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Psychology as a Science: Three Fundamental Approaches

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INTRODUCTION

A triumph of nineteenth-century science was the application of a mechanistic approach to the problems of biology. Experiment and observations showed that biological phenomena could be explained without recourse to a "vital principle." The issue had been whether such a principle would have to animate nonliving substances in order for life to exist. It was shown that, with due regard for the emergence of new properties when complex combinations of substances occurred, no single "vital" attribute remained to be accounted for.

It was only natural that scientists would attempt to extend this success of the mechanistic approach to psychology. And it would have been surprising if mechanism did not go a long way toward explaining a great deal. Beginning with Freud (1895) and Pavlov (1927) and culminating in the behaviorism of Watson (1959), Hull (1951), Spence (1956), and currently Skinner (1971), phenomena observed in the clinic and classroom were in some measure explained in terms of their biological and environmental antecedents.

These successes of the mechanistic approach ought to have eliminated mentalism from psychology as assuredly as they had eliminated vitalism from biology. But the facts have led in a different direction: Patients have shown dissociations between verbal reports of their introspections and their behavior as demonstrated instrumentally (for example, Pribram 1964; Sidman, Stoddard, & Mohr 1968; Weiskrantz & Warrington 1974). Such observations suggest that caution must be exercised in making inferences about psychological processes exclusively from one or another class of behavior and that certain inferences are more akin to our subjective experience (what we ordinarily call "mental") than others.

Meanwhile, physicists have had their own difficulties with "mechanism." Though mechanistic principles are powerful in explaining the Newtonian level of everyday experience, at both the micro- and macrophysical level relationships between variables fail to be readily specifiable in simple mechanistic cause-effect terms. Heisenberg (1959) in his uncertainty principle noted the intrusive effects of observation at the microphysical quantum level and Einstein (1956) in his special and general theories of relativity called attention to the same phenomenon at the macrophysical, cosmic level of inquiry.

Thus, both in psychology and in physics the distinction between observer and observed cannot be so simply delineated. But it is on this distinction that the Cartesian dichotomy, mental versus material, ultimately rests. When Wigner (1969), a Nobel laureate in physics, has to declare that modern microphysics and macrophysics no longer deal with "relations among observables but only with relationships among observations" matter has become dematerialized.

This dematerialization of matter can in some sense be traced to earlier formulations. For instance, physics was conceptually understandable in Clark Maxwell's day when light waves were propagated in the ether. But then, physicists did away with the ether. Still, they did not rid themselves of Maxwell's wave equations—or the more recent ones of Schrodinger (1928) or de Broglie (1964). One can readily conceptualize waves traveling in a medium—such as when sound waves travel in air; but what could be the meaning of light waves or electromagnetic waves "traveling" in a vacuum? Currently, physicists are beginning to fill that vacuum with dense concentrations of energy—antimatter, some would call it. Is antimatter "material"?

Further, when forces are postulated to exist between material bodies, the forces can still be conceptualized as "material" even though they themselves are not constituted of matter. When matter and energy are related by the equation $E = mc^2$, energy is shown to be "material" (and so neural excitation, the brain's "energy," falls readily under this rubric). But energy is measured by the amount of work that can be accomplished by using it and the efficiency of its use depends on its organization as measured by its entropy. The invention of the vacuum tube and subsequent devices has shown that minute amounts of energy can control large expenditures and that these minute organizations provide "information"—that is, they in-form, organize energy. Measures of information and entropy were thus seen related (for example, Brillouin 1962; Weizsäcker 1974). Computers were constructed to process information and programs were written to organize the operations of computers. Is the information contained in a program "material" or "mental"? If it is either, what then of the information in a book? Or the entropy that describes the behavior of a heat engine or of a warm-blooded mammal? Clearly, we have come to the limit of usefulness of a distinction between the material and the mental.

Research on "mind" using behavioral techniques also blurs a distinction which seems so clear when only the ordinary Euclidean, Newtonian domain of appearances is considered. As noted above, the organization of the behavior of organisms from which mental constructs are inferred and matched to introspections (see Pribram 1962, 1971a) can best be comprehended by recourse to concepts such as "information" and "programs" or "plans" which serve equally well in understanding the operations of machines (see, for example, Miller, Galanter & Pribram 1960). Once again the question arises, is information processing to be conceived as mental or material?

