DIALECTICAL FOUNDATIONS OF SCIENTIFIC INQUIRY*

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The discovery in neurology that the two sides of the brain think in distinct ways that are both opposed to each other and complementary might have consequences in a number of academic disciplines, and in philosophy and political consciousness as well. It is the purpose of this paper to apply concepts from the brain theory to an analysis of the rational foundations of scientific inquiry. To pursue this argument, it is unnecessary to take a position on the side of materialism or idealism, although the theory certainly is related to that issue. And it should be made clear, at the outset, that we see no possibility that the explanation of ideas can be reduced to a physical theory such as physics.[1]

The Left and Right Sides of the Brain

The higher brain functions are carried out in the cerebrum, which in man has exploded upward and outward from the brain stem. The cerebrum contains a variety of structures connected by systems of nerve fibres. One of its fundamental features is its division into left and right hemispheres which are gross mirror images of each other. Similarities in weight and metabolic rates suggest that each performs the same amount of work. Bogen writes (1969a:165): "the informational capacity of the one is just as great as the other; or, put differently, the other...is not only working just as hard, but also just as intricately." Despite overall structural similarity, impressive evidence indicates that the two hemispheres differ in cognitive functioning. The left dominates the verbal functions of speech, writing, and reading.[2] Neurologist Jackson wrote (1958:206), in 1864, that the distinguishing feagure of the left hemisphere is not possession of words, but rather its <u>use</u> of words in propositions, i.e., in sequences in which meanings of the words are interdependent. He reported that in cases of damage to the left hemisphere, "The words removed are those employed in the formation of propositions; those which remain to the speechless patient are the same words used non-propositionally." Bogen follows Jackson's term "propositioning" and names the totality of functions of the left hemisphere <u>propositional</u>.

Jackson stated further (1958:220) that, "If...the faculty of expression resides in one hemisphere, there is no absurdity in raising the question as to whether perception--its corresponding opposite--may not be seated in the other." Recent neurological studies have confirmed the pertinence of Jackson's question. There is diverse evidence indicating that while the left hemisphere dominates propositional thought, the right hemisphere dominates certain visual and constructive tasks such as drawing, copying, and assembling block designs; and constructive activity in the arts, such as poetry, literature, painting. More generally, the right hemisphere dominates thought based on the simultaneous grasping or enclosing of fragments as a whole, or gestalt. In Figure 1, e.g., the items from the Street Gestalt Completion Test (Street, 1931; Bogen, et al., 1972), can be seen as a horse and rider and a rabbit only by a simultaneous grasping of the particular fragments. Recognition does not come about through a sequence: seeing is not the end result of a logical analysis. Recognition comes about instantaneously: the animals are seen all at once or not at all. Bogen (1969b:150) has

Fig. 1. Two Items from the Street Figure-Completion Test.

given the name appositional to the totality of functions associated with the right hemisphere. This mode of thought is essentially involved in the arts, in music, in metaphorical and poetic use of words, and in practices directed to the attainment of insight or vision. We will use the term synthetic inquiries to refer to the totality of art forms, disciplines, and practices of this kind.[3]

Jackson remarked that perception is the corresponding opposite of propositioning. While it can be argued that propositional and appositional thinking constitutes what Kant called a "real opposition," they are connected by nerve fibres, the cerebral commissures (the largest being called the "corpus callosum").

In the famous "split-brain" surgeries, the nerve fibres connecting the two hemispheres are severed. This operation has been carried out in humans to relieve epileptic seizures, and on cats and monkeys to study their brains. In the higher mammals each eye is connected to both cerebral hemispheres. The optic nerves that go from the left eye to the right hemisphere, and from the right eye to the left hemisphere, meet in what is called the optic chiasm. Cutting the optic chiasm eliminates the crossed paths, with the result that each eye informs only the hemisphere on its own side. Myers (1967) trained monkeys that had undergone such surgery to choose between two symbols presented while wearing a cover over one eye. He found that once the monkeys learned to do this, the cover could be switched to the other eye, and the monkey could still select the correct symbol. A second set of monkeys learned under more difficult circumstances. They had had both their optic chiasms and corpus callosums cut. After this surgery, the monkeys could learn which of two stimuli the experimenter was rewarding with one eye covered. But this time, when the patch was switched, learning did not transfer; the other eye, in fact, could be trained to choose the opposite member of the two stimuli, so that the "correct" stimuli depended on which eye was covered. These experiments show that information is transferred from one hemisphere to the other by means of the corpus callosum, and that the two hemispheres can function independently.

There is ample evidence that the humans that have undergone the split-brain surgery have gained the ability to solve two problems simultaneously with their two hands, they have lost some capacity for integrated thought: for example, all the patients with a complete cerebral commissurotomy are unable to name an unseen object held in the left hand, even though recognition by the right hemisphere is shown by the left hand's ability to retrieve the test object when it is dropped into a bag containing a large number of similar objects.[4]

Bogen and Bogen (1969) hypothesize that while the two hemispheres can perceive, consider, and act independently, they are fundamentally complementary, and the simultaneous use of both hemispheres, made possible by the corpus callosum, is associated with the highest mental functions--with creativity. Thus in the brain theory the principle contradiction in the mind is the existence of two opposed kinds of thought, propositional and appositional, makes possible both a struggle and a unity of opposites suggesting--as Hegel argued--that the mind is dialectical.

Rationalities for Formulation

Analysis of science as a practice focuses on the written accounts of scientific inquiries that include description, conceptualization, and the presentation and testing of hypotheses and theories. In analyzing rational bases that underly the practice of science, Garfinkle (1967:262-268) finds two kinds of rationalities. The first is the rationality of common sense. The same rationality that governs everyday social behavior guides the scientist in such familiar activities as categorizing and comparing, estimating tolerable error, searching for "means," analyzing alternatives and consequences, and developing strategies. But Garfinkel (1967:267-268) is able to come up with four bases for rationality in science that are incompatible with everyday social behavior: (1) compatibility of ends-means relationships with principles of formal logic; (2) semantic clarity and distinctness; (3) clarity and distinctness "for its own sake"; (4) compatibility of the definition of a situation with scientific knowledge.

