COMMENTARY

INFERENCE AND SUCCESSFUL BEHAVIOR

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ABSTRACT

Inference procedures integrate past experience with current sense data to permit perception of the content of the sense data as objects and events. This notion impinges on views of knowledge. The dominant Western view that knowledge is "justified, true belief" is orthogonal to the classical secular view prevalent in ancient India that "knowledge is a means for successful behavior." Both views rely on inference from empirical observations, and both use formalisms and schema for "valid" inference to delineate assumptions, to evaluate liability of conclusions, to assure validity of the knowledge base, and to identify bases for controversies. The view that knowledge is successful behavior explicitly deemphasizes the a priori, while emphasizing the veridical character of the evidence rather than its "truth value." This approach is often used to deal with the unknown in unfolding events because it increases the chances of success.

"Are you the smoke from a fire that never burned?" (Derek Walcott, 1978)

INTRODUCTION

HIGHER LEVEL communication among humans has evolved from language ability. For interpretation and representation of experience, all languages make use of syntax. For example, beyond its root, a verb always has meanings that are understood by its syntax and context. Concomitant with syntax, languages also rely on inference procedures to elaborate the content of experience. Both facilitate representational abstractions; however, inference ability may not be "hard-wired," as syntax ability apparently is during development. As we will see in this essay, inference procedures are not derived from rhetoric or the idiom of language, but they are intrinsic in the way the "realist" in us has evolved to deal with the content of sense data.

Inference procedures are inherent in the way perception is structured to form a world-view. Inference processes impinge upon and derive their force from interactions with sense data, that is, by such mechanisms humans are guided and encouraged, whether by nature or nurture, to interact with objects and events. Ability to draw context-related inferences helps in generalizing from past experiences. It is obvious that individuals and groups who successfully practice such abilities can orchestrate their future: As creatures who infer, humans examine the things they desire, evaluate the level of desirability, consider alternatives, calculate means of attaining desires, and plot

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courses of action. In short, valid inferences help in creating order out of life's chaos, and in the form of a knowledge base, this order becomes a basis for successful behavior as determined by a broad range of biological and evolutionary constraints.

To facilitate discussion here, "sense data" is meant to include all inputs that lead to *awareness* of an occurrence. Furthermore, a distinction is made between awareness and *perception*. While perception results in assigning that-ness, such individuation or differentiation is not part of awareness. Although it may require some form of processing of sense data, "awareness" is "mere acknowledgement of stimuli." Awareness must precede inference-driven perception. According to this reasoning, sense data include all the steps leading up to awareness. *Awareness* can also be used to connote perception of *whole* from limited sense data, although we do not use this sense of the word.

FEATURES OF INFERENCE

Inference is necessary for perception, and useful inferences are *thought activities that integrate knowledge* based in past experience with unfolding events. Inference processing provides an understanding of the content and nature of the experience at representational, relational and hierarchical levels. Sense data is evidentially fundamental and epistemologically prior for processing of information by inference. As a guide to the arguments in this section, consider an example of activity that involves decision making while dealing with the unknown and uncertain, such as driving to a destination where one has never been before. Inference is triggered by curiosity and uncertainty. The process is purposefully propelled by extracting useful information from current facts and past experiences. Because of limitations of the sense data and knowledge base, it is necessary to constantly reevaluate conclusions. In short, although road maps and instructions may be helpful, experience shows that one needs moment-to-moment interaction with uncertainties. Thus inference is an *iterative activity,* where each conclusion may lead to more questions. To engage in successful behavior, one must not only formulate and revise working hypotheses with a fair amount of alacrity, but one must also be able to target efficiently the appropriate body of facts in the knowledge base.

Ultimately it is necessary to evaluate the *liabilities* of inferences. Aside from problems associated with the inference schema, which we shall address later in detail, liabilities of inference come from two other sources: validity of the knowledge base and reliability of sense data. Reliability of sense data is assumed, but demonstrating the reliability of the sense data cannot be addressed cursorily. Issues related to illusion and mass hypnosis are generally recognized. Problems associated with possibilities of "evil demon" and "brain in a vat" are also relevant in the general context where other elements of the inference process may be influenced. Similarly, the knowledge base is used as a *given* for future behavior. Although the knowledge base is a given, it is subjected to reexamination; in this sense it is not the a priori of Western epistemology, which treats the a priori as "self-evident" and "necessary," such as axioms, natural laws, and rules of logic.

