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AXIOMATIC THEORIES OF INTENTIONAL SYSTEMS: METHODOLOGY OF THEORY CONSTRUCTION

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This is the second article in a series relating to the development of axiomatic theories of intentional systems. This article presents a critique of methodologies for scientific discovery, and provides an alternative by which comprehensive, consistent, and complete theories in the social sciences can be developed. Further, it is argued that only axiomatic theories provide the means by which reliable evaluations and predictions can be obtained. A discussion of the hypothesis-driven methodologies of the social sciences is provided and why such methodologies do not result in scientific theories. Pursuant to Charles S. Peirce and subsequent confirmation by Elizabeth Steiner, theory development is the result of a reasoning process identified as *retroduction*. The hypothetico-deductive and grounded theory methodologies are considered and shown that they do not develop theory. It is argued that the reliance of social scientists on hypothesis-driven methodologies has compromised their ability to develop legitimate theory and has resulted in frustration by those who recognize that there is a serious problem in this industry concerning the development of social science theory.

Keywords: General systems theory, intentional systems, behavioral theory, education theory, ATIS, retroduction, abduction, theory development, axiomatic theories, hypothetico-deductive, grounded theory.

1. INTRODUCTION

In my first report, *'General System' Defined for Predictive Technologies of A-GSBT*, I briefly described the development of general systems theory and the work that led to the development of A-GSBT. Therein I indicated that the concept of defining *A-GSBT* as an *option set*. Such an interpretation is a distinct divergence from the prevailing interpretation of a general systems theory. This distinction will be explicated in this report.

An analysis of the prevailing methodologies for theory development in the social sciences is provided and why such methodologies do not develop theory.

Before discussing methodologies of theory construction, I will update my previous report with modifications that will make the definition of general system based on more basic elements, and will change the identification of the theory model to more adequately address certain issues involving connotations of 'behavioral'.

2. MODIFICATION OF FIRST ARTICLE

To avoid confusion resulting from various connotations of 'behavioral' as used in my first report with the identification of *A-GSBT* (Axiomatic-General Systems Behavioral Theory), I have renamed the theory model to *ATIS—Axiomatic Theories of Intentional Systems*. While the theory model that is

being developed may apply to a variety of systems, possibly to the full extent as conceived by Bertalanffy, the initial development is restricted specifically to *intentional systems*.

Second, I have refined the definition of *general system* by defining the *transition function set* by its more basic elements—*qualifiers*. That is:

DEFINITION: General system, $\mathcal{G}$, $=_{df}$ an ordered sequence of five parameters: *object-partitioning set* ($\mathcal{P}$), *affect relations set* ($\mathcal{A}$), *time set* ($\mathcal{T}$), *qualifier set* ($\mathcal{Q}$), and *system state-transition function* (σ).

$$\mathcal{G} =_{df} (\mathcal{P}, \mathcal{A}, \mathcal{T}, \mathcal{Q}, \sigma)$$

General system is defined as a set of partitioned components on which are defined relations that are sequenced by a time-set, controlled by a qualifier-set, and mapped by a system state-transition function.

The reason for this refinement of the definition of *general system* is that it is the qualifiers that actually determine the movement of the components of a system by the feed-transition functions. That is, any "movement" of components of a system is the result of a σ-function defined as a mapping from the product of a component-set and a qualifier-set to the target set.

In future reports, I will extend the logical development of this theory model. However, in this report I will consider a methodology of theory construction and the use of an *option set* to make *ATIS* applicable to various intentional systems. This discussion is required first so that a better understanding is obtained as to the rationale for the development of *ATIS*.

As will be shown, the hypothesis-driven methodology of the social sciences is not intended to result in the development of theory, but to answer very specific questions relating to specific observations.

3. HYPOTHESIS-BASED RESEARCH METHODOLOGIES

The social sciences, in particular, have relied on hypothesis-driven research to arrive at decisions concerning their industry. As will be seen, however, such research methodology cannot result in predictive outcomes beyond the specific case evaluated. Whereas validated hypotheses may help make decisions concerning narrowly-defined problems, they do not provide a basis for predicting outcomes under differing conditions.

The problem with hypothesis-driven methodologies has been recognized in the social sciences by various researchers, but no alternative has been generally accepted. Essentially, social scientists have defined-themselves-out of theory development as an alternative, since they keep attempting to refine a methodology that cannot devise theory.

3.1. Theory Construction in the Social Sciences

To understand the place of theory in the social sciences, it is instructive to review the different interpretations of theory that have been proposed. In particular, it is critical to understand that hypotheses do not result in theory and the almost total reliance of the social sciences on hypothesis testing is the primary reason why there are no generally accepted theories in the social sciences, and none that are comprehensive, consistent, complete and axiomatic.