These four rationalities constitute a good description of propositional thought as it is applied to the formulation of theories. For this reason, it is appropriate to refer to them as "rationalities for theory formulation."

Rationalities for Construction

The Garfinkel rationalities pose a problem. They are all expressions of propositional thought in scientific inquiry, but there exists an opposite mode of thought hypothesized to be equally intricate and elaborate. Appositional thought, however, cannot be equated with common sense; the common sense rationalities are not easily categorized according to the propositional-appositional distinction. But appositional thought can be expected to have its own rational bases, for it is known to involve construction and the production of insight or vision. It can hardly be denied that practices oriented to the production of vision or enlightenment, such as the Indian American vision quest, art forms, music, and related synthetic inquiries, are directed not to clear verbal expression but to the perceptual grasp of inner structure. The question becomes: Is there any synthetic inquiry within the practice of science? Although it has been ignored as a topic for investigation, it is obvious there are theories only to the extent that practitioners of science have insights and visions. Before a theory can be given form, it must be constructed. Appositional thought deals with structure and construction, while propositional thought deals with form and formulation; we are led to the hypothesis that there exist rationalities for theory construction in the practice of science.

By hypothesizing that propositional and appositional thought constitute "real opposites," an inventory of four rationalities for construction can be generated by changing the meanings of the Garfinkel rationalities into their opposites. This can be done by replacing terms that are interpretable as propositional into the corresponding appositional terms.

In Rationality 1, structural replaces formal and perception replaces logic. DeSantillana and von Dechend, in their treatise on the origins of science, analyzed classical myths from around the world, with the following confession about their methodology (1969:xiii): "Most frustrating, we could not use our good old simple catenary logic, in which principles come first and deducations follow. This was not the way of the archaic thinkers. They thought in terms of what we might call a fugue in which all notes cannot be constrained into a single melodic scale, in which one is plunged directly into the midst of things and must follow the temporal order created by their thoughts." We are reminded of Levi-Strauss' treatment of primitive mythology among South American Indians, in which the entire analysis is organized in terms of music which seems to resemble the structure of mythic experiences, which is described as "The Fugue of the Five Senses."[5] Thus appositional thought is not reasoning according to principles, but rather a simultaneous grasping of layers in an order.[6] For this reason, the term layers can replace principles, and the transformation yields an hypothesized rationality for theory construction: I. Compatibility of ends-means relationships with layers of structural perception.

While an explication of this rationality requires space not available here, a few remarks can be offered. The statement implies that in seeking a vision, the means, usually some discipline, has the end of direct investigation of the layers of structural perception. The object of such inquiry is to become intensely involved in some object of perception, to grasp its essential nature, and to become involved with it. This is a kind of knowing that obeys no principles, and cannot be attained through the use of formal logic and words. When the layers of an object are seen in their entwined, interpenetrated, interdependent relations, there can be an insight into the object's order. Such a grasp of the whole--with its layers of structural perception--is essential in creating art and music, and in all synthetic inquiries. It is also at work in the mind of a scientist struggling to grasp the inner structure of the object constituting his or her topic.

Rationality 2 is transformed into its opposite by replacing clarity by veiledness and distinctness by complexity. Rationality II is: Semantic veiledness and complexity. When the inner structure of an object becomes the topic for verbal explication, speech and the object spoken about transforms each other. Speech comes to be experienced not as an object in the situation but as a perception in itself. Both the object and the words pertaining to it are essentially incomplete: it is always possible to "see" new things in the object, and explication is potentially endless.

This perceptual instability contrasts sharply with scientific formulation, which is by comparison stable and invariant with respect to perception. Speech is not distinct, but provocative of deeper complexity. Each new semantic utterance adds to the complexity of the situation, providing an expansion from the one to the many. In forming words about an object of perception, we become increasingly aware of complexities within complexities, veiledness within veiledness. The words before us invoke new views of the situation, and in turn these views change the sense of the original words. The meanings of pronouncements may be grasped, but they cannot be explained exhaustively. In this sense they resemble music and myth, in that they are not directly translatable. The words do not merely stand in a mediated one-to-one correspondence with definite objects. Instead they stand at the edge of the relationship between conscious thought and other layers of awareness, and hypermediate the speech and the vision. What is seen is not vision quale and what is heard or spoken is not acoustic quale. Synaesthetic perception is the rule. The intercommunication of the senses within the inquiry leads, in the "inner structure" of the object, to a synthesis or unity of the senses (Merleau-Ponty, 1962:228-230).

Words that are fundamentally perceptual are signs rather than concepts. As such they display a property of opaqueness that Merleau-Ponty found fundamental to language. He wrote (1964b:42): "There is thus an opaqueness of language. Nowhere does it stop and leave a place of pure meaning, it is always limited only by more language, and meaning appears within it only set in a context of words. Like a charade, language is understood only through the interaction of signs, each of which, taken separately, is equivocal or banal, and makes sense, only by being combined with others."

Grasp of the inner structure of an object is necessarily symbolic. A symbol is conceived by Morris (1934:2) as a special type of sign--a sign that produces an interpretation by its juxtaposition with another sign that is in synonymous relationship. A symbol may be said to be the relationship between signs. But as Levi-Strauss notes (1963:197), that symbols are "meaningful equivalents of things meant which belong to another order or reality," and adds that "the effectiveness of symbols would consist precisely in this 'inductive property,' by which formally homologous levels of life--organic processes, unconscious minds, rational thought--are related to one another. Poetic metaphor provides a familiar example of this inductive process." Symbols can intensify perceptions of different levels, and can relate these levels in novel and radical ways. The meaning of a symbol, like the perception of an object, always remains somewhat hidden from us. Unlike a word with a formal mark--such as a name for a thing--that mediates a natural object, the meaning of a symbol is not available through a mere pointing. (We cannot point to several levels at the same time.) This limitation prevents us from knowing symbols clearly and talking about them distinctly. Symbols pertain to a multiplicity of levels, and for this reason symbolic language cannot be clear and distinct; like poetic or metaphorical language, it is veiled and complex. We can inquire into the meanings of symbols, but such investigations never enable us to point out exactly what they mean. Symbols, which play such a central role in synthetic inquiries, may then be seen to generate situations in which interpretations are necessarily incomplete but which are capable of producing awareness on many levels of reality at once.