As an end product of earlier inferences, a formalized knowledge base is essentially a construct of collective experience. Communal experience is formalized and codified to provide a framework to guide activities. The axioms and attitudes generated from inference procedures lead to an understanding of how things work the way they do. They are often useful in anticipating difficulties, for designing solutions, for systematization of the knowledge base, for representational generalizations, and for revealing inherence. Such expanded insights amount to verification of behavior. It is also possible that this fuller understanding may suggest a revision of those old behaviors that led to limited success. Yet, despite all, the endeavor may not be successful. Awareness of such anomalies signals targeting a different area of the knowledge base.

At times the knowledge base may become irrelevant, making the trial-and-error approach necessary. In such situations one becomes aware of the limitations of the schema because the particular experience does not always resemble the generalized experience enough to warrant total reliance upon the communal knowledge base. If anomalies persist, alterna-

tives are sought in terms of fresh input or additional observations. Scientific methods may enter at this point to test alternative possibilities and procedures to ensure the veridical character of the evidence at hand, that is, sense data and the knowledge base. The reliability of the conclusion is thus dependent on the accuracy of the evidence rather than the truth value of any knowledge claim. This distinction is emphasized by the Sanskrit word "pramāṇa" (*pra* for excellence or perfection and *ma* for measure, know).

INFERENCE AS PURPOSEFUL ACTIVITY

Inference is a purposeful activity for transition from doubt to certitude and from curiosity to conclusions. As an example, consider the momentary uncertainty that arises upon suddenly encountering a long cylindrical object on the ground. Initially there is the awareness of the unusual stimulus, the long cylindrical shape. This *interaction* can only be useful if the source of the stimulus is identified. This *curiosity* requires formulation of a *working hypothesis*, yet there is uncertainty in its very nature. For example, the long cylindrical shape may suggest a snake or a piece of garden hose. As a better guide to successful behavior, other things being equal, the hypothesis that the object is a snake has fewer unfavorable repercussions. In order to deal with the uncertainty, *verification* is necessary based on additional pieces of information such as size, texture, movement, and other features. A series of such iterative attempts at verification may not necessarily prove the identity of the object. Finally it is necessary to devise *falsification criteria* and to *check the liabilities* of generalizations and assumptions. In examining one's liabilities, the empirical base for philosophy is established. Its useful purpose is directed toward viable conclusions based on intelligible arguments.

In an operational sense, during processing of sense data the primary commitment is to experience and observation. Although reliance on the a priori is not ruled out, inference need not rely upon such principles or claims. In fact, the validity of inference may lie in its functionality, that is, successful behavior. This is not a truth based on a priori axioms, but the veridical character of its premises and conclusions requires empirical and independent verification. In short, the processing of the sense data from an occurrence is initiated by doubt, but with the use of the knowledge base and sustained inquiry, inference leads to certitude.

FORMALISMS FOR INFERENCE PROCESSES

A formalism for arriving at an acceptable inference is a necessary step toward articulating and communicating the content of experience. In assessing the validity of inference, conventional sets of rules assure an unbiased ground for evaluating the reliability of sense data, as well as liabilities of the knowledge base and its assumptions. Thus, suitably formulated inference procedures could form an unbiased, undogmatic, content-free matrix upon which all parties can agree. Beneficial outcomes include codes of conduct, knowledge bases, technologies, and means of communication and conflict resolution.

Formalisms for inference have evolved in various cultures. The Greek system, inspired by Plato and Aristotle, is the basis for Euro-Americans. This essay, however, is inspired by a critical review and remarkable conceptual synthesis by Bimal Krishna Matilal (1986). In his book, by critical examination of original and derived literature, Matilal develops several ancient Indian views of knowledge that have been ignored or misinterpreted by Western academics. The strength of the book lies in its detailed articulation of the secular Indian formalisms that were initiated around 500 BC by the skepticism of Buddhist and Jain monks against the use of Vedas and Scriptures as a priori. The ground rules of the Nyāya-Pramāṇa system were laid by Gautama and formalized around 400 AD in a commentary by Vatsyayana (Jha, 1939). Since then, the Nyāya system has provided a rational secular basis for discussions, debates, and conflict resolution among traditional Indian academics. It is curious to note that the growth of the Nyāya system apparently stopped by the beginning of this millenium. A historical fact may be relevant here. Since the Twelfth Century the Indian subcontinent has been repeatedly overrun by zealot nomads of Central Asia followed by Islamic and colonial invaders, all of whom were generally intolerant of other points of view.