Philosophers and psychologists of a nonbehaviorist persuasion will immediately counter that behavior is not mind and therefore any argument about mental phenomena derived from behavior is spurious. They would rather begin with "the phenomenon itself existentially experienced." But there is little that can be done with such experiences except to attempt to describe them (behaviorally) and to organize the descriptions (structurally). Thus, Merleau-Ponty, an existential philosopher, has authored a book entitled *The Structure of Behavior* (1963) which both in spirit and content shows remarkable resemblances to our own *Plans and the Structure of Behavior* (Miller, Galanter, & Pribram 1960) which tackles the issues from a behavioral and information-processing vantage. I do not mean to convey here that there is no distinction between a behavioristic and an existential-phenomenalistic approach to mind. This distinction can be formulated in terms of a search for causes by behaviorists and a search for informational structures meaningfully composed (that is, reasonable) by phenomenalists. Let us pursue this line of inquiry.

BEHAVIORISM AND PHENOMENOLOGY

Behaviorism is a discipline. As a discipline it has already made fantastic contributions to technology and the understanding of the behavior of animals and of men and women. There is therefore no reason why scientific psychology should not be *based* on such an understanding of behavior. But has it perhaps been a mistake to *identify* behaviorism with psychology?

There are limits to understanding achieved solely through the observation and experimental analysis of behavior. These limits are especially apparent when problems other than overt behavior are addressed, problems related to thought or to decisional processes, to appetitive and other motivational mechanisms, to emotions and feelings and even to imaging and perception. These problems make up a large bulk of the interests that bring students to the study of psychology, and at least one behaviorist (Skinner 1976) has grouped them under the rubric "covert behavior." Being covert, they need to be enacted to be studied (Miller, Galanter, & Pribram 1960). Enactment in overt behavior is, however, only one avenue of study—others such as computer simulation or the recording and analysis of brain electrical activity may prove just as effective in achieving scientific understanding—perhaps even more so when used in combination with behavioral enactment.

In a very real sense, therefore, psychology as a science reaches out beyond behaviorism to these covert processes. Ordinarily, these covert processes have been labelled "mental" and there is no good reason to abandon this label. Our perceptions such as vision and hearing are mental processes. Our feelings of emotion and motivation are mental, our intentions and decisions are mental, and as we shall see, even our actions are mental.

Psychology as the study of mental life, as William James and George Miller have called it, is biologically rooted—one aspect of *life* is studied. As such it aspires to be a conventional science. The problem lies in providing a useful definition of what is mental. Could not such a definition be derived from an analysis of behavior (and if so perhaps a more concrete terminology substituted)? But problems of definition also plague behaviorism.

SOME CONFUSIONS

Psychology as a behavioral science and as the science of mental life needs therefore to have clearly defined what is meant by behavior and what is meant by mental. Here, the approach will be taken that confusion has plagued psychology because both the term "behavior" and the term "mental" have remained ambiguous. Each term has in fact been used in two very distinctly separate ways and the distinctions have not been clearly kept apart.

To begin with, the meaning of the term "behavior": When a behaviorist ordinarily analyses behavior, he is studying a record of responses emitted by an organism in a specified situation. The record can be studied in any location, it could have been produced in any of a number of ways by any number of different response systems—arms, legs, beaks, and so on. The behavior under study is an environmental consequence of any of these response systems (Pribram 1971).

At other times, however, behavior is understood to mean the pattern of the organism's movements, or of his endocrine or neural responses in a situation. This definition of behavior is especially common to biological behaviorists such as ethologists, but it is also invoked by psychologists (even staunch behaviorists) when they begin to address the problems of covert behavior.

