Model-Centered Organization Science Epistemology

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Reichenbach (1938) distinguishes between "JUSTIFICATION LOGIC" and "DISCOVERY LOGIC." Weick (1989) sees theorizing as "disciplined imagination." Weick appropriately captures the essence of theory discovery/creation as "imagination." Indeed, after centuries of scientific development, no one has identified any systematic "logic" to the discovery of correct theory. But "justification" seems more appropriate than his "disciplined." Discipline might get the player to the piano practicing eight hours a day but the idea is to play the right notes. Justification logic is not about discipline and hard work. It is about developing more truthful theories.

Both the 1989 *AMR* and 1995 *ASQ* theory forums start with a problem journal editors have trying to get authors to improve the quality of their theory. The gravity of the problem is indicated by the title of the *ASQ* forum—"What Theory Is Not." When asked for better theory, authors are not being cajoled to move from good theory to great theory. Instead, they appear quite off the track on what theory *is*, preferring instead to supply raw ingredients such as more references, data, variables, diagrams, or hypotheses (Sutton and Staw, 1995) instead of effective theory. But saying, for example, that a cake is *not* eggs, *not* flour, *not* sugar, *not* butter, *not* chocolate…does not say what it *is*. The kind of theory Sutton and Staw want to see is not just the result of more discipline and more imagination. But if it is not longer lists of references and variables, and if it is not guaranteed simply from more discipline and imagination—well, **What *Is* Theory? Really!**

BACKGROUND

GOOD THEORY IS TRUTHFUL EXPLANATION

But how to decide what is "truthful" and what constitutes an explanation? This is what philosophy of science and justification logic do. The underlying problem is that justification logic has fallen into disarray in the latter half of the 20th century. The dominant bases of current methodological legitimacy in ORGANIZATION 'SCIENCE', as indicated by the *AMR* and *ASQ* theory forums (Van de Ven, 1989; Sutton and Staw, 1995) and the 1996 Handbook (Clegg, Hardy and Nord), loosely reflect the *RECEIVED VIEW* and *HISTORICAL RELATIVISM*—both of which have been abandoned by philosophers (Suppe, 1977). The Received View is Putnam's (1962) label combining LOGICAL POSITIVISM (Ayer, 1959) and LOGICAL EMPIRICISM (Nagel, 1961; Kaplan, 1964). Historical relativism marks the recognition by Kuhn (1962) and Feyerabend (1975), among others, that the text of published scientific reports is the result of interpretation by individual scientists, social construction of meanings by scientific communities, PARADIGMS, PARADIGM SHIFTS, and INCOMMENSURABILITY. In their place we have seen the growth of POSTMODERNISM, a line of discourse that rejects science and rationality as not only wrong but for having caused science-driven atrocities like the holocaust (Burrell, 1996) and political excesses like the "Pasteurization of France" (Latour, 1984), not to mention anti-science in general (Holton, 1993; Norris, 1997; Gross, Levitt, and Lewis, 1996; Gross and Levitt, 1998; Koertge, 1998; Sokal and Bricmont 1998;). For more on the dark side of postmodernism, see Weiss (2000). If (classical) POSITIVISM is dead, if the Received View is dead; if CLASSICAL EMPIRICISM is dead, if RELATIVISM is dead, and if modern science caused the holocaust, where does this leave justification logic? It is no wonder that journals focus on what theory is not and authors don't know what it is!

Vague justification logic is inevitable in multiparadigm disciplines, suggesting that multiparadigmaticism is at the core of the problem. The paradigm master himself, Kuhn (1962), says multiparadigm disciplines are prescientific—a view echoed by Azevedo (1997) and McKelvey (forthcoming). Pfeffer (1993) presents data showing that multiparadigm disciplines are given low status in the broader scientific community, with a variety of negative consequences. Donaldson (1995) counts fifteen paradigms already and Prahalad and Hamel (1994) call for even more, as do Clegg, Hardy, and Nord (1996). The natural sciences are held in high esteem because they are OBJECTIVIST—their use of external reality serves as the ultimate criterion variable for winnowing out inferior theories and paradigms (Campbell, 1974, 1995). Relativist PROGRAMS, on the other hand, in principle tolerate as many paradigms as there are socially constructed perspectives and interpretations. Hughes (1992, p. 297) says, "The naivety of reasoned certainties and reified objectivity, upon which organization theory built its positivist monuments to modernism, is unceremoniously jettisoned…[and] these articles of faith are unlikely to form the axioms of any rethinking or new theoretical directions…." If he is correct organization 'science' is destined to proliferate even more paradigms and sink to even lower status. The cost of the paradigm war is vague justification logic and loss of legitimacy from philosophers, and as Pfeffer (1993, 1995) details, from other scientists, and the external user community as well.

Multiparadigmaticism need not persist and philosophers are not dead. In the last 30 years they have developed a new, postpositivist, *SELECTIONIST, FALLIBILIST, scientific realist* EPISTEMOLOGY that avoids the extremes of the Received View and the anti-science of relativism. Elsewhere (McKelvey, 1999c), I briefly present some of these trends under the label CAMPBELLIAN REALISM, along with arguments Suppe (1977) lodges against the Received View and relativism (particularly against paradigm shifts and incommensurability). Campbell develops an objectivist epistemology that also includes the interpretive and social constructionist dynamics of relativism. Included are key elements of *scientific REALISM* (Bhaskar, 1975, 1998; Hooker, 1987; Aronson, Harré, and Way, 1994) and *EVOLUTIONARY EPISTEMOLOGY* (Callebaut and Pinxten, 1987; Hahlweg and Hooker, 1989) that support Campbellian realism. Azevedo (1997) develops both at some length.

STOCHASTIC MICROSTATES

Clegg and Hardy (1996: p. 2) contrast thirty years of organization 'science' into "NORMAL SCIENCE" and "CONTRA SCIENCE." Normal science includes "...formal research design; quantitative data facilitate[d] validation, reliability, and replicability; [and] a steady accumulation and building of empirically generated knowledge derive[d] from a limited number of theoretical assumptions." Contra science (Marsden and Townley, 1996, p. 660) includes postpositivisms such as social constructionism, interpretism, phenomenology, radical humanism, radical structuralism, critical theory, and postmodernism, all focusing on "local, fragmented specificities" (Clegg and Hardy, 1996, p. 3), that is, *stochastic* IDIOSYNCRATIC MICROSTATES (McKelvey, 1997).

The dilemma is how to simultaneously accept the existence of idiosyncratic organizational events while at the same time pursuing the essential elements of justification logic defined by the new generation of normal science realists. Justification logic is based on prediction, generalization, and falsification. These require <u>non</u>idiosyncratic events (Hempel, 1965; Hunt, 1991). The dilemma is significant since idiosyncrasy will not disappear and realism is the only scientific method available that protects organization 'science' from false theories, whether by distinguished authorities or charlatans. *The one singular advantage of realist method is its empirically based, self-correcting approach to the discovery of truth* (Holton, 1993).

REAL SCIENCE FROM CONTRA SCIENCE

I focus on whether one can apply the justification logic of normal science realist epistemology to organization theories purporting to explain or understand the nonlinear organizational ONTOLOGY recognized by contra science proponents. One might conclude that there must be some truth in each position, given the considerable discourse and level of feeling and commitment held by both sides. Suppose each side is *half* correct. The fight between normal and contra science is that the latter studies organizations as ontological entities that cannot be fruitfully studied via normal science epistemology because they are comprised of behaviors unique to each individual or subunit. Therefore they abandon normal science, calling for a new epistemology. Normal scientists see contra science epistemology as fraught with subjective bias and with no commitment toward protecting against even grossly untrue local statements let alone more generalizable ones. Wishing to follow the epistemology of "good" science, they adopt an ontology calling for levels of homogeneity among employees, behaviors, or events that do not exist—a clearly false ontology according to contra science adherents. Boiled down, we have four choices:

1- Normal Science Ontology with Normal Science Epistemology
2- Normal Science Ontology with Contra Science Epistemology
3- Contra Science Ontology with Normal Science Epistemology
4- Contra Science Ontology with Contra Science Epistemology

The paradigm war (Pfeffer, 1993, 1995; Perrow, 1994; Van Maanen, 1995a, b) pits #1 against #4. There are no present criteria for choosing one over the other, other than for each side to restate more loudly the "truth" of its position. It is equally clear that no one is advocating #2. **The only untried alternative left is #3**. Truthful explanation, thus, becomes *evolutionary realist truth* about a *contra science ontology.*

Though ignored by contra scientists, #3 is not new to normal science. It dates back to Boltzmann's statistical mechanics treatment (circa 1870) of Brownian Motion (circa 1830). Scientists have identified three methods of pursuing normal science epistemology, given idiosyncratic microstates (McKelvey, 1997): (1) *Assume them away*—as is characteristic of most Newtonian science, and more specifically, of economists' rational actor assumption; (2) *Translate them into probabilistic event arrivals*—either statistically (Hempel's (1965) deductive statistical model), or by mechanical artifice—

what the container does for Boyle's Law by translating the random kinetic motion of gas molecules into directed pressure streams of probabilistic (molecule) arrivals at some measuring station (see Cohen and Stewart, 1994); and (3) *Analyze emergent structure*—complexity scientists studying how structure emerges from the coevolution of heterogeneous agents (Holland, 1996, Mainzer, 1997) in complex adaptive systems.

REALISM

Though Suppe (1977) wrote the epitaph on positivism and relativism, a POSITIVIST LEGACY remains. Space precludes detailing it here, but essential elements are listed in McKelvey (1999c). From this legacy a *model-centered evolutionary realist epistemology* has emerged. Elsewhere (McKelvey, 1999c), I argue that model-centered *realism* accounts to the legacy of positivism and evolutionary realism accounts to the dynamics of science highlighted by relativism, all under the label *Campbellian Realism*. Campbell's view may be summarized into a tripartite framework that replaces the historical relativism of Kuhn et al. for the purpose of framing a dynamic realist epistemology. First, much of the literature from Lorenz (1941) forward has focused on the selectionist evolution of the human brain, our cognitive capabilities, and our visual senses (Campbell, 1974, 1988), concluding that these capabilities do indeed give us accurate information about the world we live in (reviewed by Azevedo, 1997).

Second, Campbell (1991, 1995) draws on the hermeneuticists' COHERENCE THEORY in a selectionist fashion to argue that over time members of a scientific community (as a tribe) attach increased scientific validity to an entity as the meanings given to that entity increasingly cohere across members. This process is based on hermeneuticists' use of coherence theory to attach meaning to terms (Hendrickx, 1999). This is a version of the social constructionist process of knowledge validation that defines Bhaskar's use of TRANSCENDENTAL IDEALISM and the sociology of knowledge components in his scientific realist account. The coherentist approach selectively winnows out the worst of the theories and thus approaches a more probable truth.