The book *Perception* is a rigorous introduction to the basic features of the Nyāya system

for Western readers. The concerns of these ancient philosophers are ever relevant. It is all the more significant because Matilal has initiated a fundamental dialogue among the Buddhist, Greek and Nyāya views of truth and knowledge. This should be useful for understanding the very nature of such issues as they have evolved in two very different cultures. The serious attempt to conceptualize basic issues and intuitive flow of underlying arguments is illustrated by the chapter titles: Philosophical Questions and *Pramāṇas*; Scepticism; The Nature of Philosophical Argument; Knowledge as a Mental Episode; Knowing that One Knows; Analysis of Perceptual Illusion; What Do We See?; Perception as Inference; Pleasure and Pain; Imagination, Perception, and Language; Particulars; Universals.

The book is not for bedside reading. An active reader, however, with curiosity, patience, understanding, and an open mind with a willingness to delve into subtle arguments would be amply rewarded with a rich experience. The book deals with topics and considerations that have baffled and aroused philosophers, that is, *how to deal with the unknown in unfolding events*. Needless to say, this is one of the motivations for doing science, and therefore the issues raised in this book are also of importance to practicing scientists. The book provides glimpses into the intellectual environment in ancient India and illustrates the importance of diversity and pluralism; however, the book is not motivated by a concern for multiculturalism. The arguments developed in the book are not necessarily against existing methods in the spirit of the arguments developed by Feyerabend (1975), but the arguments do provide a viable alternative to many of the problems and paradoxes of Western Philosophy. The practice of science relies heavily on the processing of data, and the primary process at work here, as well as in philosophical arguments, is inference. Therefore, in the rest of this essay we will examine the various inference schema and their implications.

THE MODERN INTERPRETATION OF THE GREEK SCHEMA OF INFERENCE

All humans are mortal;
All Greeks are human.
All Greeks are mortal.

As emphasized by modern Western philosophers and illustrated by the above example, the classical Greek syllogism is based on a notion of universals. The universals may be classes or genera, which can be broken down through differentiae to members or species. A proper analysis is one that looks to the essence of the thing in question, and notes its universal aspect: its similarity to other things. Although its particular aspect, its difference from other things, is not completely ignored, it is downplayed. It has also been pointed out that the syllogism is not properly equipped to deal with particulars and individuals and that it becomes so only by extrapolation:

All Greeks are mortal;
Socrates is a Greek.
Socrates is mortal.

With this understanding, Socrates as an individual is not a proper subject for investigation or knowledge claims. He becomes so only by inclusion in the class of Greeks or mortals. Thus, a system of knowledge based on the Greek system became mainly a process of learning about universals, that is, membership in a set.

Modern analytical systems of logic are based in the truth functionality of *or, and,* and *not*. The emphasis on connectives once again demonstrates that the concern about deductive inference is focused on form and pattern rather than on content. Even with inductive inference, emphasis is placed on rule formation for the process and its reliability as a means of knowing rather than on its content and application. Furthermore, inductive inferences invite doubt because the process is one of generalization of empirical observations, which may not be entirely suited to generalization. As we will see later, the Nyāya system accepts this invitation.

With this understanding of the Greek system, the proof is either correct or incorrect based on formal structure. The emphasis is placed on the pattern of reasoning, which is supposed to be independent of experience. Thus proof becomes a matter of checking argument form. The implicit "therefore" reflects the independence of the logical rules from the empirical. What has actually been demonstrated is more the proper fulfillment of a pattern than a statement of context-dependent information. Premises, which tend to be empirical in nature, are often left in uncertainty.

The only valid means of checking them requires that they too be products of reasoning. This leads one to accept the a priori as the only possible basis for knowledge. The a priori (axioms, laws, rules of logic) is consistent with the dictates of reason, but it is incomplete. An empirical base may be complete, but it is thought to be inconsistent with the criteria for truth suggested by analytic philosophers. One of the results of this line of thinking is that inductive inferences based on recurrence of phenomena yield only probability at best, which is a measure of the degree of certainty.