What then is the concern of a science of behavior? Are its laws to be formulated on the basis of descriptions of the behaviors of organisms or the behaviors of organ (response) systems? Classically, the laws describing the behavior of organ systems have been the province of physiology. There are physiologists (and physiological psychologists) who believe that a lawful description of brain processes should be coordinate with the laws derived from observations of behavior. These physiologists may well be correct, but because the brain is contained within the organism, such identifications fall easy prey to the category errors warned against by Kant, by Russell and Whitehead and by all subsequent critical philosophers. In a strict sense a brain cell does not "see" its "visual" receptive field, the cell responds to excitation of its dendritic (receptive) field which results from luminance changes that have been transduced into neuroelectric potentials by retinal receptors. Perhaps the behaviorist will be content when the laws of behavior and those describing brain function coalesce—but that has not been the tenor of those who espouse the establishment of a science of behavior, separate from physiology.

The mentalists have not fared much better than the behaviorists in stating clearly what psychology, the study of mental life, is to be about. Are mental processes to be identified on the basis of verbal reports of introspection? Are they, therefore, the contents of introspection? Or are mental processes the resultants of an organism's being-and-acting-in-the-world as Whitehead, Husserl, the phenomenologists, Gestalt psychologists, and existentialists would have it? Or are the contents of introspection nothing more than these resultants of being-(or acting)-in-the-world? If they are, what then is the difference between what a behaviorist calls covert behavior and the existentialist calls mental? Logically there is none.

SOME DIFFERENCES

However, though logic can find little to distinguish an existential psychologist from a sophisticated behaviorist, historically the gap is great between how each goes about constructing his science. The behaviorist, as already noted, is devoted to objectively observable discrete behavioral responses—he makes inferences, yes, but these inferences must be operationally and explicitly tied to the environmental manipulations that produce these discrete observable behaviors of organisms.

By contrast, phenomenologists, Gestalt psychologists, and existentialists analyze subjective experience. Contrary to opinions expressed by some behaviorists, these investigators do not eschew observation. Nor do their concepts, when derived scientifically, lack in operational rigor. As with behaviorists, the operations to which these concepts are tied are operations performed on the environment, not on the organism. Thus, they share the interests of psychophysicists. As psychologists, they use these operations to attain concepts about subjective experience (as reported verbally or inferred from nonverbal communication) instead of using them to attain laws describing behavior.

It is this remoteness of the measurable dependent variable from what is being studied that makes the mentalist's job more difficult than that of the behaviorist. But inference from observable events to nonobservable ones is a commonplace in the natural sciences. Quantum and nuclear physicists have built precise models of the micro-universe from observing the effects of events on measurable variables rather than by observing the events themselves. Physiological chemists often postulate the presence of a biologically active substance from the effect it has, many years before that substance is identified chemically. In like manner a mentalist may investigate hunger, visual illusions, states of consciousness, with the aim of modeling these experiences via their observed effects on reports of their occurrence or of finding a neuroelectric response to be coordinate with the experience.

Thus, a science of mental life is as likely to become rigorous and respectable as a science of behavior. This does not mean that the models of psychological experience and the laws of behavior will prove to be similar any more than the models of quantum physics resemble the laws of mechanics. Psychology should be able to readily encompass both levels of inquiry—and perhaps other levels such as explorations of social communication, as well. Biology as well as physics have their molecular and molar divisions—why not psychology?

Stated in this fashion behaviorism becomes essentially a reductive endeavor. True, current behaviorists do not view themselves as reductionists. Skinner and others have repeatedly claimed that they are descriptive functionalists. But description entails the possibility (though not the necessity) of reduction (Pribram 1965). By contrast, a phenomenal or existential approach eschews this possibility.

Phenomenal-existential mentalism is rooted in being-in-the-world. Basically, therefore, there is an upward—or perhaps better stated as an outward—reach, if experience is considered the starting point of inquiry. Experience is of a piece with that which is experienced. Issues of self, of intention and intentionality, are derivative and always include a being-in-the-world approach to solution. Phenomenal and existential approaches thus share with social psychology the derivation of self or person from the being-in-the-social-world.

CAUSES AND REASONS (STRUCTURE)

There is another important and related distinction that separates behaviorism from a phenomenal-existential approach to psychological issues. The experimental analysis of behavior searches for *causes* in a tried and true mechanistic fashion. Skinner is interested in the environmental contingencies that cause reinforcement to occur. Other behaviorists are utilizing such reinforcing stimuli to cause a modification in behavior.