Charles Sanders Peirce. As Peirce's *abduction* is frequently misidentified with retroduction, it is important to note that Peirce recognized the confusion. From the collected papers of Charles Sanders Peirce (Peirce, 1896), we find the following:

> **§10. KINDS OF REASONING**
>
> 65. There are in science three fundamentally different kinds of reasoning, Deduction (called by Aristotle συναγωγή or αναγωγή), Induction (Aristotle's and Plato's έπαγωγή) and Retroduction (Aristotle's άπαγωγή), but misunderstood because of corrupt text, and as misunderstood usually translated *abduction*. Besides these three, Analogy (Aristotle's παραδειγμα) combines the characters of Induction and Retroduction.

Almost 100 years prior to the work of Steiner (Steiner, 1988), in the 1890's Peirce clearly stated the process for developing theory. It is clear, however, as will be discussed below, that in the social science disciplines there has been a misunderstanding of just what that process entails.

Ludwig von Bertalanffy. In 1950, Ludwig von Bertalanffy wrote "An Outline of General Systems Theory," (Bertalanffy, 1950). The writing of this report followed his initial attempt at presenting his concepts on General Systems Theory at a lecture in 1937 at the University of Chicago. The scientific community did not receive his initial efforts well, but his report of 1950 has had widespread acceptance and has produced numerous additional related studies.

Kurt Lewin. At about the same time that Bertalanffy was developing his work on General Systems Theory; in 1936 Kurt Lewin was developing a theory of the social sciences, his "topological field theory" (Lewin, 1936). In this theory, Lewin introduced mathematical terminology to study human behavior. The problem with Lewin's work, however, was that it did not utilize mathematical topology. Although he attempted to present the image of a mathematical theory, in fact it was not. Lewin's theory was a descriptive theory that utilized mathematical concepts but not the mathematics.

For example, Lewin introduced the "mathematical equation" $B = f(P,E)$ with the intention of asserting that *behavior* is equal to a *function* of two variables, *person* and *environment*. Further, this "function" was supposed to indicate interdependence between *person* and *environment*, which it does not do. Unfortunately, he could have represented the same or more by simply saying that behavior is determined by, or dependent upon, the individual and the individual's environment, and they are interrelated in a manner that they produce mutual affect relations. The problem is, he gave no mathematical structure to the function. There was no logic and mathematical structure to provide the interpretation of the formula.

However, Lewin was attempting to give mathematical rigor to an area that Bertalanffy was also developing—the recognition that behaviors, individuals, and environments are all interrelated; that is, they are part of some *system*.

One problem that both Bertalanffy and Lewin had to confront was the prevailing methodology of classical science. Classical science was dependent on the following techniques for the development of theory: observation, hypothesis, and experiment. This was an inductive process, and one that was counter to what Peirce had already clearly analyzed. Both before and after Peirce, the classical development of theory in the social sciences was that of induction. Presented below is a parallel construction of theory in physics, a development defined by retroduction. It is instructive, therefore, to recognize that a physicist may consider the development of theory to be that of the classical science, even though it is not. Since a physicist is not so much concerned with the process of theory development as with the development of theory, this confusion is understandable. Therefore, while a physicist may assert that the development of theory is by induction, as claimed for Rock Theory, in fact physicists developing such theory proceed in a manner defined by Peirce as retroduction in the vertical development of new theory, or by extension in the horizontal development of existing theory.

Karl Raimund Popper. Karl Popper recognized the problems with the classical approach to the development of theory, although he continued to ignore Peirce. As an alternative, Popper proposed a new scientific methodology. In his two books, *The Logic of Scientific Discovery* (Popper, 1961) and *Conjectures and Refutations* (Popper, 1963), he introduced an alternative to inductive inference for theory building—the *hypothetico-deductive scientific method for theory development*.

While this approach may appear to be better than the inductive method, it falls short of clearly defining a methodology that will result in scientific theory. In fact, it but jumps to the hypothesis and explicates the "theory" from there. 'Hypothetico-deductive' is simply a process whereby we deductively determine outcomes from a hypothesis.

One problem with the hypothetico-deductive approach to theory development is that there is an assumption that the "hypotheses" are somehow part of a fully developed theory. Without this assumption, the tested hypotheses are just statements created by a researcher for the sole purpose of carrying out an experiment comparable to the classical approach they were to replace. In fact, this is so even if the hypothesis is a deduction from another hypothesis. Deductive inferences are no more

reliable than the hypotheses upon which they are founded when the hypothesis is not derived from axioms, basic assumptions.