In fairness it may be pointed out that aspects of the ancient Greek system also emphasized observation of particular phenomena. For example, Aristotle (Ross, 1928) demonstrates concern for particulars in the *Posterior Analytics*. Aristotle notes in many works that particulars do not necessarily conform to generalizations, as is most noticeable in the practice of medicine and physical training. In this methodology, which is evident in works ranging from the *Nicomachean Ethics* to the *Metaphysics*, one notices a tendency to consider various views, to argue from experience, to examine uses of words, and to attempt to apply a formalism to empirical observation and the arts and sciences. These aspects, however, have been ignored by many modern philosophers, most notably those who appeal to the a priori, such as rationalists and analytic philosophers.

THE NYĀYA SCHEME OF INFERENCE

There is fire on the hill;
(statement of the working hypothesis)
there is smoke there;
(citation of evidence)
wherever there is smoke, there is fire, as in the kitchen;
(invoking a general principle with a specific example)
tatha,
(given all the specifics above, it follows that)
there is indeed fire on the hill.
(conclusion, statement accepted)

This inference strategy permits a transition between the general principle that has been extracted from empirical data to the specific use (extrapolation) of the principle for the current experience. The "principle" invoked in this traditional example is deliberately weak. This is also the strength of the Nyāya schema as it forces consciousness of the fact that the conclusion is based on a particular example: "Wherever there is smoke, there is fire, as in the kitchen." Although the procedure may strengthen the initial hypothesis, one is not allowed to forget the limits of the knowledge base and the liabilities of the conclusion. It is through iterations of the stimulus-inference-verification cycle (by using different examples) that the degree of certainty is increased. Knowledge, then, is a formalism of past experience and derives its authority from nothing else!

The Nyāya system and most other ancient Indian systems used for judging validity of a conclusion treat inference and knowledge as events in themselves as well as parts of a general event or goal. Thus generalizations are aspects of an event rather than being aspects of objects or of the nature of things, as they are in the Greek system. Recognition of the universal, or ability to universalize, is a step in the knowledge episode. This step does not necessarily require focus on an object, nor does it require extracting an aspect of an object.

According to the Nyāya system, understanding is a matter of being *able to interact successfully* with the event or object at hand. This requires that we be aware of the similarities between events as well as of the particular nature of the event in question. Like all events the way to understand these "mental" events is to observe their causes. To judge their validity one should also look not only at their *content* and *characteristics* but also at their *effects*: behavior.

Pramāṇa are causes of a knowledge event by being the means for knowing. For example, reading a book is a means for knowing the content of the book, laboratory experiments are means for establishing or revising a theory, and seeing is a way to familiarize oneself with one's environment. These pramāṇa, when used in their appropriate domain under optimal conditions, result in successful behavior. Formalizations and articulations of the processes and their conclusions are termed "knowledge."

In the Nyāya system there is pramāṇa for each thing, even for pramāna. In order to avoid infinite regress, pramāna theorists posit that certain pramāṇa are "self-proving." This is a result of a stipulation that instrument and object roles can be assigned to the same entity. Pramāṇa theorists "prove" this stipulation by appeal to an empirical observation about light. A source of light is the means for sight, but it can also be an object for sight. Thus the light source has both "means" and "object" roles in regard to sight. Pramāṇa theorists also appeal to another analogy, that of a scale, that is, *comparison* to a *standard*. First a scale is used to weigh a lump of gold, then that lump of gold can be used to calibrate other scales, as well as to check the accuracy and precision of the first scale at other times. The basis for such "standardization" protocols lies in the fact that although the values for weights may be arbitrary and conventional, the underlying constancy of weight is not. The purpose behind this analogy is to show that with a physical object, which is real and indubitable, it is possible to test the reliability of pramāṇa. Pramāṇa may also be "self-proving" by being nondubious; that is, there are no reasonable grounds for doubting the reliability of the pramāṇa in question. This is not to suggest that the pramāṇa is a priori in the sense of being independent of experience, but rather that it is consistent with the set of other pramāṇa and with the knowledge base.

Yet these criteria may become self-serving in their circularity. In order to be sure of the objects of knowledge a reliable pramāṇa is needed, but in order to ascertain the reliability of the pramāṇa an established object of knowledge is required. In focusing attention this way, however, the pramāṇa theorist may have in mind some form of mutual dependence whereby proof strategies appear circular because of the interdependent natures involved. This is distinct from "vicious circularity," which can be avoided by taking advantage of other criteria such as intrinsic hierarchies, mutual dependence, and iterations. Through such validating procedures, both the means and the objects of knowledge are ascertained. Singular events such as revelation are also weeded out by the requirement of reproducibility. Iterative strategies involving systematic departures are useful if the key features of the system are known. Iterations differ from repetitions (as used to check reproducibility) in the sense that one or more parameters are systematically varied. Along these lines, trial-and-error approaches rely on a random search of the sense data, as well as the knowledge base.