Rationality 3, Veiledness and complexity "for its own sake," can be seen in Levi-Strauss' (1970:55) analysis of the "primitive" investigating nature. He observes that to the primitive, "animals and plants are not known as a result of their usefulness; they are deemed to be useful or interesting because they are first of all known." Such inquiry begins with the appreciation of a perception, then proceeds to make this perception interesting and useful. The primitive, in grasping the sense of the operation, executes it in a manner that is interesting, and then suggests complex alternatives. In propositional thought, on the other hand, what is interesting is what can lead to a clear solution. Although there can be many possibilities, decisions are to be made among them; a single solution represents an ideal in clarity.

Perception is concealed in its workings, and is thereby sublime. Perception can never be distinct as can written statements in which terms are carefully defined by distinct rules. Perception is sublime, essentially concealed, and unclear. It is veiled in that each percept is basically ambiguous. On this Merleau-Ponty wrote (1964a:16):

> Perception is the paradoxical. The perceived thing itself is paradoxical; it exists only in so far as someone can perceive it. I cannot even for an instance imagine an object in itself. As Berkeley said, if I attempt to imagine some place in the world which has never been seen, the very fact that I imagine it makes me present at that place. I thus cannot conceive a perceptible place in which I am not myself present. But even the place in which I find myself are never completely given to me: the things which I see are things for me only under the conditions that they always recede beyond their immediately given aspect. Thus there is a paradox of immanence and transcendence in perception. Immanence, because the perceived object cannot be foreign to him who perceives; transcendent, because it always contains something more than what is actually given. And these two elements of perception are not, properly speaking, contradictory. For if we reflect on this notion of perspective, if we reproduce the perceptual experience in our thought, we see only the kind of evidence proper to the perceived, the appearance of "something requires both this presence and this absence.

Thus veiledness and complexity, while not appropriate rationalities in the context of theory formulation, are appropriate objectives for the work of theory construction, for inquiry into the perceptual.

Rationality 4 is transformed into its opposite by replacing <u>definition</u> of a situation by <u>perception</u> of a situation, and <u>scientific</u> knowledge by <u>synthetic</u> (personal) knowledge. Thus rationality 4 is: <u>Compatibility of the perception of a situation with synthetic (personal) knowledge</u>.

Science demands that the definition of an inquirer's situation be compatible with a corpus of materials, rules, etc., that compose scientific knowledge. A transformation occurs in the work of construction: the perception of an inquirer's situation is compatible with synthetic knowledge. Clear and distinct definitions of a situation are not an organized norm in such work.

This rationality for construction is essentially intuitive. The logical empiricist school within the philosophy of science has maintained that intuition is not a fundamental component of scientific inquiry, and implies that the work of intuition stands in irreconcilable opposition to science. Nevertheless, intuition enters into even the most scientific inquiries. Husserl (1962), in his phenomenology of ideas, saw that intuition may well be the foundation of mathematical work and calls his program a "science of intuition." The problem of intuition, though a disturbing and unmanageable factor in the analysis of scientific inquiry, is a recognized beginning point in synthetic inquiries. Such inquiries view knowledge as fundamentally, though not exclusively, intuitive, and seek to develop the capacity for intuition as a prevailing concern and means of production. Intuitional thought is appositional, and the perception of a situation accomplished through intuition is worked into a compatible relationship with a system of knowledge that is determinately personal. Personal knowledge can mean that one has developed a method of "intuitive grasping" that cannot be explained clearly or distinctly.

The foregoing argument, should it be supported by adequate explication and empirical investigation of synthetic inquiries, including theory construction within scientific inquiry, lends limited support to the notion that the rationalities for theory formulation which are primarily propositional, are complemented by rationalities for theory construction, which are primarily appositional.

Enemies in Synthetic Inquiries and in Theory Construction

Castaneda (1968, 1971) has spent a decade studying a Mexican Indian sorcerer named Juan Matus. Castaneda's methodology for studying the practices of this man, whom he calls don Juan, consists of becoming don Juan's apprentice, and then making the practice, including the teaching, the topic of his ethnographic research. This practice is not idiosyncratic, as Castaneda notes (1971:19): "For the American Indian, perhaps for thousands of years, the vague phenomena we call sorcery has been a serious, bona fide practice, comparable to our science."

Thus don Juan's practices are an instance of the Indian American "vision quest." For don Juan sees the central concern of his practice as an effort to learn how to _see_. This involves the use of psychotropic plants (peyote, jimson weed, and the mushroom _Psylocybe mexicana_) which, through alternation of consciousness, make possible the experience of "nonordinary reality." Not all such vision quests involve the use of psychotropic plants. But usually there exists some method of producing stress, such as fatigue, hunger, exposure to the elements, etc., which alter one's ordinary reality.