In physics and the other mathematical sciences, there is an underlying theory upon which all hypotheses rely. That is, the researcher proceeds from an existing theory, whether that is Newtonian Physics, Einstein Physics, the Kinetic Theory of Gases, Thermodynamics, or some other theory, and this theory provides the framework in which the scientist works. Hypotheses in physics are in fact derived from an existing theory. Then the research continues as a model is developed that starts to predict what the effects should be. Then experiments test the effects. The model is refined and other researchers develop competing models. Since both models cannot be right, other researchers proceed to determine which model provides the correct interpretation of the observations. The selected model then provides for new predictions that are tested.

After much iteration, someone determines how to start at the atomic or subatomic level and develop a theory that is based on certain fundamental axioms of science and ends up predicting exactly what happens. Then, ***the predictions determine the value of the theory***. This is the critical point relating to theory construction—its main purpose is to *predict*. Further, the predictions of the theory provide new outcomes that no intuition or hypothesis could have predicted. While hypotheses are designed to state what someone believes to be true, and, clearly, cannot state anything that the designer cannot conceive, the purpose of a theory is distinctly different as follows:

> **Purpose of a Theory—**If there are no counterintuitive results derived from a theory, and if there are no predictions from the theory that are not obvious, and if the theory does not provide outcomes that were not seen, and if the theory does not obtain results that are otherwise difficult to obtain, then there is no need for the theory. Predictions from a theory are a result of equations (mathematical models) or logical derivations developed from the theory and such equations or logical schema do not rely on any preconceived notions that the effect could even exist. Therefore, *the purpose of a theory is to provide the means to develop mathematical, analytical, or descriptive models that predict counterintuitive, non-obvious, unseen, or difficult-to-obtain outcomes*.

When all we are testing are outcomes that are preconceived, then we are missing the very purpose of scientific inquiry—to determine what it is that we do not know, rather than that which we have just not yet confirmed, or patterns that we have just not yet discerned. Confirmation of a hypothesis may be interesting and of limited value, but to call a body of knowledge that does nothing more than confirms perceptions of known events is to trivialize the notion of theory to the point where any proclamation becomes a *theory*. That this is done all too frequently is confirmed by the "Charles's Law Theory" asserted by Travers as discussed below.

Possibly the best example of theory development and results comes from quantum mechanics that has predicted so many counterintuitive events. The *Josephson Effect*, a quantum-mechanical effect in superconductors, is a specific example from physics. Holding two superconductors close to each other, there is a coupling of the quantum mechanical wave functions between them. The equations governing the theory of superconductivity predicted this coupling and laboratory testing quickly confirmed the prediction. The *Josephson Effect* has become a valuable tool as a detector of extremely small magnetic fields and electrical currents, and is used in precise frequency measurements. The *Josephson Effect* has found applications in detecting variations in the Earth's magnetic fields, in fast electronic devices, and in laboratory measurements of exquisitely small changes in material properties. Voltage standards, highly-sensitive microwave detectors, high-density computer circuits and nanotechnologies, generally, have been developed with reliance on the *Josephson Effect*. Here, the theory predicted non-obvious outcomes, the very purpose of a theory.

In fact, it is interesting to note that Popper (Popper, 1963) asserts, yet does not recognize the methodology of theory development when he cites this very *non*-hypothetico-deductive example:

> We all were thrilled with the result of Eddington's eclipse observations which in 1919 brought the first important confirmation of Einstein's theory of gravitation. (p. 34)

Clearly, the theory was not devised as a result of observation. The observation was initiated as a direct result of the deductive inferences of the theory. Einstein's "hypothesis" concerning light and

gravitation was obtained deductively from his theory, and not from some hypothesis founded on an observation. A hypothesis is not a theory, and this example by Popper refutes the very nature of scientific discovery that Popper claims.

Robert Morris William Travers. While others before him recognized the problems with the classical approach to the development of theory, Robert Travers embraces it completely to the point of asserting that theory is developed directly from the data of observations. Being embraced by the education community, his representations of theory development, once again, set back the efforts to develop legitimate education theory. In 1972, R.M.W. Travers published a book entitled *An Introduction to Educational Research* (Travers, 1972). Therein, Travers states:

> In the behavioral sciences, one common practice is for the scientist to develop theories that postulate underlying mechanisms to account for behavior as it is observed. ... These imaginary mechanisms are known as *constructs*. (pp. 14-15)
>
> The problem that is eventually isolated may be stated in terms of a question for which the proposed research is designed to obtain an answer. Sometimes the question to be answered is referred to as a hypothesis. (p. 81).
>
> It will be assumed in this discussion that the hypothesis is firmly rooted in a framework of theory. (p. 81)

Travers confirms that research in the behavioral sciences as practiced is concerned with explaining observed behavior, rather than developing theories that encompass such behavior. This is an important distinction that will be further explicated in what follows.