Third, Campbell (1988, 1991) and Bhaskar (1975) combine scientific realism with semantic relativism (Nola, 1988), thereby producing an ontologically strong relativist dynamic epistemology. In this view the coherence process within a scientific community continually develops in the context of selectionist testing for ontological validity. The socially constructed coherence enhanced theories of a scientific community are tested against real-world phenomena (the criterion variable against which semantic variances are eventually narrowed and resolved), with a winnowing out of the less ontologically correct theoretical entities. This process, consistent with the strong version of scientific realism proposed by de Regt (1994), does not guarantee error free "Truth" (Laudan 1981) but it does move science in the direction of increased VERISIMILITUDE. For a counter view see Stich (1990), who argues for PRAGMATISM over selectionist explanation.

Campbellian realism is crucial because elements of positivism and relativism remain in organization 'science' (see chapters in Clegg, Hardy and Nord 1996). Campbell's epistemology folds into a single epistemology: (1) dealing with METAPHYSICAL TERMS, (2) objectivist empirical investigation, (3) recognition of socially constructed meanings of terms, and (4) a dynamic process by which a multiparadigm discipline might reduce to fewer but more significant theories.

Campbell defines a *critical, hypothetical, corrigible, scientific realist selectionist evolutionary* epistemology as follows: (McKelvey, 1999c, p. 403)

1- A scientific realist postpositivist epistemology that maintains the goal of objectivity in science without excluding metaphysical terms and entities.
2- A selectionist evolutionary epistemology governing the winnowing out of less probable theories, terms, and beliefs in the search for increased verisimilitude may do so without the danger of systematically replacing metaphysical terms with OPERATIONAL TERMS.
3- A postrelativist epistemology that incorporates the dynamics of science without abandoning the goal of objectivity.
4- An objectivist selectionist evolutionary epistemology that includes as part of its path toward increased verisimilitude the inclusion of, but also the winnowing out of the more fallible, individual interpretations and social constructions of the meanings of theory terms comprising theories purporting to explain an objective external reality.

The epistemological directions of Campbellian realism have strong foundations in the scientific realist and evolutionary epistemology communities (see Azevedo, 1997). While philosophers never seem to agree exactly on anything, nevertheless, broad consensus does exist that these statements reflect what is best about current philosophy. As the debate about organization 'science' epistemology goes forward, the points listed in Table 1 should be seriously considered as central elements of the field. These points combine key epistemological tenets developed by Campbell, de Regt (1994), and Aronson, Harré, and Way (1994)—discussed in McKelvey (1999c).

>>> Insert Table 1 about here <<<

To date evolutionary realism has amassed a considerable body of literature, as reviewed by Hooker (1987, 1995) and Azevedo (1997, this volume). Along with Campbell, and Lawson's (1997) realist treatment of economics, Azevedo stands as principal proponent of realist *social* science (see Chapter # , this volume). Key elements of her "*MAPPING MODEL of knowledge*" are:

1- Realism holds "that there is a real world existing independently of our attempts to know it."
2- "The realist adopts a fallibilist approach to science" and

truth.

3- The rise of postmodernism is based on the "inadequacies of positivism."

4- "Postmodernists show a profound ignorance of contemporary realism and a reluctance to engage in serious debate."

5- "[H]umans are products of biological evolution…[that] have evolved perceptual and cognitive mechanisms…. Natural selection would not have left us with grossly misleading perceptual and cognitive mechanisms."

6- "Valid beliefs, therefore, are achieved as a result of social processes rather than despite them."

7- Being "scientific is tied up with the nature of the structure and the norms of the institution of science…that distinguish science from other belief production and maintenance institutions" such as religion.

8- The "validity of theories is both relative to the interests that guide theory creation and a function of the reality that they represent."

9- [T]heories, like maps, are valid insofar as they are reliable guides to action and decision making."

10- "Causal analysis is the basis of validity."

11- "Explanations in terms of composition, structure, and function are as much a part of science as are causal explanations.

12- "[M]entalist explanations [based on meanings, motives, and reasons] turn out to be interpretative functional analyses.…[and] have a loose, but nonetheless specified, relationship with the [causal] transition theories they explain.…leaving the way open for a naturalist [realist] approach to the social sciences."

13- "[K]nowing a complex reality actually demands the use of multiple perspectives."

14- "The reality of some entity, property, or process is held to be established when it appears invariant across at least two…independent theories." (pp. 255–269)

Though it might seem that the Campbellian Realist approach is more model-centered than hers, nothing is more central in Azevedo's analysis than the mapping model—making hers just as model-centered as mine. And both of us emphasize ISOLATED IDEALIZED STRUCTURES. Her analysis greatly elaborates the initial social constructionist applications of realism to social science by Bhaskar (1975) and Campbell (1991, 1995) and accounts for idiosyncratic microstates as well.

THE NEW "MODEL-CENTERED" EPISTEMOLOGY

In my development of Campbellian Realism (McKelvey 1999c) I show, that model-centeredness is a key element of scientific realism, but I do not develop the argument. In this section, I flesh out the development of a model-centered science by defining the semantic conception and close with a scale of scientific excellence based on model-centering. As Cartwright puts it: "*The route from theory to reality is from theory to model, and then from model to phenomenological law*" (1983, p. 4; my italics). The centrality of models as autonomous mediators between theory and phenomena reaches fullest expression in Morrison (2000), Morrison and Morgan (2000), Morgan and Morrison (2000) as they extend the semantic conception.

MODEL-CENTERED SCIENCE

Models may be ICONIC or FORMAL. Much of organization 'science' occurs in business schools often dominated by economists trained in the context of theoretical (mathematical) economics. Because of the axiomatic roots of theoretical economics, I discuss the AXIOMATIC CONCEPTION in epistemology and economists' dependence on it. Then I turn to the semantic conception, its rejection of the axiomatic definition of science, and its replacement program.

The Axiomatic Syntactic Tradition

Axioms are defined as self-evident truths comprised of primitive syntactical terms. Thus, in Newton's second law, $F = ma$, most any person can appreciate the reality of force—how hard something hits something else, mass—how heavy something is, and acceleration—whether an object is changing its current state of motion. And the three terms, force, mass, and acceleration cannot be decomposed into smaller physical entities defined by physicists—they are primitive terms this sense (Mirowski, 1989, p. 223). A formal syntactic language system starts with primitives—basic terms, definitions, and formation rules (e.g., specifying the correct structure of an equation) and syntax—in $F = ma$ the syntax includes F, m, a, = and × (implicit in the adjoining of ma). An axiomatic formal language system includes definitions of what is an axiom, the syntax, and transformation rules whereby other syntactical statements are deduced from the axioms. Finally, a formal language system also includes a set of rules governing the connection of the syntax to real phenomena by such things as measures, indicators, operational definitions, and CORRESPONDENCE RULES all of which contribute to syntactic meaning.

The science of analytical mechanics (Lanczos, 1970) is the classic example of theories being governed by an axiomatic syntactic formalized language. It began with Newton's three laws of motion and his law of gravitational attraction (Thompson, 1989, p. 32–33):

1- Every entity remains at rest or in uniform motion unless acted upon by an external unbalanced force;

2- Force equals mass times acceleration ($F = ma$);

3- For every action there is an equal and opposite reaction;

4- The gravitational force of attraction between two bodies equals the gravitational constant (G = 6.66×10^{-s} dyne cm.^{2}/gm.^{2}) times the product of their masses (m_1m_2) divided by the square of the distance between them (d^2), that is, $F = G(m_1m_2/d^2)$.

During the 22 decades between Newton's *Principia* (circa 1687) and initial acceptance of quantum and relativity theory, physicists and eventually philosophers discovered that the syntax of these basic axioms and derived equations led to explanations of Kepler's laws of planetary motion, Galileo's law of free fall, heat/energy (thermodynamic) laws, electromagnetic force (Maxwell's equations), and thence into economics (Mirowski, 1989). Based on the work of Pareto, Cournot, Walras, and Bertrand, economics was already translating physicists' thermodynamics into a mathematicized economics by 1900. By the time logical positivism was established by the Vienna Circle circa 1907 (Ayer, 1959; Hanfling, 1981), science and philosophy of science believed that a common axiomatic syntax underlay much of known science—it connected theories as far removed from each other as motion, heat, electromagnetism, and economics to a common set of primitives. Over the course of the 20th century, as other sciences became more formalized, positivists took the view that any "true" science ultimately reduced to this axiomatic syntax (Nagel, 1961; Hempel, 1965)—the origin of the "Unity of Science" movement (Neurath and Cohen, 1973; Hanfling, 1981).

Now, the axiomatic requirement increasingly strikes many scientists as more straight-jacket than paragon of good science. After quantum/relativity theories, even in physics Newtonian mechanics came to be seen as a study of an isolated idealized simplified physical world of point masses, pure vacuums, ideal gases, frictionless surfaces, linear one-way causal flows, and deterministic reductionism (Suppe, 1989, p. 65–68; Gell-Mann, 1994). But biology continued to be thought—by some—as amenable to axiomatic syntax even into the 1970s (Williams, 1970, 1973; Ruse, 1973). In fact, most formal theories in modern biology are not the result of axiomatic syntactic thinking. Biological phenomena do not reduce to axioms. For example, the Hardy-Weinberg "law," the key axiom in the axiomatic treatments of Williams and Ruse is:

$$p = \frac{AA + 1/2\,Aa}{N},$$

where p = gene frequency, A & a are two alleles or states of a gene, and N = number of individuals. It is taken as prerequisite to other deterministic and stochastic derivations. But instead of being a fundamental axiom of evolutionary theory, it is now held that this "law," like all the rest of biological phenomena is a <u>result</u> of evolution, not a causal axiom (Beatty, 1981, p. 404–405).

The so-called axioms of economics also suffer from the same logical flaw as the Hardy-Weinberg law. Economic transactions appear to be represented by what Mirowski refers to as the "heat axioms." Thus, Mirowski shows that a utility gradient in Lagrangian form,

$$\mathbf{P} = \text{grad } U = \left[\frac{\partial U}{\partial x}\ \frac{\partial U}{\partial x}\ \frac{\partial U}{\partial z}\right] = \left\{P_x, P_y, P_z\right\},$$

is of the same form as the basic expression of a force field gradient,

$$\mathbf{F} = \text{grad } U = \left[\frac{\partial U}{\partial x}\ \frac{\partial U}{\partial y}\ \frac{\partial U}{\partial z}\right] = \left\{X, Y, Z\right\}.$$

As Mirowski (1989: 30–33) shows, this expression derives from the axiom $F = ma$. Suppose that, analogous to the potential or kinetic energy of planetary motion defined by the root axiom $F = ma$, an individual's movement through commodity space (analogous to a rock moving through physical space) is $U = ip$, (where i = an individual, p = change in preference). The problem is that Newton's axiom is part of the causal explanation of planetary motion, but the economists' axiom could be taken as the *result* of the evolution of a free market capitalist economy, not as its root cause. Parallel to a Newtonian equivalent of an isolated physical system where axioms based on point masses and pure vacuums, etc., are effective, the axiom, $U = ip$, works quite well in an isolated idealized capitalist economy—but as we have discovered recently—not in Russia. This "axiom" is not a self-evident expression that follows an axiomatic syntax common to all "real" sciences. It is the result of how economists think an economy *ought* to behave, not how economic systems *actually* behave universally. Economists are notorious for letting *ought* dominate over *is* (Redman, 1991)—economic theory still is defined by axiomatic syntax (Blaug, 1980; Hausman, 1992).