Castaneda writes (1968:78-83, 253) that "Becoming a man of knowledge was not a permanent accomplishment, but rather a process." And don Juan says: "To be a man of knowledge has no permanence. One is never a man of knowledge, not really. Rather, one becomes a man of knowledge for a very brief instant, after defeating the four natural enemies." These are in order: _Fear_: "He must be fully afraid, and yet he must not stop.... And a moment will come when...[t]his intention becomes stronger. Learning is no longer a terrifying task." _Clarity_: "That clarity of mind, which is so hard to obtain, dispels fear, but also blinds.... [H]e must defy his clarity and use it only to see.... And a moment will come when he will understand that his clarity was only a point before his eyes." At the moment clarity is overcome, the third enemy is encountered. It is _Power_: "Power is the strongest of all enemies. And naturally the easiest thing to do is to give in; after all, the man is truly invincible. He commands; he begins by taking calculated risks, and ends in making rules, because he is a master." However, "He has to defy it, deliberately. He has to come to realize the power he has seemingly conquered is in reality never his.... If he can see that clarity and power, without his control over himself, are worse than mistakes, he will reach a point where everything is held in check. He will know then when and how to use his power." A man who has mastered these three enemies finally encounters the cruelest of all enemies, _Old Age_: "he has an unyielding desire to rest.... But if a man sloughs off his tiredness, and lives his fate through, he can then be called a man of knowledge, if only for the brief moment when he succeeds in fighting off his last, invincible enemy. That moment of clarity, power, and knowledge is enough."

We concur with don Juan's penetrating analysis of his own practice, and hypothesize that these four enemies are present in any synthetic inquiry. Further, if the rationality in producing the vision for a theory is, as argued here, an instance of synthetic inquiry, then it can be expected that the opposites of these four enemies, in order, stand in the way of the formulation in science.

Enemies in Theory Formulation

The enemies in theory formulation are hypothesized to be Belief, Veiledness, Weakness, and Immaturity. If sensible interpretations can be made for these terms, further evidence is obtained for the hypothesis that theory construction and theory formulation involve the opposite kind of thinking.

Belief

In ancient and medieval times, decadent religious institutions persecuted science and its practitioners. While science has overcome this obstacle to some extent, the victory is less than total. Science everywhere continues to be denied resources if it dares to challenge philosophical and political doctrines. In advanced technological societies, science is subordinated to the state and to the economic system. In the physical sciences, theories are no longer repressed, but the application of theories remains firmly in the grasp of political and economic elites.

At the same time, modern science remains immersed in its belief in objectivity. Frankel writes (1967:24-25): "Objectivity in thought and judgment, generally speaking, is a social achievement the product of long cooperation processes of controlled questioning, communication, and mutual criticism." And Novak asserts (1967:37): "Objectivity is a highly selective, highly developed, subjective state. It is the selection of one set of values in preference to others, the shaping of perception and other mental operations along specified lines, and the establishment of social means of verification." Novack adds (ibid.):

> Objectivity, in short, has the logical status of a myth: it builds up one sense of reality rather than others. It is a myth whose attainment and maintenance demands of its subjects a rigorous and continual asceticism.... [S]tudents who wish to give their lives to this myth through careers in science or technology are often taught that they must learn to censor flights of fancy, dreams, impulses, wishes, preferences, instincts, and spontaneity of many sorts, to do so not only occasionally but habitually, and not only in their immediate professional activities but for long supporting stretches of their lives as well. Science and technology ask of their practitioners a whole way of life for which young people must be socialized by many years of schooling.

But such inculcation does not develop real science. Novak notes (1967:38): "Insofar as the objective mind is thought to be impersonal, detached, analytic, verbal, precise, and clear, the theory of objectivity represents only a part of human judgment." In the vocabulary developed here, it can be said that the belief in objectivity stultifies the development of the practice of science, stopping the practitioner in his tracks. For above all, to do science is to suspend belief, to question everything. Novak writes (1967:46): "The drive to question operates through every stage of awareness: through dreams, images, experiences, perceptions, orientations, conceptions, theorizing, decisions, and actions. Insofar as these moments of awareness can be ordered among themselves in various ways, the drive to question may also be directed to different sequences and complex combinations."

A scientist vanquishes his first enemy the moment it is realized that everything can be questioned. Novak (1967:14) sees this capacity to question as "The necessary condition for the experience of nothingness.... Whatever the presupposition of a culture or a way of life, questions can be addressed against them and other alternates can be imagined...." Also, (1967:12-13), "...the experience of nothingness casts doubt...on the reasons and methods of sociology (and every other science or philosophy), ... [and is] beyond the limits of reason.... It is terrifying.... The person gripped by the experience of nothingness sees nearly everything in reverse image. What other persons call certain, he sees as pretend; what other persons call pragmatic or effective, he sees as a most ironical delusion.... The experience of nothingness is an awareness of the multiplicity and polymorphousness of experience...."

Veiledness

Once practitioners of science vanquish the value assumptions and beliefs that exclude possible topics and restrict mental capacities to propositional thought, they have an enhanced capacity for vision and theoretical insight. And here the scientist encounters the second enemy--veiledness. A scientist attains an insight or vision only through protracted struggle to see. Whatever might have been previously believed is dispelled, and it becomes possible to develop the courage to pursue the vision.

It is a fundamental challenge in the practice of science to convert a vision--the idea for a theory--into a point before the eyes. The vision must be defied and the character of its order must be changed from entwined ideas at the edge of words to a linear order in which the ideas are unraveled and set forth in the form of a propositional argument. The ideas need to be brought within written language, and ranged one before another, in a relation of order or spatial succession.

In the vision quest of don Juan, clarity--which is just such a point before the eyes--is an enemy. But for the scientist the creation of clarity before the eyes is the essence of the practice. The need to be clear imposes discipline on the inquiry. This discipline comes about through rendering verbal accountings of phenomena compatible with principles of propositional reasoning, including formal logic.

Thus the practice of science involves both the construction of the idea for a theory, and its eventual formulation. Setting down a vision in a clearly written form, such that the laws of the theory are about the inner structure of phenomena, is not a problem in formal logic. In theory construction--which is work with structure--the logic-in-use may involve the rationalities of appositional thought working with propositional thought and the senses. Thus theory building is creativity of a nonlinear order. The formulated theory is the product of this inquiry, and yet the logic contained in it does not exhaustively describe the rationality involved in constructing the idea for the theory and formulating it. In this process, the scientist uses the rationalities for theory construction and his enemies are fear, clarity, power, and old age.