First, it must be established beyond doubt but that theory is not derived from observations, and, in particular not from the collection of data. Observation may suggest phenomena for which a legitimate theory could assist in predicting outcomes, but the theory itself must come from some other source. For example, once it is discovered from observation that the earth travels in an orbit around the sun, a question might be: What keeps the earth in this orbit rather than traveling off into space?

It is clear that no "gravity waves" were observed, and, therefore, no empirical data identifying gravity is available by which some "theory" could be derived that would describe *gravity*. The theory is clearly derived from some other means— *it is the imagination and creative insight of the innovator by which theory is developed*.

With respect to gravity, we start with *Newton's Law of Universal Gravitation*—a statement about the relationship between bodies. This statement is not a theory; it simply defines mathematically what can be observed concerning the "gravitational attraction," the effect of the construct called "gravity," between two physical bodies. It tells us nothing about what gravity is. However, there are numerous theories of gravity. One of the more well-known theories is Einstein's General Relativity Theory of Gravity from which Newton's Law can be derived. Other theories of gravity include: the Dynamic Theory of Gravity, the Inertial Theory of Gravity, and the String Theory of Quantum Gravity. It should be clear that none of these, especially String Theory, were obtained by collecting data.

The "isolated problem" cited by Travers is posed as a hypothesis. Surprisingly, Travers asserts that "the hypothesis is firmly rooted in a framework of theory." But, what theory is he referring to? Travers, quoting F.N. Kerlinger (Kerlinger, 1973), defines 'theory' as follows:

> A theory may be defined as "a set of interrelated constructs (concepts), definitions, and propositions that presents a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena" [Fred N. Kerlinger, *Foundations of Behavioral Research*, 2nd ed. (New York: Holt, Rinehart and Winston, 1973), p. 9].
>
> Theories knit together the results of observations, enabling scientists to make general statements about variables and the relationships among variables. For example, it can be observed that if pressure is held constant, hydrogen gas expands when its temperature is increased from 20° to 40°C. It can be observed that if pressure is held constant, oxygen gas contracts when its temperature is decreased from 60° to 50°C. A familiar theory, Charles's Law, summarizes the observed effects of temperature changes on the volumes of all gases by the statement "When pressure is held constant, as the temperature of a gas is increased its

> volume is increased and as the temperature of a gas is decreased its volume is decreased." The theory not only summarizes previous information but predicts other phenomena by telling us what to expect of any gas under any temperature change. (p. 15)

Travers, like many before and after him from the social sciences, attempts to rely on theory construction in the physical sciences, and physics, in particular, to justify his vision of how theory is developed. Unfortunately, such vision is tainted by a misinterpretation resulting from a misunderstanding of just how theory in physics is actually developed. While it is legitimate to use theory from physics as a paradigm for theory construction in the social sciences, when that paradigm is misunderstood, legitimate theory in the social sciences is compromised.

Travers asserts: "Theories knit together the results of observations." As cited previously, it is clear that theories of gravity were not obtained as the result of observing gravity and Newton's Law is not theory. Newton's Law may have "knit together the results of observations," but theories of gravity were not derived for such knitting; they were derived for something far more substantive—to explain what gravity is and predict the effects of such gravity, such as the bending of light rays. The bending of light rays was not observed until a theory of gravity was developed that predicted such light ray bending. The observation confirmed the theory; the theory was not derived to somehow explain an observation.

By citing Charles's Law as an example of what behavioral scientists consider as "theory," Travers confirms that the behavioral scientist is not concerned with the development of theory—Charles's Law is *not* a "theory." "Knitting together results of observations" does not develop theory.

Charles's Law determines specific ratios of certain empirical events. It does not design a theory concerning such events; it simply establishes equations by which such events can be measured.

For example, just because Fibonacci numbers may express a relation concerning the pattern of pinecone spirals, does not mean that we have a Fibonacci Pinecone Theory. We may have discovered an interesting empirical observation, but it hardly amounts to "theory"—any more than does Charles's Law, regardless of its perceived importance. "Importance" is not a criterion for determining "theory."

The Ideal Gas Law is a generalization of both Boyle's Law and Charles's Law. The Kinetic Theory of Gases encompasses the Ideal Gas Law.

For example, although Kinetic Theory describes the motion of many particles and how the kinetic energy of those particles produces an averaged effect of pressure, its axioms were not obtained or predicted by observing the rising of a balloon filled with gas, as was Charles's Law. The three assumptions upon which the Kinetic Theory is based are:

- Matter is composed of small particles (molecules or atoms).
- The particles are in constant motion.
- When the particles collide with each other, or with the walls of a container, there is no loss of energy.

These axioms are assumed from general considerations of matter, and not the specific filling of a balloon with gas. It is patent that these axioms were not obtained as the result of "observation" of any empirical event.