Sporadic axiomatic attempts in linguistics (Chomsky, 1965), various behavioral and social sciences, and even in organization 'science' (Hage, 1965) have all failed. So much so that following the Kuhnian revolution the social sciences took historical relativism as license to invent various "alternative" relativist postpositivisms (Hunt, 1991), of which there are now many—ethnomethodology, historicism, humanism, naturalism, phenomenology, semioticism, literary explicationism, interpretism, critical theory, and postmodernism.

In logical positivism, formal syntax is "interpreted" or given SEMANTIC MEANING via correspondence rules (C-rules). For positivists, THEORETICAL LANGUAGE, V_T, expressed in the syntax of axiomaticized FORMAL MODELS becomes isomorphic to OBSERVATION LANGUAGE, V_O, as follows (Suppe, 1977, p. 16):

> The terms in V_T are given an explicit definition in terms of V_O by correspondence rules C—that is, for every term 'F' in V_T, there must be given a definition for it of the following form: for any x, $Fx \equiv Ox$.

Thus, given appropriate C-rules, scientists are to assume V_T in an "identity" relation with V_O.

In the axiomatic conception of science one assumes that formalized mathematical statements of fundamental laws reduce back to a basic set of axioms and that the correspondence rule procedure is what attaches discipline-specific semantic interpretations to the common underlying axiomatic syntax. The advantage of this view is that there seems to be a common platform to science and a rigor of analysis results. This conception eventually died for three reasons (Suppe, 1977): (1) Axiomatic formalization and correspondence rules, as key elements of logical positivism, proved untenable and were abandoned; (2) Newer 20th century sciences did not appear to have any common axiomatic roots and were not easily amenable to the closed-system approach of Newtonian mechanics; and (3) Parallel to the demise of the Received View, the semantic conception of theories developed as an alternative approach for attaching meaning to syntax.

Essential Elements of the Semantic Conception

Parallel to the fall of the Received View and its axiomatic conception, and starting with Beth's (1961) seminal work dating back to the Second World War, we see the emergence of the semantic conception of theories, Suppes (1961), van Fraassen (1970), Suppe (1977, 1989), and Giere (1979, 1988). Cartwright's (1983) "simulacrum account" followed, as did the work of Beatty (1987), Lloyd (1988), and Thompson (1989) in biology; Read (1990) in anthropology. I present four key aspects.

From Axioms to Phase-Spaces. Following Suppe, I will use *phase-space* instead of Lloyd and Thompson's state-space or Suppes' set-theory. A phase-space is defined as a space enveloping the full range of each dimension used to describe an entity. Thus, one might have a regression model in which variables such as size (employees), gross sales, capitalization, production capacity, age, and performance define each firm in an industry and each variable might range from near zero to whatever number defines the upper limit on each dimension. These dimensions form the axes of an n-dimensional Cartesian phase-space. Phase-spaces are defined by their dimensions and by all possible configurations across time as well. They may be defined with or without identifying underlying axioms—the formalized statements of the theory are not defined by how well they trace back to the axioms but rather by how well they define phase-spaces across various state transitions. *In the semantic conception, the quality of a science is measured by how well it explains the dynamics of phase-spaces—not by reduction back to axioms*. Suppe (1977, p. 228) recognizes that in social science a theory may be "qualitative" with nonmeasurable parameters, whereas Giere (1979) says theory *is* the model (which for him is stated in set-theoretic terms—a logical formalism). Nothing precludes "improvements" such as symbolic/syntactic representation, set-theoretic logic, first predicate (mathematical) logic, mathematical proofs, or foundational axioms.

Isolated Idealized Structures. Semantic conception epistemologists observe that scientific theories never represent or explain the full complexity of some phenomenon. A theory may *claim* to provide a generalized description of the target phenomena, say, the behavior of a firm, but no theory ever includes so many variables and statements that it effectively accomplishes this. A theory (1) "does not attempt to describe all aspects of the phenomena in its intended scope; rather it abstracts certain parameters from the phenomena and attempts to describe the phenomena in terms of just these abstracted parameters" (Suppe, 1977, p. 223); (2) assumes that the phenomena behave according to the selected parameters included in the theory; and (3) is typically specified in terms of its several parameters with the full knowledge that no empirical study or experiment could successfully and completely control all the complexities that might affect the designated parameters. Suppe (1977, p. 223–224) says theories invariably explain *isolated idealized systems* (his terms). And most importantly, "if the theory is adequate it will provide an accurate characterization of what the phenomenon *would have been* had it been an isolated system…." Using her mapping metaphor, Azevedo (1997) explains that no map ever attempts to depict the full complexity of the target area—it might focus only on rivers, roads, geographic contours, arable land, or minerals, and so forth—seeking instead to satisfy the specific interests of the map maker and its potential users. Similarly for a theory. A theory usually predicts the progression of the idealized phase-space over time, predicting shifts from one abstraction to another under the assumed idealized conditions.

Classic examples given are the use of point masses, ideal gasses, pure elements and vacuums, frictionless slopes, and assumed uniform behavior of atoms, molecules, genes, and rational actors. Laboratory experiments are always carried out in the context of closed systems whereby many of the complexities of real-world phenomena are ignored—manipulating one variable, controlling some variables, assuming others are randomized, and ignoring the rest. They are isolated from the complexity of the real world and the systems represented are idealized. Idealization also could be in terms of the limited number of dimensions, the assumed absence of effects of the many variables not included, or the mathematical formalization syntax, the unmentioned AUXILIARY HYPOTHESES relating to theories of experiment, data, and measurement.

Model-Centered Science and Bifurcated Adequacy Tests. Models comprise the core of the semantic conception. Figure 1a portrays the *axiomatic conception*: (1) Theory is developed from its axiomatic base; (2) Semantic interpretation is added to make it meaningful in, say, physics, thermodynamics, or economics; (3) Theory is used to make and test predictions about the phenomena; and (4) Theory is defined as empirically and ontologically adequate if it both reduces to the axioms and is INSTRUMENTALLY RELIABLE in predicting empirical results. Figure 1b depicts the *organization 'science' approach*: (1) Theory is induced after an investigator has gained an appreciation of some aspect of organizational behavior; (2) An ICONIC MODEL is often added to give a pictorial view of the interrelation of the variables, show hypothesized path coefficients, or possibly a regression model is formulated; (3) The model develops in parallel with the theory as the latter is tested for empirical adequacy by seeing whether effects predicted by the theory can be discovered in the real-world. Figure 1c illustrates the *semantic conception*: (1) Theory, model, and phenomena are viewed as independent entities; (2) Science is bifurcated into two not unrelated activities, ANALYTICAL and ONTOLOGICAL ADEQUACY. Following Read (1990), my view of models as centered between theory and phenomena sets them up as autonomous agents, consistent with Morrison (2000), Cartwright (2000), and others in Morgan and Morrison (2000)—though I see model autonomy as coming more directly from the semantic conception than do Morrison or Cartwright. Read gives the most thorough analysis I have seen of the interaction between analytical and ontological adequacy tests—which is frequently confused and misinterpreted. Read, a mathematician, also implicitly offers a litany of reasons why agent-based models will eventually dominate math models in model-centered social sciences.

>>> Insert Figure 1 about here <<<

Analytical Adequacy focuses on the theory–model link. It is important to emphasize that in the semantic conception "theory" is always expressed via a model. "Theory" does not attempt to use its "If *A*, then *B*" epistemology to explain "real-world" behavior. It only explains "model" behavior. It does its testing in the isolated idealized world of the model. "Theory" is not considered a failure because it does not become elaborated and fully tested against all the complex effects characterizing the real-world phenomena. A mathematical or computational model is used to structure up aspects of interest within the full complexity of the real-world phenomena and defined as *"within the scope"* of the theory, and as Azevedo (1997) notes, according to the theoretician's interests. Then the model is used to test the "If *A*, then *B*" propositions of the theory to consider how a firm—as modeled—might behave under various possibly occurring conditions. Thus, a model would not attempt to portray all aspects of, say, laptop computer firms—only those within the scope of the theory being developed. And, if the theory did not predict *all* aspects of these firms' behaviors under the various relevant real-world conditions it would not be considered a failure.

Ontological Adequacy focuses on the model–phenomena link. Developing a model's ontological adequacy runs parallel with improving the theory–model relationship. How well does the model *represent* real-world phenomena? How well does an idealized wind-tunnel model of an airplane wing represent the behavior of a full sized wing in a storm? How well does a drug shown to work on "idealized" lab rats work on people of different ages, weights, and physiologies? How well might a computational model from biology, such as Kauffman's (1993) *NK* model that, Levinthal (1997), Baum (1999), McKelvey (1999a, b), and Rivkin (2000) apply to firms, actually represent coevolutionary competition in, for example, the laptop computer industry? In this case it involves identifying various coevolutionary structures, that is, behaviors, that exist in industry and building these effects into the model as dimensions of the phase-space. If each dimension in the model—called MODEL-SUBSTRUCTURES—adequately represents an equivalent behavioral effect in the real world, the model is deemed ontologically adequate (McKelvey, 2000).

Theories as Families of Models. A difficulty encountered with the axiomatic conception is the belief that *only one* theory–model conception should build from the underlying axioms. In this sense, only one model can "truly" represent reality in a rigorous science. Given this, a discipline such as evolutionary biology fails as a science. Instead of a single axiomatically rooted theory, as proposed by Williams (1970) and defended by Rosenberg (1985), evolutionary theory is a *family of theories* including theories explaining the processes of (1) variation; (2) natural selection; (3) heredity; and (4) a taxonomic theory of species (Thompson, 1989, Ch. 1). Even in physics, the theory of light is still represented by two models: wave and particle. More broadly, in other mature sciences there are competing theories/models about the age of the universe, the surface of the planet Venus, whether dinosaurs were cold or warm blooded, the cause of deep earthquakes, the effect of ozone depletion in the upper atmosphere, and so on.

Since the semantic conception does not require axiomatic reduction, it tolerates multiple theories and models. Thus, "truth" is not defined in terms of reduction to a single axiom-based model. Set-theoretical, mathematical, and computational models are considered equal contenders to more formally represent real-world phenomena. In physics both wave and particle models are accepted because they both produce highly reliable predictions. That they represent different theoretical explanations is not a failure. Each is an isolated idealized system representing different aspects of real-world phenomena. In evolutionary theory there is no single "theory" of evolution. In fact, there are even lesser families of theories (multiple models) *within* the main families. Organization 'science' also consists of various families of theories, each having families of competing models within it. Most chapters in this volume, in fact, present families of theories pertaining to the subject of the chapter. Axiomatic reduction does not appear in sight for any of these theories. Under the semantic conception, organization 'science' may progress toward improved analytical and ontological adequacy with families of models and without an axiomatic base.