Theory is constructed in the appositional mode of thought, or as a result of an interplay, or working together, of the two kinds of thinking. The logic contained in the published version of a theory--the end product--does not exhaust the rationality of construction and formulation. A theory may be reduced to logic in the sense that it can be seen in its purely formal aspect, but the theory also is about inner structure, the layers of the perceived world we know only tacitly in words.

Weakness

When a scientist, or a community of scientists, go beyond the first two enemies of the practice, and have set forth a vision in a clearly formulated theory, the third enemy--*weakness*--is encountered. For a formulated theory may prove not to be true, and the vision, however promising and imaginative, must be adjudged to be in error. A scientific community must have the *power* to reject a theory found inconsistent with data gathered to test it. To the extent that this power is lacking, *weakness* is present.

Second, hypotheses derived from the general statements, or laws, of a theory must be consistent with empirical observation, so that it can be determined to what systems, if any, the theory applies. If hypotheses are consistent with observations, it is said that the theory is externally valid, and that it is empirically true.

Assuming a theory is logically consistent, there are two types of errors that can be made regarding its external validity:

Type I: A true theory can be falsely rejected;

Type II: A false theory can be falsely not rejected.

There are difficulties in attaching a numerical probability to a theory, and these problems have been dealt with in the philosophy of science (See, e.g., Carnap, 1945). However difficulties in attaching a numerical probability to establish such probabilities in actual practice, at the conceptual level, we can attempt to indicate the probability of making a Type I error and the probability of making a Type II error . The complement of , 1 - , is defined as the *confidence* we can have in the test of the theory. The complement of , 1 - , is called the *power* of the test of the theory--which is the probability that it will be found out that the theory is false. Consistent with this, the probability, , that the false theory will not be rejected can be defined as *weakness*.

The history of science contains numerous examples of Type I errors. Martin Gardner (1957:9) describes a few instances of novel scientific views which did not receive an unbiased hearing, and which later proved to be true.... The opposition of traditional psychology to the study of hypnotic phenomena...is an outstanding instance. In the field of medicine the germ theory of Pasteur, the use of anesthetics, and Dr. Semmelweiss' insistence that doctors sterilize their hands before attending childbirth are other well known examples of theories which met with strong professional prejudice.

Probably the most notorious instance of scientific stubbornness was the refusal of eighteenth century astronomy to believe the stones actually fell from the sky.... Even the great Galileo refused to accept Kepler's theory, long after the evidence was quite strong, that planets move in ellipses. Fortunately there are always, in the words of Alfred Noyes, "The young, swiftfooted, waiting for the fire," who can form the vanguard of scientific revolutions.

There is some defense for this inherent "conservatism" in science. Gardner notes (1957:11): "...a certain degree of dogma--of pig-headed orthodoxy--is both necessary and desirable for the health of science. It forces the scientist with a novel view to mass considerable evidence before his theory can be seriously entertained. If this situation did not exist, science would be reduced to shambles by having to examine every newfangled notion that came along." Thus, while Type I errors are to be avoided, theories whose time have come, no matter how odd or radical they may seem to the orthodox practitioner, will in time receive a fair hearing.

On the other hand, a Type II error poses a more fundamental enemy of science. Popper's analysis of theory testing illustrates the priority of overcoming the weakness of Type II errors. He writes (1964:75):

> ...all tests can be interpreted as attempts to weed out false theories--to find the weak points of a theory in order to reject it if it is falsified by the test. This view is sometimes considered paradoxical; our aim, it is said, is to establish theories, not to eliminate false ones. But just because it is our aim to establish theories as well as we can, we must test them as severely as we can; that is, we must try to find fault with them, we must try to falsify them. Only if we cannot falsify them in spite of our best efforts can we say that they have stood up to severe tests. This is the reason why the discovery of instances which confirm a theory means very little if we have not tried, and failed, to discover refutations. For if we are uncritical we shall always find what we want: we shall look for, and find, confirmations, and we shall look away from, and not see, whatever might be dangerous to our pet theories. In this way it is only too easy to obtain what appears to be overwhelming evidence in favor of a theory which, if approached critically, would have been refuted. In order to make the method of selection by elimination work, and to ensure that only the fittest theories survive their struggle for life must be made severe for them.

New theories often need reworking and clarification. Laws may have to be added or deleted. The conditions under which a theory can be expected to hold--the domain of the theory--can be explored. Sometimes, after protracted efforts to overcome weaknesses in a theory by changing its internal structure in an effort to bring its hypotheses into closer correspondence with observation, the entire enterprise is abandonned. The land of science-past is haunted by theories that were, in their time, widely accepted, but that are now labelled "error," and with occasional exceptions, this labelling is justified (See Kuhn, 1962:2).

Immaturity

As scientists develop their theories it is centrally important to inform themselves regarding what has been discovered, what is hypothesized, what is known, what is rejected. The problem is enormous, for science has expanded into a vast enterprise containing scientists working intensively on theoretical topics, publishing their work in innumerable books and journals. At the frontiers of scientific disciplines, elite communities of scientists, that de Solla Price (1963:62) calls "invisible colleges," exchange written descriptions of their work with each other for information and criticism. At times theories develop so rapidly that nearly every practitioner engaged in a particular topic will read versions of the most advanced thought and its experimental support long before it comes to be preserved in academic journals and eventually described in textbooks. Students in advanced training for careers in science often only have access to these formal records of the practice, and have difficulty inferring the actual practice and its logic-in-use from these published accountings and their logic, reconstructed so that it all appears perfectly clear and orderly, as if only propositional thought were involved in the enterprise. Even the most competent practitioners are continually in danger of not adequately keeping up with current investigations, of doing what has been done, of repeating error, and in general of proceeding with insufficient information. An overall grasp of a scientific discipline as a whole, together with a sense of its history and prospects, comes only with protracted effort, and enables the practitioner to deal with the enemy immaturity. While many discoveries come as a surprise, others are expected, so that several people are working simultaneously on the edge of the same discovery. The result is frantic activity on the frontier of a scientific discipline, with practitioners apt to dispute one another for the credit for an idea whose time is here (de Solla Price, 1963).

