system's behavior highly conditional on the task environemnt -- on the task goals and on the clues extracted from the environment that indicate whether progress is being made toward those goals. It will be a program that analyzes, by some means, its own performance, diagnoses its failures, and makes changes that enhance its future effectiveness. It is a simple question of fact whether a computer program can be written that will have these properties. And the answer to this question of fact is that such programs have been written."

"I can now, in summary, state the central hypothesis of the theory of problem solving I am proposing: In solving problems, human thinking is governed by programs that organize myriads of simple information processes -- or symbol manipulating processes if you like -- into orderly, complex sequences that are responsive to and adaptive to the task environment and the clues that are extracted from that environment as sequences unfold. Since programs of the same kind can be written for computers, these programs can also be used to describe and simulate human thinking. In doing so, we are not asserting that there is any resemblance between the neurology of the human and the hardware of the computer. They are grossly different. However, at the level of detail represented by elementary information processes, programs can be written to describe human symbol manipulation, and these programs can be used to induce a computer to simulate the human process" (25). While he says that computer hardware and human neurology are not the same, these major statements, combined with the previous diagrams, imply that the brain is much like a computer.

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