An Example

Consider a recent paper by Contractor et al. (2000) using structuration theory (Giddens 1984) to predict self-organizing networks. It is not axiomatic nor does it offer more than a minimalist iconic model. Most importantly, it does not attempt to make a *direct* predictive leap from structuration-based hypotheses to real-world phenomena, noting that there are a "…multitude of factors that are highly interconnected, often via complex, non-linear dynamic relationships" (Contractor et al., p. 4). Instead, the substructure elements are computationally combined into a model "outcome" and this outcome is predicted to line up with real-world phenomena. The model-substructures are easily identified (shown in Table 2).

>>> Insert Table 2 about here <<<

There are three key steps embodied in the semantic conception:

1- A (preferably) *formalized model* is developed—either mathematical or computational;

2- *Analytical adequacy* is tested—theory and model coevolve until such time as the model (in an isolated idealized setting such as a lab or computer) correctly produces effects predicted by the theory, given the model-substructures and various other conditions or controls structured into the model;

3- *Ontological adequacy* is tested—substructures are tested against real-world phenomena, and if possible, the composite model outcome is also tested against predicted real-world behavior.

The Contractor et al. research implements Step 1 (Table 2), and begins Steps 2 and 3.

Step 2. The *analytical adequacy* test—using the model to test out the several causal propositions generated by the theory. This involves several elements in the coevolution of the *theory–model link*. Contractor et al. start with structuration theory's recursive interactions among actors and contextual structure. Structuration and negotiated order are linked to network dynamics and evolution (Barley, 1990; Stokman and Doreian, in press). Monge and Contractor (in press) identify ten GENERATIVE MECHANISMS posited to cause emergent network dynamics. Contractor et al. end with ten model-substructures—each a causal proposition—rooted in structuration theory and hypothesized to affect network emergence. Each rests on considerable research. These reduce to ten equations (Table 2): Seven exogenous factors, each represented as a matrix of actor interactions; and three endogenous factors with more complicated formalizations. For example, in the equation $\Delta C_{W_{ij}} = W_{ij}$ the value of $\Delta C_{W_{ij}}$, "the change in communication resulting from interdependencies in the workflow" represented as the matrix W_{ij}, "is a workflow matrix and the cell entry W_{ij} indexes the level of interdependence between individuals *i* and *j*" (p. 21).

Contractor et al. begin the lengthy process of theory–model coevolutionary resolution, but:

1- Debate remains over which elements of structuration theory are worth formalizing;

2- Not all generative mechanisms thought to cause network emergence are represented; additional theorizing could mean additions and/or deletions;

3- Formalization of model-substructures could take a variety of expressions; and

4- "*Blanche*" is only one of many computational modeling approaches that could be used.

In short, it will take a research program iteratively coevolving these four developmental process elements over some period of time before theory, the derived set of formalized causal statements, and modeling technology approach optimization—recognizing that evolutionary epistemologists hold that this seldom, if ever, fully materializes.

Step 3. The *ontological adequacy* test—comparisons of model-substructures with functionally parallel real-world subprocesses. Empiricists are not held to the draconian objective of testing model-to-real-world isomorphism for all substructures at the same time—that is, matching the composite outcome of the model against equivalent real-world phenomena. Experience in classical physics shows that if each of the substructures is shown to be representative, then the whole will also refer. This means that model–phenomena tests may be conducted at the substructure or composite outcome levels.

The increased probability of nonlinear substructure effects (individually or in combination) in social science, demonstrates the increased importance of model-centered science. Given nonlinear substructure interactions, it is more likely that the model's *composite* outcome will fair better in the ontological test. Contractor et al. actually do both kinds of tests. In a quasi-experiment, they collect data pertinent to each of the model-substructures and to the composite outcome of the model. Their sample consists of 55 employees measured at 13 points over two years. They do not test whether a specific model substructure predicts an equivalent subcomponent of the emergent network. For example, they do not test the relation between the model's workflow interdependence matrix and the equivalent real-world matrix. They could claim, however, that each causal substructure has already been well tested in previous research. They find that the model's composite outcome predicts the empirically observed emergent network. Four of the ten substructures also significantly predict the observed emergent network.

Testing the *model–phenomena link* also involves several coevolutionary developments:

1- Decompose the model into key constituent substructures, which may need further ontological testing.

2- Identify equivalent generic functions in real-world phenomena, perhaps across a variety of quasi-experimental settings, presumably improving over time as well.

3- Define the function of each substructure in generic real-world operational terms; here, too, improvement over time is expected.

4- Test to see if (a) the model substructures are isomorphic

> with the real-world functions; and (b) if the model's composite outcome represents real-world phenomena—both expected to develop interactively over time.

Needless to say, several empirical tests would be required before all aspects of the model are fully tested. In the Contractor et al. study, six of the substructure expressions do not separately predict the real-world outcome. This could be because of the nonlinear interactions or because the substructures do not validly represent real-world phenomena in this instance. The ontological adequacy of the model is not fully resolved. More generally, sensitivity analyses would test the presence or absence of specific substructures against changes in level of ontological adequacy. Furthermore, since theory and model coevolve toward analytical adequacy, it follows that tests for ontological adequacy would have to be updated as the theory–model link coevolves.

A GUTTMAN SCALE OF EFFECTIVE SCIENCE

So far I have identified four nonrelativist postpositivisms that remain credible within the present-day philosophy of science community: the *Legacy* of positivism, *Scientific Realism*, the *Semantic Conception*, and *Selectionist Evolutionary Epistemology*. As a simple means of (1) summarizing the most important elements of these four literatures; and (2) showing how well organization 'science' measures up in terms of the institutional legitimacy standards inherent in *these* postpositivisms, I distil seven criteria essential to the pursuit of effective science (Table 3):

>>> Insert Table 3 about here <<<

The list appears as a GUTTMAN SCALE. It goes from easiest to most difficult. To be institutionally legitimate and effective, current epistemology holds that theories in organization 'science' must be accountable to these criteria. Existing strong sciences such as physics, chemistry, and biology meet all of them. Many, if not most, organization 'science' theory applications to firms do not meet any but the first. I submit that this is why organization 'science' has so little institutional legitimacy from scientific, philosophical, and user communities.

1. Avoidance of Metaphysical Terms.

This criterion *could* have been the most difficult for organization 'science' to meet and is seen as a significant issue (Godfrey and Hill, 1995). If we were to hold to the "avoid metaphysical entities at all costs" standard of the positivists, organization 'science' would fail even this minimal standard since even the basic entity, the firm, is hard to put one's hands on—that is, gain direct knowing about. Scientific realists, and especially Aronson, Harré and Way (1994), remove this problem by virtue of their "PRINCIPLE OF EPISTEMIC INVARIANCE." They argue that the "metaphysicalness" of terms is independent of scientific progress toward truth. The search and truth-testing process of science is defined as fallibilist with "probabilistic" results. Given this, it is less important to know for sure whether the fallibility lies (1) with fully *metaphysical* terms (e.g., "corporate strategy"), eventually DETECTABLE TERMS (e.g., "idiosyncratic resources"), or as measurement error with regard to OBSERVATION TERMS (e.g., "# of company cars"), or (2) the probability that the explanation or model differs from real-world phenomena (discussed in McKelvey 1999c). Whatever the reason, empirical findings are only true with some probability and selective elimination of any error improves the probability. Since metaphysicalness has been taken off the table as a standard by the scientific realists, it is one standard organization 'science' meets, if only by default.

2. Nomic Necessity.

NOMIC NECESSITY holds that one kind of protection against attempting to explain a possible accidental regularity occurs when rational logic can point to a strong relation between an underlying structure—force—that, if present, produces the result—if force *A*, then regularity *B*. Consider the "discovery" that "…legitimization affects rates of [organizational] founding and mortality…" (Hannan and Carroll, 1992, p. 33). Is this an accidental regularity? The posited causal proposition is "If legitimacy, then growth." But, there is no widely agreed upon underlying causal structure, mechanism, or process that explains the observed regularity (Zucker, 1989). Thus, if legitimacy is removed, do (most) growing firms disappear? Since there are many firms with no legitimacy that have grown rapidly because of a good product, the proposition seems false (Baum and Oliver, 1992; and Hybels, Ryan and Barley, 1994).

A different aspect of the theory of population dynamics, however, is clearly not an accidental regularity. In a niche having defined resources, a population of firms will grow almost exponentially when the population is small relative to the resources available, and growth will approach zero as the population reaches the carrying capacity of the niche (Hannan and Freeman, 1989). This proposition explains changes in population growth by identifying an underlying causal mechanism—the difference between resources used and resources available—formalized as the Lotka-Volterra logistic growth model: $dN/dt = rN(K - N/K)$.

In this case, the law came to organization 'science' before the discovery of the hypothesized organizational regularities since it was imported from theoretical ecology (Levins, 1968) by Hannan and Freeman (1977), hence the prospect of an accidental regularity is reduced. The model expresses the underlying causal mechanism and it is presumed that if the variables are measured and their relationship over time is as the model predicts then the underlying mechanism is *mostly likely* present—truth always being a probability and fallible.

3. Bifurcated Model-Centered Science.

My use of "model-centeredness" has two meanings:

(1) Are theories mathematically or computationally formalized? and (2) Are models the center of bifurcated scientific activities—the theory–model link and the model–phenomena link? Carley's (1995) review of the use of formal models in organization 'science' shows around 100 instances (see also her chapter in this volume). More now appear in the journal she co-edits, *Computational and Mathematical Organization Theory*, as well as in books such as Masuch and Warglien (1992), Carley and Prietula (1994), Burton and Obel (1995), and Prietula, Carley, and Gasser (1998). Yet a review of journals such as *ASQ*, *AMR*, *AMJ*, *OS*, and *SMJ*, not to mention Academy of Management presentations, indicates that organization 'science' is a long way from routinely formalizing the meaning of a theoretical explanation, as is common in physics, economics, and in the journal, *Management Science*. And almost no data-based empirical studies in *ASQ*, et al. have the mission of empirically testing the real-world fit of a formalized model—they invariably try to test unformalized hypotheses directly on the full complexity of the real world.

4. Experiments.

Witchcraft, shamanism, astrology, and the like, are notorious for attaching *post hoc* explanations to apparent regularities that are frequently accidental—"disaster struck in '38 after the planets were lined up thus and so." Though nomic necessity is a necessary condition, using experiments to test the propositions reflecting the law (LAW-LIKE relation) in question is critically important. Meeting nomic necessity by specifying underlying causal mechanisms is only half the problem, as has been discovered with the "legitimacy explanation" in population ecology. The *post hoc* use of "legitimacy" is an example of sticking an explanation to an accidental regularity absent the correct underlying causal mechanism. Cartwright (1983) goes so far as to say that even in physics all theories are attached to causal findings—like stamps to an envelope. The only recourse is to set up an experiment, take away cause *A* and see if regularity *B* also disappears—add *A* back in and see if *B* also reappears. Unlike marketing research and micro OB, both of which use experiments frequently, organization 'science' seldom does. Organization theory and strategy are fields particularly vulnerable to pinning theories to accidental regularities. Given that lab studies of firms are borderline impossible, naturally occurring quasi-experiments and computational experiments offer constructive substitutes.