Thermodynamics is the theory of physics that encompasses the Kinetic Theory of Gases. Therefore, Charles's Law is not a theory, but an explication of the Theory of Thermodynamics or its sub-theory, the Kinetic Theory of Gases. These theories, while explaining certain empirical observations such as those relating to gasses, were not developed as a result of Charles's observations; they were developed to explain the behavior of large volumes of particles in gases.

Once again, the social scientist has misunderstood the meaning of theorizing by which theories for the social sciences can actually be developed. The paradigm of theory development in physics is of little value if it is not understood. Theory development in physics as in any other science is the result of the logical process of retroduction by which relationships are recognized as an emendation of a point of view, whether that point of view is devised from existing theory or from the *whole cloth* of relevant knowledge. *Retroduction* is the result of the *imagination* of the innovator and not by the mechanical process of data-mining techniques by which data-patterns are devised. Data-mining is certainly an important pursuit, although quite mechanical in nature, but it does not lead to the *creative development of theory—it is the imagination and creative insight of the innovator by which theory is developed*. [*Retroduction* is discussed more thoroughly in my next article.]

Donald Ary, Lucy Cheser Jacobs, and Asghar Razavieh. Again, in 1985, Ary, et al. (Ary, 1985), in *Introduction to Research in Education*, continue to promote the misinterpretation of how theory is developed. However, the misinterpretation is now directed at believing that when explicating a theory, that the premises; that is, axioms, must be "true." They assert:

> We must begin with true premises in order to arrive at true conclusions. (p. 5)
>
> The conclusions of deductive reasoning are true only if the premises on which they are based are true. (p. 6)

Unfortunately, such is not the case. The physicist has no concern whether or not Einstein's assumptions are "true" in fact; they just proceed as though they are. Actual validity is not the concern. In 1963, Arthur S. Otis published a book entitled *Light Velocity and Relativity* (Otis, 1963) in which he tried to "prove" that Einstein's theory was "false"—"Einstein theory found invalid" was his proclamation. When the Chairman of the Physics Department at a top university in the United States was asked whether or not the department would be interested in pursuing the claims of Otis, the response was:

> "We don't care if Einstein's theory is true or not, we just proceed as though it is."

Until researchers in the social sciences understand the import of this position, no legitimate theory in education or any other social science is possible.

In addition to misunderstanding the nature of assumptions, or axioms, in the development of scientific theory, Ary et al. also confuse the place of deduction and induction in the process of theory development. They provide the following examples:

> The difference between deductive and inductive reasoning may be seen in the following examples:
>
> A. Deductive: Every mammal has lungs.
> All rabbits are mammals.
> Therefore, every rabbit has lungs.
>
> B. Inductive: Every rabbit that has ever been observed has lungs.
> Therefore, every rabbit has lungs. (pp. 6-7)

First, the example of deduction provided is that of a syllogism and not from an axiomatic theory. They are not the same. However, assuming that axiomatic deductive inferences are also included, and that the example given for induction can be appreciated, the interpretation of induction is also misleading. What has actually been demonstrated by the inductive inference is that the observations of rabbits with lungs have confirmed the deductive inference that they in fact do have lungs. Induction validates theory, it does not develop theory. The validation has contributed to the "preponderance of evidence" that supports the deductive inference, and, therefore, the theory.

Most telling is their lament:

> In spite of their use of the scientific approach and accumulation of a large quantity of reliable knowledge, education and the other social sciences have not attained the scientific status typical of the natural sciences. The social sciences have not been able to establish generalizations equivalent to the theories of the natural sciences in scope of explanatory power or in capability to yield precise predictions. (p. 19)

What they fail to recognize is the reason for this lack of theory development. As Popper (Popper, 1961) points out: "a science needs a point of view, and theoretical problems" (p. 106). And, as he confirms, the amassing of huge amounts of data does not, and cannot, amount to theory. If one were to amass the daily traffic flow at a major city intersection, one would have a large amount of data providing "reliable knowledge" about such traffic flow. However, other than gaining the knowledge that may indicate that a traffic light is required, there is nothing by which a scientific theory could be developed. This is the state of affairs in the social sciences—great amounts of knowledge have been

acquired from hypothesis testing, but it is of absolutely no value for the development of an education or any other social science theory.

Rather than adhering to a process referred to as "the scientific approach," it would be more constructive to recognize that possibly even physical scientists do not follow "the scientific approach" and move to determine just what it takes to develop a theory for educologists and other social scientists. Theories in physics were not developed as the result of the "accumulation of a large quantity of reliable knowledge," they were developed as the result of the *creativity, insight and innovativeness of the researcher* to recognize emendations of existing theories or from the *whole cloth* of relevant knowledge. Until the social scientist recognizes what has to be done to be creative, the lament of Ary et al. will continue to characterize the search for legitimate theory in the social sciences.