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Immaturity is also a problem for a scientific discipline as a whole. It is well known that the behavioral and social science disciplines are immature in comparison with the biological and physical sciences. Most formulations within behavioral and social science are not clear enough to be considered theories, and the formulations that clearly are theories often do not contain sufficient explications of the concepts and the domain of the theory so that they can be tested empirically. The reasons for the relative immaturity of the social sciences is a most interesting topic that awaits an adequate explanation. Philosophers in the logical empiricist tradition have found that social, biological, and physical sciences do not differ fundamentally in their basic methodologies, so the explanation must lie elsewhere. The reason must have something to do with the values of a civilization convinced that its problems can be solved by technology, by machines, and by applied physical science.

Dialectical Rationalities in Science

To this point it has been argued that propositional and appositional thinking constituted opposites, that the rationalities for theory construction and theory formulation are opposites, and that enemies in the work of constructing a vision and of giving a vision form are opposites. This argument that the practice of science contains a contradiction-in-itself implies that it is founded on laws of dialectics. That is, it is argued here that in addition to the common sense rationalities, the rationalities for theory construction, and the rationalities for theory formulation, there are rationalities for connecting formulating theories to their object, such that theories can be tested empirically. That is, it is hypothesized that laws of dialectics constitute the rational bases of scientific methodology.

Analytic thought, as formal logic, can be contrasted with appositional thought, but it has also been contrasted to a method of thinking applied to material content, called dialectical thought. Kant explained that analytic thought examines and estimates the application of formal rules, which must then be tested to determine their truth or falsity in relation to an empirical object. Kant recognized that formal logic alone is insufficient to establish positive truth, and produces only the semblance of objective assertions. He explained (1961:60): "For as logic teaches with regard to the content of knowledge, but lays down the formal conditions only of an agreement with the understanding which, so far as the objects are concerned, are totally indifferent, any attempt at using it...in order to extend and enlarge our knowledge...can end in nothing but mere talk, by asserting with a certain plausibility anything one likes or, if one likes, denying it."

Kant (1961:60) saw analytics as inadequate to unite form and content. This unity, the precondition for the establishment of empirical truth, requires collecting "trustworthy information, in order afterward to attempt its application." Formal logic and abstract argument alone cannot determine objective truth. The error of dialectical semblance--the assumption that the form of understanding can establish truth--leads to the reification of knowledge. It is observed in practice as sophistry, which Kant identified as the "...art of giving to one's ignorance...the outward appearance of truth, by imitating the accurate method which logic always requires, and by using its topic as a cloak for every empty assertion."

Kant added <u>real</u> dialectics to logic as "a <u>critique</u> of dialectical semblance." Dialectics is thus an effort to criticize incorrect application of analytics to objective content. It contains principles of reason beyond the edge of analytic thought.

A modern scholar whose views are close to Kant's is Levi-Strauss, who writes (1970:246):

> In my view dialectical reason is always constitutive; it is the bridge, forever extended and improved, which analytical reason throws out over an abyss: it is unable to see the further shore but knows that it is there, even should it be constantly receding. The term dialectical reason thus covers the perpetual efforts analytical reason must make...if it aspires to account for language, society and thought; and the distinction between the two forms of reason in my view rests only on the temporary gap separating analytical reason from the understandings of life.

The view of dialectics as beyond the edge of analytics is implied by distinctions within the philosophy of science. Hempel, for instance, writes (1960: 72-73): "Broadly speaking, then, the formulation of a theory will require the specification of two kinds of principles; let us call them internal principles and bridge principles for short. The former will characterize the basic entities and processes invoked by the theory and the laws to which they are assumed to conform. The latter will indicate how the processes envisaged by the theory are related to empirical phenomena with which we are already acquainted, and which the theory may then explain, predict, or retrodict." The internal principles are the analytic systems used in the theory, including formal logic, mathematics, and natural language. The bridge principles are the ways in which such propositional thought, with its capacity for abstract analysis, can be dynamically connected to objects.

Kant, the last great philosopher of the static, claimed that instruction in dialectics is beneath the dignity of philosophy. But the development of Western philosophy demanded that dialectics be pursued. It was Hegel who went where Kant refused to go, and attempted to study the dynamic involvement of mind beyond the edge of analytics.

In its struggle with its first enemy, science vanquished belief but at the same time banished metaphysics--which Hegel (1929:33) defined as "the intellect occupying itself with its own pure essence...." Belief was not destroyed, but transformed into its opposite, disbelief. Hegel wrote (1929:33, 39) that when science abandoned metaphysics it was "...exchanged for emotions, for popular practicality, and learned historicity." He added: "When such metaphysical shadows and such colorless self-concentration of the introspective spirit, has been brushed aside, existence seemed to be transformed into the sunny land of flowers--and, as we know, no flowers are black." To see requires reaching into the shadows of the mind, into self-concentration, into the invisible, colorless, realm within. Everything we look at has color: but we can see beyond our looking, by having vision manifested as a quality of perception.

Hegel saw philosophy as "Ordered Knowledge," which "cannot borrow its Method from a subordinate science, such as Mathematics, any more than it can rest satisfied with categorical assertion of pure intuition, or using reason based on external reflection." "Ordered Knowledge" comes about through reason. Hegel wrote:

> Reason is negative and dialectical because it dissolves into nothing the determinations of Understanding; Reason is positive because it is the source of the Universal in which the Particular is comprehended.... [I]n its real truth Reason is Mind--Mind which is higher than either Reason which understands, or Understanding which reasons. Mind is the negative, it...constitutes the quality alike of dialectical Reason and of Understanding: it negates the simple and thus posits that determinate distinction which is the work of Understanding, and just as truly it resolves this distinction, and is thus dialectical. Yet it does not abide in the negative, which thus results, but is therein just as much positive.