5. Separation of Analytical and Ontological Tests.

This standard augments the nomic necessity, model-centeredness, and analytical results criteria by separating theory-testing from model-testing. In mature sciences theorizing and experimenting are usually done by different scientists. This assumes that most people are unlikely state-of-the-art on both. Thus, if we are to have an effective science applied to firms, we should eventually see two separate activities: (1) Theoreticians working on the theory–model link, using mathematical or computational model development, with analytical tests carried out via the theory–model link; and (2) Empiricists linking model-substructures to real-world structures. It is possible that some researchers would be able to compare model analytic results with real-world quasi-experimental results, as do Contractor et al. Without evidence that both of these activities are being pursued independently, as per Figure 1c, organization 'science' will remain amateurish, immature, illegitimate, and unrecognized. The prevailing organization 'science' focus on only a direct theory–phenomena link is a mistaken view of how science progresses.

6. Verisimilitude via Selection.

I ranked this standard here because the selection process happens only over time. For selection to produce any movement toward less fallible truth there need to have been numerous trials of theories of varying quality, accompanied by tests of both analytical and ontological adequacy—as defined by Steps 2 and 3 in the Contractor et al. (2000) example. So, not only do all of the previous standards have to have been met, they have to have been met across an extensive mosaic of trial-and-error learning adhering to separate analytical and ontological adequacy tests. Population ecology meets this standard quite well. As the Baum (1996) review indicates, there is a 20 year history of theory–model and model–phenomena studies with a steady inclination over the years to refine the adequacy of both links by the systematic removal of the more fallible theories and/or model ideas and the introduction and further testing of new ideas. The lack of contrived experiments has already been noted—though quasi-experiments are possible when population regulation dynamics are shown to readjust after a technological or deregulation discontinuity (Tushman and Anderson 1986, Baum, Korn and Kotha 1995).

7. Instrumental Reliability.

A glass will fall to earth every time I let go. This is 100% reliability. Four hundred years ago Kepler, using Tyco Brahe's primitive (pretelescope) instruments, created astronomical tables that improved the reliability of predicting the locations of planets to within $\pm 1'$ compared to the up to $5°$ of error in the Ptolemaic/Copernican tables. Classical physics achieves success because its theories have high INSTRUMENTAL RELIABILITY, meaning that they have high analytical adequacy—every time a proposition is tested in a properly constructed test situation the theories predict correctly and reliably. It also has high ontological adequacy because its formal models contain structures or phase-space dimensions that very accurately represent real-world phenomena "within the scope" of various theories used by engineers and scientists for many of their studies. Idealizations of models in classical physics have high isomorphism with the physical systems about which scientists and engineers are able to collect data. But, as Gell-Mann (1994) observes, laws in modern physics are no longer exact but probabilistic. *The more accurate physicists' measures, the more probabilistic their laws!*

It seems unlikely that organization 'science' will ever be able to make individual event predictions (McKelvey, 1997). Even if organization 'science' moves out from under its archaic view of research—that theories are tested by looking directly to real-world phenomena—it still will suffer in instrumental reliability compared to the natural sciences. The "*isolated idealized systems*" of natural science are more easily isolated and idealized, with lower loss of reliability, than those studied by social scientists. Natural scientists' lab experiments more reliably test nomic-based propositions and their lab experiments also have much higher ontological representative accuracy. In other words, their "closed systems" are less different from their "open systems" than is true for socio-economic systems. Consequently natural science theories produce higher instrumental reliability.

The instrumental reliability standard is truly a tough one for organization 'science'. The good news is that the semantic conception makes this standard easier to achieve. Our chances improve if we split analytical adequacy from ontological adequacy. By having some research focus only on the predictive aspects of a theory–model link, the chances improve of finding models that test propositions with higher analytical instrumental reliability—the complexities of uncontrolled real-world phenomena are absent. By having other research activities focus only on comparing *model-structures* and *processes* across the model–phenomena link, ontological instrumental reliability will also improve. In these activities, reliability hinges on the isomorphism of the structures causing both model and real-world behavior, not on whether predictions occur with high probability. Thus, in the semantic conception instrumental reliability now rests on the joint probability of two elements: (1) *predictive analytic reliability*; and (2) *model-structure reliability*, each of which is higher by itself.

Of course, instrumental reliability is no guarantee of improved verisimilitude in transcendental realism. The semantic conception protects against this with the bifurcation above. Instrumental reliability does not guarantee "predictive analytical reliability" tests of theoretical relationships about transcendental causes based on nomic necessity. If this part fails the truth-test fails. However, this does not negate the "success" and legitimacy of a science resulting from reliable instrumental operational-level event predictions even though the theory may be false. Ideally, analytic adequacy eventually catches up and replaces false theories in this circumstance.

If a science is not based on nomic necessity and centered around (preferably) formalized computational or mathematical models it has little chance of moving up the Guttman scale—it is not even on the same playing field. Such is the message of late 20th century (postpositivist) philosophy of normal science. This message tells us very clearly that in order for organization 'science' to avoid or recover from scientific discredit, and institutional illegitimacy it must become model-centered. The nonlinearity of much of our phenomena makes model-centeredness even more essential, as Contractor et al. (2000) observe.

CONCLUSION

Organization 'science' has lost its legitimacy with two external institutions, philosophy of science and user community. Philosophical legitimacy is missing for three reasons: (1) Bench scientists have never followed the Received View, whether logical positivism or logical empiricism (Suppe, 1977); (2) Whatever partial legitimacy organization 'science' might have gained from the Received View or historical relativism (Kuhn, 1962; Feyerabend, 1975) disappeared when these two epistemological programs were abandoned by philosophers in the 1970s (Suppe, 1977); and (3) Organization 'science' seems largely ignorant of the normal science postpositivisms emerging after the abandonment, with an active subgroup bent on setting up postmodernism and other relativist postpositivist epistemologies (Reed and Hughes, 1992; Hassard and Parker, 1993; Burrell, 1996). Pfeffer (1993) more than anyone worries about the lack of legitimacy among external user communities—managers and consultants largely ignore the Academy of Management and our research findings do not make front page news.

Instead of the postmodernists' anti-science path, my proposal emphasizes the four *other* postpositivisms in current philosophy of science: The *Legacy* tenets remaining from the Received View; *Scientific Realism* and *Selectionist Evolutionary Epistemology* as interpreted for organization 'science' via *Campbellian Realism* (McKelvey, 1999c); and the *Semantic Conception*. In essence, scientific activities bifurcate, focusing on (1) the coevolutionary development of the *theory–model* link and truth-testing for *analytical adequacy*—the ability of the model to test the predictive nuances of the theory, given various conditions; and (2) the coevolutionary development of the *model–phenomena* link and truth-testing for *ontological adequacy*—the ability of the model to represent real-world phenomena defined as within the scope of the theory. I conclude with a Guttman scale of scientific effectiveness criteria. It is clear that organization 'science' barely registers on this scale and that much work remains to be accomplished before its research hits the top of the scale. Population ecology does best by this scale. Perhaps this explains why it has grown so quickly in organization 'science' while remaining a minor subfield in biology.

Empirical tests in organization 'science' typically are defined in terms of a direct "theory–phenomena" corroboration, with the result that: (1) We do not have the bifurcated separation of theory–model analytical and model–phenomena ontological tests; (2) The strong analytical type of theory confirmation is seldom achieved because the attempt is to predict real-world behavior rather than model behavior; (3) Model-structures are considered invalid because their inherent idealizations usually fail isomorphically to represent real-world complexity—instrumental reliability is very low; and (4) Our models are not formalized—though this may be optional. While the semantic conception in no way represents a shift away from formalized models, Suppe (1977, p. 228) does admit the possibility of qualitative models. Though formal models exist in organization 'science' (Carley, 1995), they are marginally used at best—most theory articles do not end with a formal model, whether computational or mathematical, and most empirical studies do not begin their model–phenomena test with a formalized model.

Organization 'science' could move to a stronger epistemological footing if it followed the semantic conception. Bifurcating activity into theory–model predictions and model–phenomena comparisons would enhance both analytical and ontological adequacy—it would actually make the task of producing a more effective science easier. If model-structures representing a complex real world can be developed, then: (1) Theoreticians can work on developing formalized mathematical or computational models, both activities of which require technical skills outside the range of many organization scientists; (2) The organization 'science' equivalent of laboratory scientists can work on enhancing model–phenomena adequacy by making and testing predictions to test analytical statements; (3) Empiricists can make comparison tests between model and phenomena "within the scope" of the theory and work on generating findings comparing model-structures with functionally equivalent real-world structures.

Campbellian realism combined with the model-centered semantic conception makes effective science a more realistic organization 'science' objective for several reasons:

1. A fallibilist realist epistemology lowers the standard of truth-seeking from unequivocal Truth with a capital T, to a more approachable human scale definition of verisimilitude, that is, more truthlike theories remain after the more fallible ideas have been selectively winnowed away.
2. A model-centered epistemology that separates the theory–model link from the model–phenomena link makes each activity more manageable, sets up differentiated standards for truth-testing, and allows scholars to become more specialized in one or another side of science, if they wish.
3. The new normal science postpositivisms are actually closer to the logic-in-use in organization 'science' than reconstructions following narrowly from the Received View, though the standards imposed by the Guttman scale are still far from being achieved.
4. An organization 'science' that is more legitimate in terms of the current normal science postpositivisms should produce results that in fact will also increase legitimacy in terms of criteria held dear by user constituencies.

The best way to fend off the anti-science attack by the postmodernists is to develop an organization 'science' that works better because it better meets the institutional legitimacy requirements of both academic and external user communities. I consider how organization studies might become a more legitimate science in McKelvey (forthcoming).