A question can arise at this point: "How do we know that we will ultimately survive and thrive with the pramāṇa of trial and error?" Another way of asking this question is, "How do we know that trial and error is the most efficient way to arrive at a result?" This we do not know. We know that we have been successful so far, but we do not know whether another pramāṇa might have given us greater success. To some extent, however, survival does count as proof that trial and error is a valid pramāṇa for survival. Nevertheless, there may be others, and as a result the status of knowledge is placed in question. In response a pramāṇa theorist might say that in order to test alternative means for survival and thriving, one would have to use trial-and-error pramāṇa because one does not know unless it is tried. Thus trial and error must be a valid (but not necessarily the most efficient) pramāṇa, and through interations along with other applications of it in terms of other pramāṇa, the methods and conclusions are validated. Although it cannot be concluded that trial and error is the most efficient pramāṇa, it can be claimed that at this stage it is the most efficient pramāṇa available. If a more efficient pramāṇa should be discovered, it would be through trial and error.

COMPARATIVE ANALYSIS OF THE NYĀYA SYSTEM

Yet a holder of the "justified, true belief" theory might object that pramāṇa must be evidence as well as cause. Cause-and-effect analysis would seem to avoid the problems involved with justification, yet evidence is still needed as to why anything counts as knowledge rather than just as an experience. Although confirmatory behavior is sought, if events are translated in terms of the pramāṇa, the proof for the validity of the pramāna is circular. For example, in the analogy to light used by the pramāṇa theorists, light may be an object as well as the means for sight, but

it does not make sight veridical. Sight, a pramāṇa, is assumed to be veridical; then observations are used as evidence to "prove" other claims.

Although it is true that we have sight, we cannot know that seeing is an accurate way to perceive reality. To claim that successful behavior results from acting on sight is not entirely helpful, for this does not guarantee that things are perceived as they really are, but rather that appearances can be manipulated. Consider the analogy to people chained to the walls of a cave in Book 7 of Plato's *Republic* (Hamilton and Cairns, 1961). These people are presented with various shadows on the cave wall and become quite apt at interacting, predicting, and talking about them. The purpose of this example is to emphasize that we are prisoners of our words and sense perceptions. The experience that inspired this metaphor is a common occurrence in the interpretation of scientific sense data such as micrographs, spectral peaks, and tracks of the cloud chamber.

Of course, the unknowable possibility that there may be other aspects of reality that are not accessible cannot be addressed. Nevertheless, it is recognized that sense data may be inaccurate by virtue of being transformed, incomplete, or flawed in some unknown fashion. To discuss this problem and the pramāṇa theorist's response to it, it will prove helpful to examine how Nyāya theorists deal with the problem of illusion. Take the case in which a piece of garden hose is mistaken for a snake. According to Nyāya, in a case of illusion there is superimposition of memory on perception. This involves a misplacement owing to a similarity of features between two objects, one of which is actually perceived, the piece of garden hose. The likeness between a perception of a snake and the illusory awareness also comes into play because the two experiences are similar in some of their characteristics. What is experienced, then, is actually a revival of memory triggered by the garden hose. This temporal overlap is enough to cause the mistaken awareness. Most likely a yet undefined judgment is involved here. Along these lines, Buddhists claim that all perception is laden with concepts and judgments, and that these can be wrong. A response that would be consistent with the Nyāya position may lie in the fact that the awareness of the snake is *momentary*, but perception cannot be momentary.

The uncertainty of whether an experience is an awareness or a perception introduces Gettier-like problems considered by Matilal. Consider the following. One sees a cow in a field. The creature is identified as a cow by its dewlap. What one identifies as a dewlap, however, is a piece of cloth tied around the cow's neck. Thus it is not clear whether the event is a knowledge event. On the one hand, it is a knowledge event because the object of perception is correctly identified; it is indeed a cow. On the other hand, it is not a knowledge event, for one has used a faulty piece of evidence, the cloth-as-dewlap, in reaching this conclusion. Exacerbating this situation is the Nyāya claim that one need not know that one knows in order for the experience to count as a knowledge event. This claim could be applied to this case to suggest that one does know that there is a cow in the field, but one does not know that one knows it.