Hegel essentially argues that the perceived world of our understanding loses its certainty, its apparent simplicity dissolved, when reason is applied to it. Since Reason is Mind, and Reason is dialectical, it follows that Mind is dialectical.[7] In this theory the determinant of dialectical thought is identified by Hegel as the movement of thoughts in Notions. Lenin explained (1963:355) "human concepts are not fixed but are eternally in movement, they pass into one another, they flow into one another, otherwise they do not reflect living life. The analysis of concepts...demands study of the movement of concepts, of their interconnection, of their mutual transition...." The second determinant of dialectics given by Hegel (1929:240) is "the opposition of thought to outward appearance or sensous Being...and in the objective existence we see the contradiction which it has in itself, or dialectics proper." Lenin explained: that dialectics is the study of contradiction in the essence of objects.

Hegel's theory deals explicitly with the opposition between analytic and synthetic cognition. He recognized that these two kinds of thought are brought together in the moment that an abstract proposition, or "Judgment," (e.g., "The rose is red.") is attached to its "Other," (the rose). He wrote (1929:473): "This equally synthetic and analytic moment of the Judgment, by which the original universal determines itself out of itself to be its own Other, may rightly be called the dialectic moment."

Engels (1971:26) summarized Hegel's law of dialectics as follows:

> It is...from the history of nature and human society that the laws of dialectics are abstracted. For they are nothing but the most

general laws of the two aspects of historical development as well as thought itself. And indeed they can be reduced in the main to three:

The law of the transformation of quantity in quality and <u>vice versa</u>;
The law of the interpenetration of opposites;
The law of the negation of the negation.

<u>Quality, Quantity, and Measure</u>

These three "laws of dialectics" can now be examined to explore the hypothesis that they constitute rationalities for methodologies in science.

Hegel (1892:157) provided a succinct analysis of the mediation of quality and quantity:

> Each of the three spheres of the logical idea proves to be a systematic whole of thought-terms, and a phase of the Absolute. This is the case with Being, containing the three grades of quality, quantity, and measure. Quality is, in the first place, the character identical with being: so identical, that a thing ceases to be what it is, if it loses its quality. Quantity, on the contrary, is the character external to being, and does not affect the being at all. Thus, e.g., a house remains what it is, whether it be greater or smaller; and red remains what it is, whether it be brighter or darker. Measure, the third grade of being, which is the unity of the first two, is a qualitative quantity. All things have their measure: i.e., the quantitative terms of their existence, their being so or so great, does not matter within certain limits; but when these limits are exceeded by an additional more or less, the things cease to be what they were.

Given that the unity of quality and quantity is brought about through measure, it follows immediately that this dialectical law refers to measurement within scientific inquiries. Engels explained (1971:27): "All qualitative differences in nature rest on differences of chemical composition or on different qualities or forms of motion (energy) or, as is almost always the case, on both. Hence it is impossible to alter the quality of a body without addition or subtraction of matter or motion, i.e., without quantitative alteration of the body concerned. In this form, therefore, Hegel's mysterious principle appears not only quite rational but even rather obvious." And Mao Tse-Tung writes (1967:45): "There are two states of motion in all things, that of relative rest and that of conspicuous change.... When the thing is in the first state of motion, it is undergoing only quantitative and not qualitative change and consequently presents the outward appearance of being at rest. When the thing is in the second state of motion, the quantitative change of the first state...gives rise to the dissolution of the thing as an entity and thereupon a qualitative change ensues, hence the appearance of a conspicuous change."

In scientific inquiry the unity of quality and quantity comes about through an effort to describe the object of study as consisting of variables and relationships between variables. The object of investigation, while itself fundamentally a unity, is broken down into the many, generating as much fragmentation as is necessary to describe the behavior of the object over time (its per<u>form</u>ance, as it were, or its form as its law of development). First the scientist substructs the

the object of his attention into parts, and then he attempts to reassemble these parts in a coherent whole. The unity of the object can be seen if the reassembly is viable, if its form is in correspondence with the external form of the object.

When a general system of equations connecting the variables for an object being studied leads to measureable description, then the scientist can employ measurement techniques and replace the variables with constant terms, rendering the resulting particular statement capable of being adjudged as consistent or inconsistent with measure.

Hegel's theory of being views measure, where quality and quantity are a unity, as the completion of Being. He wrote (1892:210): "Being, as we first apprehend it, is something utterly abstract and characterless: it is the very essence of Being to characterize itself, and its complete characterization is reached in Measure."

Interpenetrating Opposites

Hegel's second law of dialectics posits a unity between opposites. Real opposites are defined by their capacity for unity, or by the fact that one implies the other. Thus left and right, yang and yin, black and white, propositional and appositional thought, and so forth, are opposites. Processes in the world are knowable by their "self-development," the struggle of opposing tendencies within.

In dialectics, development is not seen as a harmonious and mechanical unfolding, but as "struggle" between opposing tendencies that are inherent in objects. Thus the interpenetration of opposites involves destruction of the old and construction of the new. The forces behind such development are not seen as the results of external causes, but, in Hegel's terms, as "self-movement." Thus the oppositions inherent in a thing are opposed to its identity, for they contain the seeds of both transformation and structural change to a new order, which contains other contradictions. The concept of opposition is opposed to the concept of identity. Hegel argued that identity determines only simple immediacy, a static being, while the interpenetration of opposing tendencies within an object is a source of its motion; things change because they possess internal contradictions that struggle with one another. While self-identity is static, self-contradiction is dynamic.