Stating hypotheses in a vacuum without their associated theory will result in confusion when trying to identify the underlying assumptions. Although Travers recognized the need to anchor hypotheses in theory, he failed to recognize what that theory had to entail. Regardless of how careful one is when preparing a hypothesis, it is almost certain that hidden or unknown assumptions have not been stated. Hypotheses must be part of some theory structure, or they are nothing more than the opinion of the researcher, even if that opinion is subsequently "validated." It is this process of hypothesis creation that has resulted in numerous "tests" of the same subject area resulting in differing conclusions—for example, "human involvement is responsible for a substantial part of global warming," versus "humans are responsible for less than 7% of the global warming effect"; or "placing girls and boys together in the same class results in better learning for all students," versus "separating boys and girls for instruction results in better learning for all students." Is it possible that with both of these hypotheses, especially the latter, that there are unstated political agendas at work that compromise the integrity of the validation?

The problem is not necessarily the tests that provide differing results, but that there is no full recognition of the underlying assumptions of the theory in which the hypothesis is stated. Theory generates hypotheses, hypotheses do not create theory nor are they themselves theory. Theory, hidden or clearly stated, produces hypotheses, or theorems in more formal theories.

The problem with the hypothetico-deductive methodology is that it does not produce theory. In education, this process has never resulted in any comprehensive new theory. The next article of this series corrects that problem by providing a theory-building process that leads to legitimate theory. A proper methodology requires testing theory-derived hypotheses and all new applications derived from the hypotheses until the evaluations lead to a new theory that describes the problem based on first principles, "accepted *assumptions*"—*not* "true premises."

Glaser and Strauss. As an alternative to the hypothetico-deductive methodology, Glaser and Strauss developed the "Grounded Theory" approach (Glaser, 1967) to develop theory in the social sciences. Although subsequent to the publication of their joint text Glaser and Strauss have been involved in some on-going disputes concerning the details of the approach, essentially all such approaches are flawed at the outset by grounding any theory development on acquired data.

However, their dissatisfaction with hypothesis-driven research is well taken. The problem is that they did not recognize the underlying reason for this dissatisfaction—hypothetico-deductive methodologies or any other hypothesis-based methodology itself does not develop theory.

The "Grounded Theory" approach asserts that theory is "discovered" as the result of systematically analyzing data. As a result, this approach is very similar to, if not identical to the data mining procedures used to structure unstructured data. The response to each is the same, structuring unstructured data is certainly helpful in recognizing established patterns within systems to evaluate existing theory, but it does not produce theory.

The work of Steiner (Steiner, 1988) confirms that neither approach is well founded. Steiner resolves the problems by clearly stating the distinctions between retroduction, deduction and induction as presented by Peirce in the 1890's:

- Retroduction devises theory.
- Deduction explicates theory.
- Induction evaluates theory.

(With the work that is now being first reported in this article, these three types of theory development are expanded to include a fourth, *abduction*, which is explicated in my next article.)

An inductive process grounded or not, does not develop theory, whether one claims that induction was responsible for directly proposing a theory or the theory is deductively inferred from hypotheses—neither process actually resulted in theory construction.

Even trying to argue that Glaser and Strauss's Grounded Theory is in some way associated with Peirce's abduction fails. First, as noted above, abduction is not retroduction. Glaser and Strauss consider Grounded Theory as a means for obtaining theory from data patterns—that is, data mining techniques. Theory development is a retroductive process, and not an inductive process nor an abductive process. In this case, 'abduction' as 'retroduction' is misinterpreted.

Since the Grounded Theory of Glaser and Strauss is relied upon in the social sciences, we need to take a closer look at just what they say. Concerning Grounded Theory:

> Most important, it works—provides us with relevant predictions, explanations, interpretations and applications. (p. 1)

This should not be surprising, since the purported theory is a direct reflection of the data. Whether or not such direct reflection provides "relevant predictions" that could not be otherwise observed is questionable. The final three criteria go directly to the fact that theory is in fact not being developed. What is being developed is akin to Charles's Law and Newton's Law of Universal Gravitation; that is, Grounded "Theory" is doing nothing more or less than describing what one observes concerning the interrelations of phenomena as defined by the data—"explanations, interpretations and applications."

One of the more telling representations is that it is claimed that theory is "discovered":

> The basic theme in our book is the discovery of theory from data systematically obtained from social research. (p. 2)

It seems as though theories are out there somewhere just waiting to be "discovered" as one would discover any other empirical event or object.