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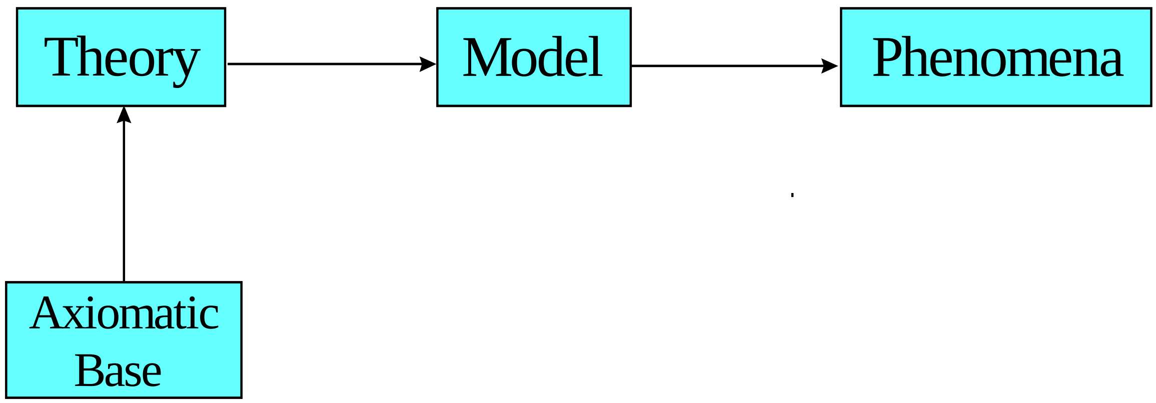
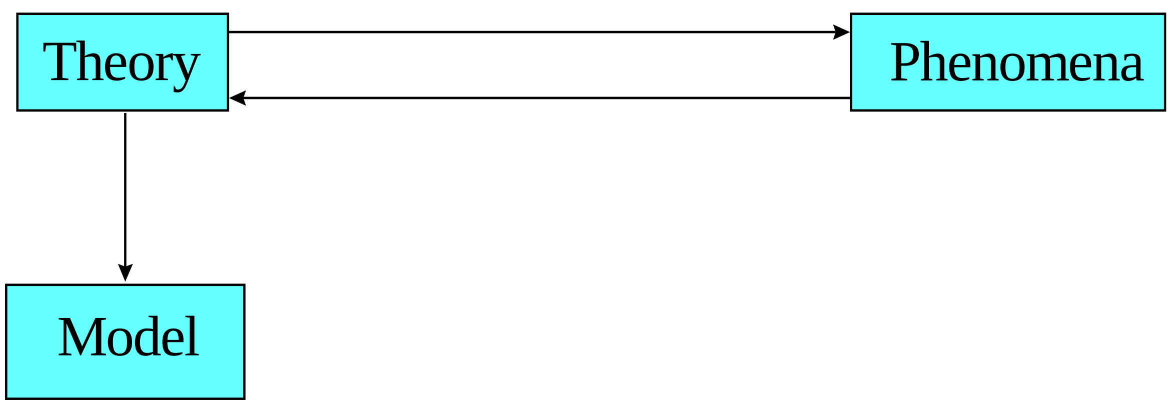
*Underlining identifies suggested background readings.

Figure 1 **Conceptions of the Axiom-Theory–model–phenomena Relationship**

1a Axiomatic Conception



1b Organization Science Conception



1c Semantic Conception

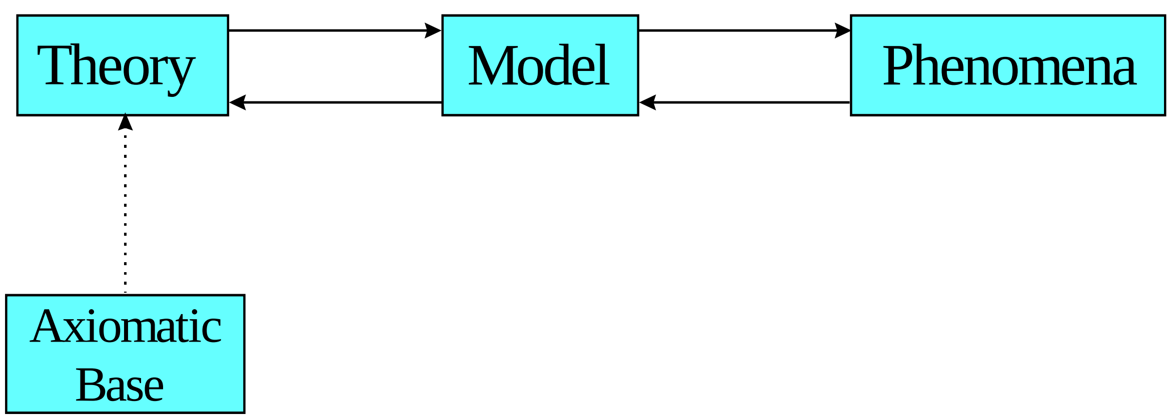


Table 1 Suggested Tenets for a Campbellian Realist Organization Science

Organization science:

1. Is an objectivist science that includes terms in all three REALMS.
2. Recognizes that though the semantic meanings of all terms are subject to interpretation and social construction by individuals and the scientific community, this semantic relativism does not thwart the eventual goal of an objective, though fallible, search for increased verisimilitude.
3. Includes a selectionist evolutionary process of knowledge development that systematically winnows out the more fallible theories, terms, and entities over time.
4. Does not, as a result of its selectionist process, systematically favor either operational or metaphysical terms.
5. Accepts the principle that the true/false dichotomy is replaced by verisimilitude and degrees or probabilities of truthlikeness. †
6. Includes theories that are eventually the result of fallible incremental inductions eliminating those having less probable verisimilitude. †
7. Because knowledge concerning Realm 1 and 2 terms and entities is at best probable, tentative belief in the probable existence and verisimilitude of Realm 3 terms is no less truthlike than the fallible truth associated with theories comprising Reams 1 and 2 terms and entities. †
8. Defines theories to consist of LAW-LIKE statements having predictive elements capable of being tested for analytical adequacy. ‡
9. Insists that theories be based on (preferably formalized) models representing that portion of phenomena within the scope of the theory and subject to tests for ontological adequacy. ‡
10. Defines verisimilitude in terms of the content of its models. ‡
11. Is based on a convergent realism in which there is a functional relationship such that increased verisimilitude serves to reduce the error in measures and predictions and vice versa. ‡
12. Holds that the relation between (1) theory and prediction; and (2) organizations and how they behave, remains independent of whether terms and entities are in Realms 1, 2, or 3. ‡

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† From de Regt (1994).

‡ From Aronson, Harré and Way (1994).

Table 2 Model Substructures Defined †

Exogenous Mechanisms

$\Delta C_{S_{ij}} = S_{ij}$: Cell S_{ij} is coded 1 if *i* is the superior of *j* (or vice versa)—because supervisors initiate more communication with subordinates than the reverse.

$\Delta C_{HL_{ij}} = HL_{ij}$: Cell HL_{ij} is weighted more if *i* and *j* are higher level managers—because coordination oriented communication is directly related to level in the hierarchy.

$\Delta C_{P_{ij}} = P_{ij}$: Cell P_{ij} is weighted to indicate the proximity of *i* to *j*.

$\Delta C_{E_{ij}} = E_{ij}$: Cell E_{ij} is coded 1 if *i* and *j* email each other.

$\Delta C_{W_{ij}} = W_{ij}$: Cell W_{ij} is indexed to reflect workflow interdependency between *i* and *j*.

$\Delta C_{F_{ij}} = F_{ij}$: Cell F_{ij} is coded 1 if *i* reports that *j* is a friend (or vice versa).

$\Delta C_{A_{ij}} = A_{ij}$: Cell A_{ij} is indexed to show the number of common activity foci between *i* and *j*.

Endogenous Mechanisms

$\Delta C_{tr_{ij_t}} = \sum_{k=1}^{N} C_{ik_{t-1}} C_{kj_{t-1}}$: Cell C_{ij} is indexed upward if *i* and *j* both communicate with *k*, reflecting Heider's (1958) balance theory.

$\Delta C_{co_{ij_t}} = \left(g_{d_{t-1}} - g_{d_{mean_{t-1}}} \right)$: Cell C_{ij} is indexed to show the level of network density of *i* and *j*'s group relative to the mean of all group network densities—because groups with higher levels of cohesion have higher levels of communication among members, reflecting Homans (1950).

$\Delta C_{HO_{ij_t}} = -\left(\sum_{k=1}^{N} \frac{C_{jk_{t-1}} C_{ki_{t-1}}}{\left(C_{\max_{t-1}}\right)^2} + \sum_{k=1}^{N} \frac{C_{ki_{t-1}}}{C_{SE_{jk_{t-1}}} - C_{SE_{\min_{t-1}}} + 1} \right)$: Cell C_{ij} is weighted downward to the extent that structural equivalence reduced the need for *i* and *j* to communicate directly with each other, following Burt's (1992) structural hole theory.

† From Contractor et al. (2000).

Table 3 Guttman Scale

1.	Avoidance of Metaphysical Terms	Minimal Scientific Standard
2.	Nomic Necessity	↑
3.	Model-Centeredness	
4.	Experiments	
5.	Separation of Analytical and Ontological Tests	
6.	Verisimilitude via Selection	↓
7.	Instrumental Reliability	Highest Scientific Standard

Glossary*

1. **ANALYTICAL ADEQUACY** indicates the ability of a model, to accurately match or represent the real-world phenomena within the scope of the theory upon which the model is based.
2. **AUXILIARY HYPOTHESES** are unstated relationships presumed to be true in any specific empirical test. For example, suppose an investigation explicitly states the hypothesis that poor performance leads to diversification and includes several control variables. The many economic, psychological, social, and strategic governing relationships presumed true, other effects presumed randomized, and theories of experiment, method, and data not explicitly stated, all exist as unstated auxiliary hypotheses.
3. **AXIOMATIC CONCEPTION** presumes that all laws in a science can be mathematically deduced from basic axioms stated in mathematical syntax. In physics, Newton's three laws of motion (including $F = ma$) and law of gravity are consider the root axioms. Once it was discovered that laws of motion, heat/energy, and electromagnetism all could be reduced to axioms of common mathematical SYNTACTICAL form, POSITIVISTS concluded that fields of study not build on this aspect were not science. As Mirowski (1989) argues, economists base the legitimacy of their field on the axiomatic conception.
4. **CAMPBELLIAN REALISM** is a concept of REALISM begun by Donald Campbell and elaborated by McKelvey (1999c) holding that social science can be objective even when using METAPHYSICAL TERMS; move toward improved truth via the evolutionary selection out of poorer theories; describe a changing science using RELATIVIST assumptions; without excluding individual interpretation nor SOCIAL CONSTRUCTION.
5. **CLASSICAL EMPIRICISM** holds that knowledge of the real world rests only upon direct human observation and experience and is build up from atomized facts. See POSITIVISM.
6. **COHERENCE THEORY** is an element of hermeneutics focusing on how scholars come to agreement, given initially varying interpretations of language, a key feature being the "principle of charity" wherein scholars initially presume that the views of each participating scholar have merit.
7. **CONTRA SCIENCE** is a label Clegg and Hardy (1996) use to refer to EPISTEMOLOGIES outside NORMAL SCIENCE, such as RELATIVISM, interpretism, functionalism, phenomenology, radical humanism, POSTMODERNISM, etc.
8. **CORRESPONDENCE RULES** are used by LOGICAL POSITIVISTS to define THEORETICAL TERMS, guarantee their cognitive significance, and to specify the procedure by which they are attached to OBSERVATION TERMS. Since theory terms are not allowed independent meaning, but could not be METAPHYSICAL either, the CORRESPONDENCE RULES were required to tie theory terms explicitly to real-world phenomena. For example, these rules would tie the number seen on a particular kind of scale with the abstract, general concept of mass.
9. **DETECTABLE TERMS** (REALM 2 terms) fall in between the REAL and METAPHYSICAL ends of a continuum. REAL TERMS are those that are, in principle, accessible by the human senses. METAPHYSICAL TERMS are not, given today's conception of science and the real world. Detectable terms, in principle, could become REAL. For example, Jupiter's moons were not real for Kepler since he did not have a telescope; were more real for Galileo since he saw through his telescope what he thought were moons; and are very real if, eventually, one was in a rocket that crashed on one of them.
10. **DISCOVERY LOGIC** is a misnomer. There is no "logic" to discovery. "Many, if not most, major scientific discoveries are flashes of perceptual insight…." (Hunt 1991, p. 24). A classic is Kekulé's reputed "discovery" of the structural formula for the benzene ring because of seeing imaginary snakes in the flames in his fireplace when one seemed to form a ring by biting its tail.
11. **EPISTEMOLOGY** is the study of kinds of knowledge, how we come to know, by what right we can believe some statement to be true, which is to say, by what rules of JUSTIFICATION LOGIC have we come to a particular belief about the real world.
12. **EVOLUTIONARY EPISTEMOLOGY**, a key element of CAMPBELLIAN REALISM, holds that the dynamics of science are best interpreted as an evolutionary Darwinian SELECTIONIST process in which a less FALLIBLE version of