If an attempt is made to analyse the event in terms of its causes, its characteristics may be clearer, but it may still be impossible to decide whether it is a knowledge event. There are at least three causes to this particular, complex, knowledgelike event: the piece of cloth, the misidentification of the cloth as a dewlap, and the inference from a dewlap to a cow. The inference from a dewlap to a cow is unproblematic; it is a valid inference. Noting the use of "tatha" in the Nyāya system, it does indeed follow that there is a cow in the field. Nonetheless, there is misidentification of the dewlap. Thus, although the inference to cow is inviolate, the inference to dewlap is not; and the "dewlap" is one of the causes of the event. Therefore, even if the conclusion is correct, it is not a knowledge event. Yet a possible escape from this quandary lies in the idea of confirmatory behavior. The Nyāya theorist would probably respond that it is through iteration that the first experience is validated or invalidated. Rarely are judgments formed or decisions made based on one look at something.

Yet there may be some instinctual reactions to first appearances. In the case of the garden

hose-snake, the instinctual behavior would be avoidance. Thus there may be error, but it is better to err on the side of caution rather than on the side of completeness. That is, survival and successful behavior may require quick reaction to sense data resembling that from a snake. Thereafter the validity of the initial awareness can be checked by iterating the process. In the long run, one who acts in this fashion is more apt to be successful than one who attempts to see whether the object is a snake before reacting.

The philosopher, however, does not disagree with the biologist on the utility of sight and reactions to it. That could be called "wisdom." The philosopher's concern is focused on the reliability of sight as a way to know. Although it is possible to explain why a piece of hose might be mistaken for a snake, this does nothing to alleviate the skepticism about knowing-as-seeing. An organism deals with uncertainties at two levels. First impressions are confirmed, and then the veracity of the evidence is established. Both of these require multiple "looks" and consistency. Sense experiences are *sometimes* in error. Yet this knowledge requires independent experiences. In order to demonstrate that a particular sense experience is in error, it must be compared to other sense experiences. Thus the claim that sense experience is generally invalid as a means to know results in a paradox. Once out of the quandary of having conflicting sense experiences, additional criteria can be invoked to establish veracity. The empirical character of the evidence is implicit here. Thus in order to say that *some* sense experiences are mistaken, sense experiences must be admitted as a framework for making judgments. This moves the argument of Classic Skeptics (Bury, 1933), who suggest suspension of judgment as the proper response to the uncertainty involved in sense data, to the level invoked by the consistency of the sense data.

Nevertheless, a philosopher might remain skeptical. Although iterations to confirm and disconfirm sense experience are effective, what is being confirmed or disconfirmed still remains unclear; it may only be appearances and not the thing-in-itself. Thus there is no guarantee that "truth" or "knowledge" as viewed in some circles (Kraft, 1953) will ever be established this way. The Nyāya and biologist's position seems to merge here: As long as successful behavior results, what point is there in doubting? In order to know, we do not need to know that we know; we only need to be free of systematic doubt. Nyāya is not merely calling for psychological certainty, it is also calling for theoretic certainty.

INTERPRETATION AND REPRESENTATION

Perception in a knowledge episode comes from sense data through inference and concept attachment. Attempts to comprehend beyond dimensions amenable to direct observation require representation by extrapolation or intrapolation. The representation and interpretation of "whole" from limited sense data requires perception of and assumptions about internal order and relations. Traditional methods used for creating a knowledge base include standardization, pattern recognition, and differentiation with reliance on conceptualization, comparison, organization, systematization, and use of inherence or intrinsic hierarchies. Such manipulations and generalizations require different degrees of interpretation and representation of the original sense data to create observations that facilitate search for particulars and universals. Several "cross-currents" may be at work here. Initial awareness may be of the universal, however for various reasons one learns to differentiate, that is, nature favors universals whereas nurture directs toward particulars. Then again, developing a perception of whole from parts, as well as the search for the underlying order and causality, directs us toward phenomena and universals.