Glaser and Strauss attempt to refute logico-deductive theory as follows:

> In contrasting grounded theory with logico-deductive theory and discussing and assessing their relative merits in ability to fit and work (predict, explain, and be relevant), we have taken the position that the adequacy of a theory for sociology today cannot be divorced from the process by which it is generated. (p. 5)

Here Glaser and Strauss misidentify "logico-deductive theory" as a process similar to Grounded Theory. Grounded Theory, by definition, is the result of a process of theory development. A theory that is constructed so that it can be logically explicated by deductive means is not dependent upon the source by which the theory was developed. It is a strange scientific position to assert that one should not be concerned with the logical-deductive inferences that can be obtained from a theory, even if that theory was purportedly developed from the ground up. There essentially is no "contrast" here to be made. And, again, they address logico-deductive theory:

> Verifying a logico-deductive theory generally leaves us with at best a reformulated hypothesis or two and an unconfirmed set of speculations; and, at worst, a theory that does not seem to fit or work. (p. 29)

A scientist not in the social sciences and steeped in the tradition of empirical axiomatic theories may wonder just what is being said here, until the previous paragraph is revisited:

> This situation (with respect to grounded theory) is in contrast to the risk of testing a logico-deductive theory, which is dubiously related to the area of behavior it purports to explain, since it was merely thought up on the basis of *a priori* assumption and a touch of common sense, peppered with a few old theoretical speculations made by the erudite. The

> verifier may find that the speculative theory has nothing to do with his evidence, unless he *forces* a connection. (p. 29)

Here Glaser and Strauss show their frustration with the manner in which social scientists have been developing theories for much too long—as should any other scientist who is taking a critical look at the condition of such theory development.

While one must applaud both Glaser and Strauss for their dissatisfaction with theory development in the social sciences, their solution does nothing to further that end. It is pretty much irrelevant whether your hypothesis is derived *a priori* or from the ground up, hypotheses do not generate theories. To clearly discern the nature of the statements being developed, consider the following *discovery and generation of a performance-reward process* cited by Glaser and Strauss:

> In a study of organizational scientists, the analyst discovered that scientists' motivation to advance knowledge was positively associated with professional recognition for doing so. This finding suggested the theoretical inference that recognition from others maintains motivation. [Tests then followed to theoretically verify this "theoretical inference."] (p. 212)

Once again, theory seems to be something that we "discover." However, more to the point, this appears to be nothing more than an attempt to describe an event, in the same way that Charles's Law and Newton's Law of Universal Gravitation describe empirical facts. While such descriptions are certainly applicable to any number of incidents, although such applications may be questioned as to their similarity, that does not make such descriptive correlations a theory; it simply means that one has made a rather universal observation that; for example, when people are in a position of power without controls, they will abuse their position. Regardless of how many groups one analyzes to accumulate data that further confirms this observation, no theory has been developed. It may be an interesting observation, but it is not a theory—unless, of course, social scientists wish to recognize the Fibonacci Pinecone Theory.

Essentially, the scientific methodology of the social sciences has been hypothesis-driven. That is, the definitions of both induction and hypothetico-deduction theory-building methodologies are such that each relies on a hypothesis that is devoid of the foundations required of a legitimate theory.

Retroduction develops legitimate theory, whether that retroductive process results from the development of new theory from existing theory or the development of new theory from the *whole cloth* of relevant knowledge. For example, the existing theories of Set Theory, Information Theory, Graph Theory and General Systems Theory can be used to develop theory in a very analytic manner, as was done for the development of the SIGGS theory model. Alternatively, a *whole cloth* perspective of mathematics, education, chemistry, physics and the behavioral sciences develops theory by recognizing a wholeness of concepts they contain that provide a perspective that describes and predicts what is found in education systems. For example, General Systems Theory was developed from a *whole cloth perspective*.

Further, as Popper and others have recognized, theory must be axiomatic with all of its associated safeguards. In addition, as cited above, the social sciences have attempted to produce theories that have a rigor similar to the physical sciences by introducing mathematical constructs. Although descriptive theories are possible, only logico-mathematical foundations provide the means required for general acceptance and validation. Moreover, it is essential that if logic and mathematics symbolisms are a part of a descriptive theory they are not so by mere reference, cited without substance, but the logic and mathematics must be an integral part of the theory.

This is where historical and current research in education and the social sciences generally has failed, as research continues to proceed from a position of validating hypotheses. Education research is hypothesis-driven, rather than theory-driven. While axiomatic logico-mathematical theories are far more difficult and complex than hypothesis-driven methodologies, such theories are required if educology is to move beyond a "My Theory" methodology to that of developing a consistent, comprehensive, complete, and axiomatic theory of education. And to simply assert *a priori* that formal, axiomatic, or mathematical theories cannot apply to the social sciences is a clear refutation of any "scientific process" and places such social scientists outside the realm of science.