truth results as the more fallible individual interpretations of facts and expositions of theory and SOCIAL CONSTRUCTIONS of facts by scientific communities of real-world (causal) processes, are winnowed out over time. This is not to say there is any guarantee of convergence on a nonprobabilistic, absolutist Truth (Laudan 1981), only that inferior ideas are winnowed out over time.

13. **FALLIBILIST** (realist) epistemology lowers the standard of truth-seeking from unequivocal, absolutist Truth, to a more approachable human-scale definition of verisimilitude, that is, more truthlike theories remain after the more fallible ideas have been selectively winnowed away.

14. **FIRST PHILOSOPHY** is the metaphysical analysis of "being" or entitativity. If an entity is to be taken as "real" it must either be an individual thing, or an event, or a property, or a relation or distance to other things and events. First philosophy developed criteria for defining these characteristics. At issue is whether the things, et al. are "material" (real) or in the minds of observers and, thus unreal or "idealistic." The debate continues between normal science realists and postmodernist anti-realists.

15. **FORMAL MODEL** is one stated in a formal language such as set-theory, mathematics, symbolic logic, or computer programming language.

16. **FOUNDATIONALISM.** In this view there are two kinds of beliefs or statements: Foundational beliefs (or statements) are not inferentially justified by reference to other beliefs. They stand on their own as true—hence "foundational." The second kind of beliefs become true because they are inferentially justified by reference to foundational statements. This is the *radical* form of foundationalism. The *modest* view recognizes both kinds of statements, but does not hold that foundational statements are guaranteed with certainty to be true (Audi 1995, p. 277).

17. **GENERATIVE MECHANISMS** are the (usually) unobservable processes, that realists believe are nonetheless real, at higher or lower levels of analysis that cause behavior at a given level of analysis and, thus, are the bases of scientific explanation.

18. **GUTTMAN SCALE** is one in which each higher level of the scale includes all of the information, attributes, or elements measured at lower levels of the scale—it is cumulative.

19. **HISTORICAL RELATIVISM**, built upon the founding works of Kuhn (1962) and Feyerabend (1975), holds that an objective view of phenomena and cause cannot exist because individual scientists interpret means of terms "relative to a *Weltanschauung* [world view] or conceptual perspective upon which the meanings of terms are dependent" (Suppe 1977, p. 120). Depending upon the *Weltanschauung* of which they are members, scientists have idiosyncratic interpretations of what they see, what they read, and how they apply the rules of JUSTIFICATION LOGIC, leading to an "anything goes" standard of what qualifies as truth. This is particularly true over time as scientific communities shift from one dominant PARADIGM or *Weltanschauung* to another. This leads to INCOMMENSURABILITY.

20. **ICONIC MODEL** is a pictorial, graphic, physical, or mechanical representation—could be boxes-and-arrows, an airplane wind tunnel model, a working mechanical device, and so on.

21. **IDIOSYNCRATIC MICROSTATES**, called agents in agent-based modeling, are below the lower bound of normal puzzle solving in a science. Traditionally they were assumed uniform, and therefore ignored for the sake of instrumental convenience, but now they are often assumed stochastically idiosyncratic (McKelvey 1997) with the question becoming, How does order emerge from such agents?

22. **INCOMMENSURABILITY** is a term dating back to Kuhn's 1962 book. Given that PARADIGMS SHIFT, Kuhn held that there would be sufficiently dramatic enough changes in (1) problems to be solved; (2) meanings of theoretical terms and concepts; and (3) standards and methods of JUSTIFICATION LOGIC that it would be impossible for adherents of the previous PARADIGM to assess the truth value of the new paradigm.

23. **INSTRUMENTAL RELIABILITY** pertains to the level of accuracy and consistency that event a at time t predicts event b occurring at time $t + n$.

24. **ISOLATED IDEALIZED STRUCTURES** are simplified views of complex real-world phenomena such as pure elements and vacuums, ideal gases, frictionless surfaces, perfectly round masses (planets), 'standard conditions', unmutated genes, and rational actors—what the semantic conception view holds that theories attempt to explain. This is to say that no theory is actually about real-world phenomena in its full complexity.

25. **JUSTIFICATION LOGIC** refers to the rules and criteria a scientific community imposes on its members in an attempt to assure that they have an objective, replicable, and useful (operational) means of assessing the truth value of their hypotheses, laws, and theories.

26. **LAW-LIKE statements** are statements have a high probability of truth (in scientific realist terms) and but are not yet proven to be universally true (in positivist terms). Thus, the law of gravity is accepted as universally true, whereas the population ecology statement, that organizational failures happen because environmental carrying capacity has been reached, is highly corroborated, and reasonably lawlike, but not yet accepted as a universal law.

27. **LOGICAL EMPIRICISM** is exemplified in the work of Nagel (1961), Kaplan (1964), and Hempel (1965). It attempted to recover from the misguided excesses of logical positivism. It gave up the notion of VERIFIABILITY and, thus, "positivism" in favor of Carnap's "gradually increasing confirmation" and "testability" and Reichenbach's introduction of probability. It emphasized laws, theories, and explanation. It continued the positivist's aversion to metaphysical terms including causality, maintained the distinction between theory and observation terms and because of this retained CORRESPONDENCE RULES, and equated explanation and prediction. Hempel's (1965) deductive-nomological and deductive statistical models of explanation represent it best. "Causality" is a term assiduously avoided throughout the Hempel and Kaplan books!

28. **LOGICAL POSITIVISM** began with the so-called Vienna Circle in 1907 as a response against German idealism. It emphasized the analysis of scientific language and

especially the use of formal logic such as mathematics—hence the "logical." The use of "positivism" in the label emphasized its: abhorrence of METAPHYSICAL TERMS, including causality; its reliance on facts directly accessible to the human senses; reliance on instrumentalism (one variable predicts another) instead of searching for underlying, seemingly unreal (metaphysical) causal GENERATIVE MECHANISMS; strict separation of theory terms from observation terms and as a result of this; use of correspondence rules to allow tight connection between empirical facts and theories. All for the purpose of assuring VERIFICATION of Truth—a statement is either totally and verifiably true or it is false.

29. MAPPING MODEL is Azevedo's (1997) way of connecting theory to the semantic conception's 'isolated idealized structures'. A "map" in her usage is a simplified (isolated idealized) rendition of a complex reality designed with the specific interests of the map maker in mind—location of for minerals, identification of rivers and mountains, delineation of roads, etc. It is useful simply because it does not attempt to describe all of a complex reality. Semantic conceptionists view theory similarly.

30. METAPHYSICAL TERMS and concepts (REALM 3) are those LOGICAL POSITIVISTS believe have no likelihood of being directly observable or potentially DETECTABLE by methods currently imaginable by a scientific community. To Ernst Mach, atoms were metaphysical. To other scientists, seeing tracks in a cloud chamber, atoms are accepted as "detected." The reader can decide whether psychological needs, norms, transaction costs, strategies, or transcendental causes are real, detectable, or metaphysical.

31. MODEL-SUBSTRUCTURES are identified by semantic conceptionists as components of a model that represent a usually causal element of complex real-world phenomena thought within the scope of the theory the model depicts.

32. NOMIC NECESSITY holds that the occurrence of any phenomenon cannot be due to chance but instead is due to some other phenomenon. The requirement of nomic necessity is to protect against attempting to build a theory or explanation on an accidental regularity—the occurrence of an event by chance. Any theoretical statement must have one or more elements that meet the nomic necessity requirement. This requirement is an element of the legacy of logical positivism that still has philosophical legitimacy.

33. NORMAL SCIENCE is the stage of science (including normal puzzle solving) that occurs between paradigm shifts in Kuhn's framework. For others "normal science" usually refers to what natural and life scientists do as they conduct their investigations—whether or not paradigm shifts are underway. Relativists and postmodernists use the term to refer to people doing (modernist) science that more or less looks like what is seemingly (really falsely) described by logical positivism and logical empiricism.

34. OBSERVATION LANGUAGE refers to OBSERVATION TERMS or concepts designed to explicitly measure observable phenomena. For POSITIVISTS this means facts directly accessible to the human senses—and for LOGICAL POSITIVISTS no theoretical term can be an observation term (a distinction impossible for them to maintain).

35. OBSERVATION TERMS refer to observable facts directly accessible by the human senses. LOGICAL POSITIVISTS held that they were strictly separate from theoretical terms. CORRESPONDENCE RULES were devised to connect the two. Eventually it was found impossible to keep them separate—one of the many critiques against the RECEIVED VIEW. An OBSERVATION TERM may have one or more competing OPERATIONAL TERMS.

36. ONTOLOGICAL ADEQUACY in the semantic and realist conceptions refers to the ability of a model to represent the real-world phenomena (entities and properties) within the scope of the theory. Ontological adequacy may be tested substructure by substructure when the phenomena covered by the model (and theory) cannot reasonably be separated out as an ISOLATED IDEALIZED behavior, that is, reasonably disconnected from extraneous effects not included in the model.

37. ONTOLOGY is the study of beingness—whether anything actually exists as an entity in the real world having properties of some kind. Scientific realists take an ontologically strong view that entities and relationships do exist in the world "out there" and serve as criteria against which models are to be tested for representation (Aronson, Harré and Way 1994).

38. OPERATIONAL TERMS are not the same as observation terms (making up observation language) in logical positivism. An operational term is the actual measure—a "number" coming from a mercury barometer vs. one from an aneroid barometer. An observation term accessible to the human senses could be measured any one of several competing operational terms.