At the basic level the connectives can be broken into analytical truth functions (*and*, *or*, and *not*), which have served well in developing an algebra and consequent technologies. Yet it has been difficult to address more complex or "open" systems by this approach, although attempts continue. One way to get around this limitation is to look for inherence, that is, explanations in terms of other levels of hierarchy. This process is also inference-based, and it aids in developing "hierarchical" perception of what is hidden from view. The impossibility of a complete analytical descrip-

tion of whole from parts has been demonstrated (Gödel's theorem). By entertaining doubt and controversies in this search for *whole* and order, skeptics, mystics and dialecticians focus on different pramāṇa. Formats, formal methods, criteria, schema, and protocols to accommodate such demands are necessary and are still evolving. Some of those used in ancient India are described by Matilal, and they bear remarkable resemblance to those currently accepted. For example, the "atomist" Nyāya view called for three levels in the representation of the particulars in the material world: "substance," "qualities" and "motion." These can be roughly interpreted as atomic, bonding and kinetic characteristics of matter, which together constitute the basis of the modern chemical world view: The properties of molecules are represented in terms of the bonding relations of atoms, and the behavior of macromolecules is interpreted as an extension of the thermodynamic and kinetic properties of smaller molecules and their environment.

Ancient Indian philosophers had also addressed questions related to universals, and the basic elements of their approach are interesting. Spatiotemporally speaking, no two objects or events are identical. The origin of systematic doubt in representation and interpretation lies in ascertaining the similarities of the current experience with others in the past, and at the same time in recognizing the distinctness of the present. The idea of thingness is generated and elaborated in terms of the percept (identity of the object) and concept (identityhood, class, or sets). According to one view, only the particular is perceived, and the universal is a concept that is necessary for inference and for "seeing" the unknown. Also, in an attempt to capture the diversity through language and universals, approximations are necessary that force an order by pruning away certain features of individuals. Such conceptual artifacts attempt to capture the "essence" rather than the individual aspect. Consider the case of identity of an apple and its essence that makes "an apple an apple," that is, a member of the apple family distinct from the pear family.

Even though there is doubt intrinsic in representation, the means for introducing the doubt and attempts to resolve it are empirical. Satisfactory formalisms or schema to assign membership to a class are often based upon some intrinsic property rather than just on appearances. Yet trial and error shows the liabilities of such representations. It is clear that whenever such concerns arise, the representational framework accommodates by allowing additions and modifications. Such constructs are necessary; however, the underlying limitations have not been adequately explored.

According to the Nyāya view, conceptualization is a useful faculty that helps us organize and sort undifferentiated sense data. A skeptic Buddhist view is that that-ness (reality) is beyond representation even as a concept. The origin of this dialectic probably lies in the following. Concepts verbalized as words are limited in scope as means of effective communication, because the overall process, reconstruction of the message by the listener, requires the use of inference schema and a knowledge base. The knowledge base of two individuals can never be identical; therefore it is also possible that with the same inference schema and sense data, the conclusions may differ. Thus intrinsic limits of conclusions should be kept in focus if one appreciates that concepts are only a part of the relevant knowledge base chiseled by specific inference procedures.

The transition between articulation and the origin of the underlying concept has intrigued many Indian philosophers because Sanskrit scholars have traditionally assumed that concepts and language are intrinsic to mind. Around 500 AD, Bhartrahari (Abhyankar and Limye, 1965) argued that reality is an impartite whole that is cognized under the guise of concepts and universals. The role of nonverbal thoughts and awareness was recognized; however, such awareness was deemed "not effective enough." In this state there is a "speech potency" (*sphota*) that is innate to all humans. It is the language for cognition and it is precursor to the formal language, but it is not the formal spoken language. Thus, in our verbal behavior, the meaning is divorced from the real "word" of the innate language, and it is attributively identified with the thing. It would be interesting to see if such ideas

have validity in developing a better grasp of our representational universe, which is in effect the object of all scientific pursuits.

EPILOGUE: PHILOSOPHY AND SCIENCE

The answer to the poetic question posed by Derek Walcott is the metaphorical "yes, indeed, there is intellectual fire where this smoke came from." It is a fire for cooking, not for incineration; it provides warmth for growth, rather than the heat for analytic refinement. Trends toward the two views of knowledge have existed in most cultures, and most individuals seem to be aware of such possibilities. Preferences of different cultures seem to be reflected in or arise from the a priori. The views contrasted here are but two orthogonal approaches to evaluate awareness of events and to reconstruct the world, but the differences between them cannot be undermined. The basis of such activities may lie in some of the mechanisms that process sense data. The importance of inference activity for successful behavior also has Darwinian overtones. Although we do not wish to be drawn into detailed discussion of social and political implications, it may be provocatively suggested that many of the unpleasant episodes of world history have been inspired by misinterpretation of views of knowledge. Both views of knowledge are subject to misinterpretation: In one case there are temptations for "short-term success," in the other case personal beliefs are justified as "true beliefs." For example, recall the premises of "new world order" promised by holy wars, crusades, racial genocide, colonial domination, and "manifest destiny." The main difficulty with the justified, true belief approach lies in the fact that justification is always limited by the knowledge base, and the knowledge base is limited by the constraints under which humans operate. Therefore the true belief remains merely a promise of a premise.