Science is constructed out of visions; in this sense theory construction employs the rationalities, and possesses the enemies, of synthetic inquiries, which are the opposites of the rationalities and enemies of science. The scientific rationalities are directed to the conversion of these visions of structure into form. The practice of science thus presupposes its own opposite, and has the practice of a synthetic inquiry in itself.

Kant saw that inquiry into logic "teaches nothing with regard to the content of knowledge, but lays down the formal conditions only of an agreement with the understanding, which, so far as the objects are concerned, are totally indifferent." Yet, within the practice of science, it is absolutely necessary that events be explained by statements formally deduced from the laws of a theory. Thus sentences--which are indifferent to content--must be brought into unity with observation. To this end scientists devise abstract implements constituting methodologies, to evaluate if events implied by a theory are in unity with, or are mirrored by, formal statements. The scientist has the problem of creating a unity between form and structure, generating statements that can, with sensory observation and methodology, be critically evaluated as to whether they are actually about the topic of the theory.

There is both struggle and unity of opposites in science. It is a struggle to have a vision, bringing its image into form. Thus the struggle of opposites in science comes at the level of theory construction; the unity of opposites, in contrast, comes in observation of events predicted by a theory.

The Negation of the Negation

In Hegel's Science of Logic the law of the negation of the negation is used rather than written about, for it is the fundamental law for construction of the entire system. The law essentially states that every object has an appropriate way of being negated, such that it gives rise to development, to an historical process.

Hegel contrasted Quality (determinate Being) with Negation. Yet he saw negation as related to quality; a change of quantity into quality negates the previous quality, so that the new quality in turn develops, leading to its own negation. Negation does not mean mere denial or destruction of a thing, but its transformation into its opposite. It expresses the transcendence of its first negation. Beginning with a thesis, an antithesis (the real opposite of the thesis) is generated, and the negation of the antithesis produces a synthesis.

In science, the law of the negation of the negation comes into play in the fundamental operation of empirically testing theories. If a theory is not consistent with the events deduced from it, it can be said to have false laws in it. Karl Popper (1959) argues that such a theory, containing one or more false laws, should be declared, as a whole, to be false. In this sense, theories can be proven false; but they can never be proven true, as this would involve an impossible requirement: it would be necessary to make observations at all times, everywhere. However, if a theory consistently leads to observations consistent with events deduced from it, then there is no basis for rejecting it, and scientists can presume that the theory will continue to weather future attempts to find weaknesses in it.

The test of a theory, therefore, comes down to a choice:

1. Reject the theory;
2. Do not reject the theory.

The first choice means "Not the theory," or "The theory is not true." The second choice means "Not not the theory," or that the theory, being consistent with observed events, cannot be declared false, and therefore is as a whole, dynamically connected to its object. This is the role of the law of the negation of the negation in the methodology of theory testing, a fundamental operation in science. The methodology of theory testing constitutes a dialectic basis of scientific inquiry, and gives science practical value. By means of establishing theories consistent with observation, science synthesizes the negative reason represented by the theory and the positive reason represented by the observation and measurement of events that follow logically from the theory. This indeed shows that as, Hegel claimed, dialectics is the soul of scientific knowledge.

Footnotes

*We are grateful for helpful suggestions and criticism provided by Joseph E. Bogen, Suzanna DeRooy, Ronald DeZure, and Donna Seid.

[1]This view has been advanced, e.g., by Wooldridge, who advocates mechanist reduction of consciousness to brain functioning, and writes (1963) that research on brain mechanisms "may well be the only sound procedure for permanently plugging the hole in the logical structure of the mechanist philosophy: to accept the sense of consciousness itself as a natural phenomena suited to being dealt with by the body of laws and methods of the physical sciences." Critique of this view is provided by Polanyi (1958:262-263).

[2]See Bogen (1969a, 1969b), Levy-Agresti and Sperry (1969:1151), Nobel (1968), Milner (1971), and Kimura (1964).

[3]This argument is more fully developed in TenHouten and Kaplan (1973), in which the Tarot, a practice involving divination by fortune-telling cards, the I Ching (Book of Changes), and the Indian American vision quest are used as case studies of synthetic inquiry. Much of the argument presented here is from this book.

[4]See Bogen and Bogen (1969:195). They write: "Every such patient fails to replicate, with one hand, complicated postures imposed on the other. There is a wide variety of similar defects in interhemispheric transfer following commissural section."

[5]Levi-Strauss writes (1969:15-16) that music and myth, both synthetic inquiries, share the property of "requiring a temporal dimension in which to unfold. But this relation to time is of a rather special nature: it is as if music and mythology needed time only in order to deny it. Both, indeed, are instruments for the obliteration of time. Below the level of sounds and rhythms, music acts upon a primitive terrain, which is the physiological time of the listener; this time is irreversible and therefore irredeemably diachronic, yet music transmutes the segment devoted to listening to it into a synchronic totality, encloses it within itself." Inquiry through music, myth, and in general through the synthetic inquiries are fundamentally atemporal, if time is defined as linear.

[6]To say there are "layers" in an order should not bring to mind the notion of an hierarchy with distinguishable layers. Instead, the layers in an order each have boundaries with other layers, such that they form a whole and context. The notion of layers is used in the sense of "principal components" within a "perfect scale," as formulated by Guttman (1950).

[7]In mind, the development of two distinct modes of thought in the two sides of the brain constitutes the fundamental contradiction, and this very struggle between opposed modes of thought insures mental development. Bogen has seen this struggle between the propositional and appositional modes of thought as absolute, and on this basis he finds it appropriate to refer to each as a "mind." Bogen also argues that communication between the brain hemispheres, via the corpus callosum, is related to creativity. In the terminology used here, it can be said that the two modes of thought associated with the hemispheres constitutes the fundamental opposition or contradiction in mind, and is the basis of struggle that is absolute, and unity that is relative, coming about in moments of creative realization--of an idea, the recognition of an order, the creation of art, or an illuminating insight.

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