39. ORGANIZATION 'SCIENCE'. A reading of Kuhn's (1970) chapter 2 makes it quite clear that *organization science* is "prescience" and not "science," as does Azevedo (this volume). I elaborate on this at some length in McKelvey (forthcoming). I could have used organization *studies*, as did Clegg, Hardy, and Nord (1996) in the title of their *Handbook of Organization Studies*, but then I would be confusing their postmodernist anti-science predilections with my pro-science recognition of organization 'science's' prescience state. Consequently I simply remind the reader of its questionable status by using "organization 'science'."

40. PARADIGM SHIFTS, in Kuhn's (1962) framework, separate one program of normal puzzle solving from a subsequent one. Based mainly on a reading of physics, Kuhn argued that stable periods of normal puzzle solving were punctuated by revolutions—called paradigm shifts. His view of scientific change as a series of revolutions was a dramatic departure from the prevailing view of LOGICAL EMPIRICISTS—that change was a slow, smooth, cumulative, and incremental process as new facts forced revisions in theories. During a prolonged period of normal puzzle solving, anomalies accumulate to the point where they topple an existing paradigm. After the shift INCOMMENSURABILITY results.

41. PARADIGMS became one of the most discussed elements of epistemological discourse after Kuhn's (1962) book appeared. A paradigm is "a set of scientific and metaphysical beliefs that make up a theoretical framework within which scientific theories can be tested, evaluated, and if necessary, revised" (Audi, 1995). They define: legitimate problems to be studied, exemplar methods, concrete problem solutions underlying JUSTIFICATION

LOGIC, and the nature of scientific training programs. These all create inertia preventing change. Masterman (1970) shows that Kuhn uses paradigm in twenty-one different ways. As a result of this and other complaints, Kuhn (1970, Postscript) introduces "disciplinary matrix" to avoid the definitional confusion. Disciplinary matrix represents the totality of beliefs connected to "paradigm." He substitutes "exemplar" where a paradigm plays the role of setting up standards and defining training programs.

42. **POSITIVISM** (classical positivism) dates back to August Comte and Ernst Mach's views that any theory not based on observable fact is meaningless. An organizational version of classical positivism is Pfeffer's (1982) call for a focus on observable organizational demographics—which Lawrence (1997) shows was unsuccessful in that subsequent organizational demographers kept using metaphysical terms anyway!

43. **POSITIVIST LEGACY**. Suppe (1977) identifies ten elements remaining from the RECEIVED VIEW that continue to have value in subsequent epistemology—reference to empirical reality, logical rigor, AUXILIARY HYPOTHESES, FORMAL MODELS, and semantic interpretation. Hunt (1991) adds six additional elements emphasizing NOMIC NECESSITY and experiments. These are listed in McKelvey (1999c). These elements are carried forward—all too often rather implicitly—in the recent scientific realist literature.

44. **POSTMODERNISM** is a many faceted statement against the Enlightenment. More specifically it is against reason, rationality, and instrumental rationality—the idea that the main purpose of knowledge is for social control and to direct innovation and change (Hassard 1993). Postmodernists focus "…on the constructed nature of people and reality, emphasizing language as a system of distinctions which are central to the construction process, arguing against grand narratives and large-scale theoretical systems such as Marxism or functionalism, emphasizing the power/knowledge connection and the role of claims of expertise in systems of domination, emphasizing the fluid and hyperreal nature of the contemporary world and role of mass media and information technologies, and stressing narrative/fiction/rhetoric as central to the research process (Alvesson and Deetz 1996, pp. 192–193). At its core, postmodernism rests on RELATIVISM.

45. **POSTSTRUCTURALISM.** Structuralists have their origin in Saussure's "scientific" model of language as a closed system of elements and rules. They place equal emphasis on the "*signifier*" ("the sound image made by the word 'apple'") and the "*signified*" (the apple), with the linguistic "*sign*" or relationship between the two a matter of social convention. Poststructuralists, starting with Derrida, made the signifier dominant with little determinable relation to extra-linguistic referents. "Structuralism sees truth as being 'behind' or 'within' a text, poststructuralism stresses the interaction of reader and text…" Poststructuralism is "…quite radically anti-scientific" (Sarup, 1993, pp. 2–3)

46. **PRAGMATISM** holds that true beliefs are those that lead to desirable actions and results. The development of knowledge is guided by interests and values—it is an instrumental tool for organizing experience. Truth cannot be determined solely by epistemological criteria.

47. **PRE-SCIENTIFIC.** Kuhn (1970) emphasizes the "class of schools" (paradigms) as the dominant indicator the pre-scientific status of a field. Other signs are low consensus on problems, more speculative theories, high journal rejection rates, books the preferred medium, gathering of "random" readily available facts as low hanging fruit, less separation of field from society (Hoyningen-Huene, 1993, p. 190; Pfeffer, 1993).

48. **PRINCIPLE OF EPISTEMIC INVARIANCE** holds that "When it comes to gathering evidence for our beliefs, *the epistemological situation remains the same for observables and unobservables alike*, no matter whether we are dealing with observables, possible observables or unobservables [REALMS 1, 2, and 3]" (Aronson, Harré and Way 1994, p. 194; their italics). This epitomizes the scientific realists' blurring of the consequences of real vs. metaphysical concepts and terms. Their argument is that since the truth of a statement or theory is more or less probable—(as opposed to VERIFIABLY True or False as absolutes), and since there are various probabilities associated with any research method, the relative realness or metaphysicalness of terms is just another probability to be included amongst the others as a statement or theory becomes more truthlike and/or LAW-LIKE.

49. **PROGRAM** is a label applied to a body of work that extends beyond a few articles and represents a significant, extended, and coherent intellectual or epistemological development. Hooker's several books on naturalist EVOLUTIONARY EPISTEMOLOGY are an example, as is Bhaskar's book on TRANSCENDENTAL REALISM. Campbell's accumulation of papers about his "*critical, hypothetical, corrigible, scientific realist selectionist evolutionary* epistemology" also fits.

50. **REAL TERMS.** See REALM 1 entities.

51. **REALISM** (scientific or metaphysical realism) holds that there are (1) real entities in the world "out there;" (2) that exist independently of our perception, experience, or knowledge of them; and (3) that they have properties and relationships that are independent of the concepts or language we use to describe them (Audi 1995, p.488). Scientific realists blur the distinction between METAPHYSICAL and REAL terms, holding that underlying GENERATIVE MECHANISMS or causes not directly accessible to the human senses are nevertheless real, and not to be relegated to the scientific dustbin.

52. **REALMS.** *Realm 1* entities are currently observable (number of employees in a firm); *Realm 2* entities are currently unobservable but potentially detectable (process event networks in a firm); and *Realm 3* entities are metaphysical and beyond any possibility of observation by any conception of current science (psychological need, environmental uncertainty, underlying cause) (Harré 1989). Pols (1992) terms Realm 1 observations "*direct knowing*" and Realm 3 observations "*indirect knowing*."

53. **RECEIVED VIEW** refers to LOGICAL POSITIVISM and its evolved successor, LOGICAL EMPIRICISM.

54. **RELATIVISM**. Cognitive (here epistemological) relativism holds that the world has no intrinsic characteristics—there are just different ways of interpreting it. Rorty is quoted as saying, """objective truth is no more and no less than the best idea we currently have about how to explain what is going on" (Audi 1995, p. 690). Relativism "denies the existence of any standard or criterion higher than the individual by which claims to truth and knowledge can be adjudicated" (Siegel quoted in Hunt 1991, p. 218). For many, relativism especially characterizes the work of Kuhn (1962) and Feyerabend (1975) to the effect that "anything goes"—since each scientist has an idiosyncratic interpretation of facts and linguistic terms, there can be no such thing as an universally objective justification logic. See HISTORICAL RELATIVISM.

55. **SELECTIONIST** is an adjective used to describe any approach that more or less follows Darwinian natural selection theory—over time, in the context of external criterion variables, less favorable entities are winnowed out.

56. **SEMANTIC MEANING** is attached to formal theoretical terms via CORRESPONDENCE RULES. Thus, the syntax, $x = yz$, could appear as the more familiar $F = ma$ with meanings from the study of motion attached via correspondence rules. Or different rules could attached different meanings to the $x = yz$ syntax in thermodynamics, electromagnetism, economics, etc.

57. **SOLIPSISM** (broadly) holds that behavior is a function of desires, hopes, and fears that are psychological states occurring inside the mind or brain and, thus, are the only causes of observable human behavior. Each individual is said to be isolated from all other persons or external things as a result of egocentrism and unique: experiences, semantic interpretations, and psychological states. This leads to ontological solipsism, which holds that there is no reality external to our minds, and that we are epistemologically isolated from the real world as well.

58. **THEORETICAL LANGUAGE** consists of theoretical terms. These are allowed by logical positivists as useful abbreviations of more complicated and varied OBSERVATIONAL and OPERATIONAL descriptions. Thus, there is the theory term, mass; descriptions of mass or weight meaningful to human senses such as planet, ball, big truck; and various operational weight measures with numbers. The danger was that theory terms could become disassociated from observation terms, thereby becoming meaningless metaphysical terms. But if they are they same as operational terms they are unnecessary. This is known as the theoretician's dilemma (Hempel 1965, p. 186).

59. **TRANSCENDENTAL IDEALISM** (from Kant) holds that it is possible for a scientific community to move toward an intersubjectively valid and even objectively based imagining of properties such as sound and color as existing relative to our sensibilities while at the same not accepting that they exist as real entities. Transcendental idealism accepts that social construction exists in scientific communities. Bhaskar (1975) appropriately places transcendental idealism between classical realism (science can only be based on atomistic facts having observed regularity) and transcendental realism which holds that there are intransitive entities and relations among them existing independently of human perception.

60. **UNITY OF SCIENCE.** A view, held mainly by logical empiricists, that all sciences could eventually be reduced to a universal observation language, and that all theories could eventually be reduced to one basic theory (in physics). This view gained headway when it was discovered that analytical mechanics, thermodynamics, electrodynamics, and economics could be reduced to the root axiom, $F = ma$. This led to the AXIOMATIC CONCEPTION of science.

61. **VERIFICATION PRINCIPLE** holds that all scientific statements are to be logically or empirically shown to be True or False, otherwise they are meaningless. Statements are subdivided into elements, each of which is then logically (formally) analyzed as to Truth or Falseness or connected to a fact. Elements are recombined into a truth-table to ascertain the Truth of the more complex statement. Absent this, statements are meaningless.

62. **VERISIMILITUDE** is the same as truthlikeness. Because philosophers moved away from an absolutist view of theoretical statements as either True or False (that is, the LOGICAL POSITIVISTS' verification of theories), toward Carnap's testability and evolutionary epistemology, Popper (1979) developed the idea of verisimilitude. As poorer theories are winnowed out in selectionist fashion, theories with improved verisimilitude remain.

Unless otherwise specified the definitions are based on discussions in Hunt (1991) and Audi (1995).