While the justified, true belief approach may be an early stage in the evolution of the social order to establish the power of a group or an individual, viable and vibrant cultures have often adhered to knowledge as a means to successful behavior. Not only is such a view less likely to be perceived and interpreted in absolute dogmatic terms, but also an appreciation of the liabilities of the assumptions intrinsic in the knowledge base provides for an environment of discussion, exchange, acceptance, and coexistence. In a naive way, we believe that sciences, arts and philosophies prosper in such an environment of "live and let live."

The mainstream philosophy of science is based on the view of knowledge as justified, true belief, and the epistemology based on this view dominates. Such analyses have tended to be historical, as they examine status quo views and the way changes occur in these views. According to this premise of paradigm, science is a means to derive or arrive at the truth by paradigm shift (Kuhn, 1962). Yet in practice, this approach has created dilemmas, Gettier problems, and a realization of the fact that analytical solutions are applicable only to isolated and closed systems. Awareness of such limitations is intrinsic in the very nature of science as practiced on more complex systems or to deal with unfolding events.

At the level of initial discovery, observation and data gathering dominate science. In order to process and systematize data it is useful to have suitable working hypotheses. Generalizations and representations evolve from empirical methods. Here philosophy and science converge in inference, as Nyāya theory makes clear. In the microcosm of the workbench or textbook, methodologies based on the formalisms for inference could introduce a new degree of flexibility into the learning and knowledge-gathering process. At the stage where one relies on gathering and interpreting data and formulating theory, one must be keenly aware of not only errors in data but also liabilities in the knowledge base and inference schema. Targeting these areas may provide guidance in obtaining useful information to be added to the knowledge base so as to minimize these liabilities. This requires use of nonoverlapping iterative procedures by different methods to circumvent the limitations of each individual method. In short, a useful blend of philosophical attitudes and scientific methods is a key to successful behavior in both fields.

Explicit recognition of liabilities has deeper implications. In the Nyāya system, the liabilities of the inference are built into the knowl-

edge base that is relegated by *tatha* to arrive at the certitude of the conclusion. Uncertainty in the knowledge base would necessarily introduce uncertainty in conclusions. If the conclusion is found to be "wrong" by the criteria of successful behavior, the schema permits modification of the knowledge base. This is not a trivial issue, because in a subtle way the inference process acts as a check on the internal consistency of the schema, and any uncertainty should find its expression in the sense data or the knowledge base. This is a built-in self-correcting *mechanism* that comes into play by the iterative procedures forced and set in motion by the link *tatha*. It makes the Nyāya-Pramāṇa schema not just a statement of premises and paradigms, but it becomes a mechanism to evolve the internal and intrinsic relationships between sense data and the knowledge base. Explanations invoking inherence (such as atomic to cellular) are the examples of such a process at work.

To recapitulate, the Nyāya schema is similar to certain aspects of the Ancient Greek system, which have been largely ignored by modern philosophers. Although viable formalisms based on deductive schema have certain advantages and are probably responsible for the technology oriented attitudes, the advantages of Nyāya schema over the analytic schema cannot be ignored. One of the key differences is in the way Nyāya focuses on the eventhood of knowledge and inference rather than fixating on some object of knowledge and employing inference merely as a means to deduce it. In the Nyāya theory, there are two main causes of a "knowledge event": empirical observations and pramāṇa. A philosophy that incorporates the concerns of Nyāya, and thus those aspects of Greek thought that have largely been ignored, could add valuable insight into methodology, as well as validity and formalisms for inference. Both the practice and philosophy of science based in empiricism would be more efficient than those based on the premise of justified, true belief. Since the criterion for knowledge would be contained within empiricism itself, there would be no need to generate an additional theory to ground its truth. At the same time scientists would be aware of the liabilities of any inferences they make. Thus a combination of the orthogonal methods of Nyāya and analytic reasoning is the key to successful behavior in both philosophy and science.

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