To assist in bridging the gap from hypothesis-driven to axiomatic-theory-driven science, a parallel development in physics will be considered. Even in physics, which is frequently considered as being "proven" or "empirically valid," theories are considered to be acceptable for describing the physical world as a result of a "preponderance of evidence" that they produce accurate predictions of the physical world. The same will hold in the social sciences; that is, a theory is accepted because of the "preponderance of evidence" that it produces consistently valid predictions.

Following is an example of the retroductive development of a theory in physics.

Rock Theory
Desired Theory: Electrical Properties of Rocks
Existing Theory: Electrical Properties of Glass

By conjecture, the electrical properties of rocks are similar to the electrical properties of glass. Therefore, the existing Electrical-Glass-Property Theory is used to retroductively develop an Electrical-Rock-Property Theory.

This new Rock Theory is an emendation of the existing Glass Theory. As such, it brings with it the basic logic of that theory, which is comparable to other theories in physics; but, in addition it introduces new content and the resulting Rock Theory will contain more than what was brought to it from Glass Theory. Glass Theory provided the devising model by which Rock Theory is developed.

It is important to recognize that this is not an inductive process in that there is no extensive data from which "patterns" are developed that "suggest" that somehow rocks are similar to glass. To the contrary, it was the Glass Theory itself that was utilized to develop Rock Theory as the result of the insight of the innovator who recognized that the properties of the two mediums may be similar.

4. The "Hypothesis" and "Axiom" Distinction

One of the first tasks in moving from a hypothesis-driven methodology to a theory-driven one is to be able to recognize the distinction between a *hypothesis* and an *axiom*.

In the social sciences, 'axioms' and 'hypotheses' are frequently considered to have the same meaning. However, in theory development, these two terms are distinctly different.

In fact, the distinctions between 'axiom' and 'hypothesis' provide strong confirmation why there has been no comprehensive theory developed for the social sciences, and why hypothesis-driven research *cannot* provide a basis for any such theory development.

Essentially, the distinction is that a 'hypothesis' is a conjecture about an observation or a perceived empirical event that is stated as a conclusion of fact. An 'axiom' is a statement that relates properties of a theory, or the components of a theory to its properties.

When a hypothesis is stated, there is no intent that it is meant to develop theory—it is meant to be validated as an assertion of fact. For example, consider the following statement:

HYPOTHESIS: Student choice and independence are the primary motivators for learning.

As stated, this is a hypothesis. It is stated as a conclusion of fact that is to be validated. If it is validated, it provides no relevant relation to any other statements that might be part of a theory and there are no leading assertions from which additional theory statements can be derived. This is so even if the statement is framed as an implication as follows:

HYPOTHESIS: If student choice and independence are related to learning, then establishing student choice and independence in the classroom will confirm them as the primary motivators for learning.

Now consider the following statement:

AXIOM: Students are independent systems (where *independent system* is a property defined by a systems theory).

This statement is an axiom, as it relates the components of a theory, *students*, to a property of the theory, *independent system*. It is not a conclusion of fact, as there is nothing to validate, but a theoretical construct, an axiom for a theory, that informs us about a theory property by which students are identified. Further, this statement is neither "true" nor "false"—it is simply an assertion that is "assumed" to be true. Further, there is no amount of testing that can ever confirm the validity of this assertion. Whether or not this axiom is valid will be determined by the theorems (or hypotheses) that are deductively obtained from it and other axioms of the theory.

For example, if as a result of the definition of *independent system* along with other system properties and axioms it is determined that "individual choice and independence are motivators for learning," then it is as a result of some theory derivation, and not an *a priori* assertion of fact. Then, through various empirical analyses it can be determined whether or not in fact "choice and independence" are the "*primary* motivators for learning." However, even the validation of this conclusion, should it actually be derived, will depend on all of the assumptions and qualifications it took to arrive at this conclusion. Tests are not set up at the discretion of a researcher, but are determined by the parameters of the theory.

The distinction between *axiom* and *hypothesis* is seen to be quite profound for theory development, and it is important to keep clear their differences.

In my next article I will discuss examples of hypotheses in the social sciences and how to convert them to axioms that would be part of an axiomatic theory; and then the efficacy of such a task.

5. CONCLUSION

In this article, we updated the development of ATIS as represented in the fist article, we discussed hypothesis-based research methodologies for the social sciences and found them wanting, and we considered the distinction between *hypothesis* and *axiom*. During this discussion it was shown that hypotheses cannot produce theories and is the very reason for the confusion and frustration encountered by social scientist researchers. In future articles, examples of hypotheses in the social sciences will be considered and how to convert them to axiomatic theories and the reason for so doing, and the formal development of *ATIS* will be further explicated.

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