The existential-phenomenal approach is entirely different. Up to now it has not been very clear in its methods. I suggest that multidimensional analyses (factor analysis, principle components analysis, step-wise discrimination analysis) might serve well as tools to investigate the *structure* of experience-in-the-world. Linguists have also provided models of analysis: after all, structuralism derives from the social and linguistic analyses of Levi-Strauss and de Saussure (1922). At its most lucid, however, existential-phenomenal psychology is concerned with the structure of experience-in-the-world (Merleau-Ponty 1963). Thus, as noted above, it is significant that when George Miller, Eugene Galanter, and I enlarged our compass and became subjective behaviorists, we titled a book *Plans and the Structure of Behavior*, while Merleau-Ponty, attempting a precise formulation of existentialism, authored *The Structure of Behavior*. An analysis of structure does not involve a search for causes. Structure is multiply determined and has many *reasons* for being.

BRAIN, MIND, AND NEUROPSYCHOLOGY

The considerations of a subjective behaviorism lead directly into a discussion of the ever-vexing dichotomous formulation of mind versus brain initiated by Descartes. I have dealt with this subject extensively elsewhere (Pribram 1962, 1968, 1970, 1971, 1976a, 1976b, 1977) with the suggestion that Cartesian dualism ought not to be ignored but explained and transcended. In the earlier sections of this paper it was pointed out that the mental-material duality can be discerned only at the Euclidean-Newtonian mechanistic level of ordinary experience. Some additional comments can be made, however: the mind-brain gap can to some extent be closed when experimental results obtained in the two adjacent universes of discourse, the neural and the behavioral, are simultaneously manipulated. Reference terms between these universes thus result. The caution was voiced that communication would never amount to complete transliteration. The limitations encountered in any communication (even within the same universe of discourse) have been ably discussed by Quine (1960). These limitations apply to an even greater extent when the levels at which the discourse is directed are disparate. But it is in the very recognition of these limitations that the problem becomes resolved: pseudo-monistic identity of the material with the mental process (or the converse) and dualistic parallelism are no longer possible solutions. Once levels of discourse are recognized as such, and the potentialities and limitations of communication between them are accepted, the only recourse is to a truly monistic, seemingly pluralistic, multilevel, structural mindbrain. As one scientist-philosopher (Rioch, personal communication) aptly put it, to have mind there must be at least two brains.

Mental terms are primarily derived from propositional verbal reports of introspection; these verbal reports must be analyzed in the linguistic social context within which the speaker and listener communicate, and interpreted in conjunction with nonpropositional aspects such as the kinesics of the verbal report and other instrumental behaviors supplied by the reporter. But validity is a level-loving thing; when levels can become meshed we are apt to consider a report valid. So, to the extent that neural (or other organ system) data extend validity into the biological realm of discourse, mental terms become respectable even to the tough-minded physicalist. Ask any physical or biological scientist to discuss vision and he won't bat an eyelid, though this term is no less mental than is its generic concept, perception; and if we recognize perception, what about emotion, cognition, or volition? The difference is, of course, the degree to which meshing of levels of discourse has taken place. In the case of vision, the physical descriptions of the energies that activate the eye, the minute structure of the eye, the afferent paths into and through the central nervous system, and the central control over the optic mechanism are all thoroughly in hand, as are some of the relations between these structures. Furthermore, these descriptions go into the structure of the perceptual events in detail; knowledge at different levels is available about color, pattern, brightness, and visual field. Finally, level-by-level reference terms are daily encountered, not only in the ophthalmological and neurological clinics, but as well in the daily experience of everyone who does bat his eyelids to demonstrate the relation between "I see" and "eye."

PROCESS, COMPLEMENTARITY, AND INDETERMINANCY

Structure, hierarchically arranged by reference terms among levels: this is what the biologist usually refers to as process. When process is so conceived, it does not violate logic and experience as does the usual extreme mechanistic, reductionist position. The Beethoven symphony to which I am at the moment listening is not in one sense reducible to the mechanics of the score, nor of the recording, receiver, amplifier, and speaker system which is emitting it; nor is it completely described by the contortions set up in my auditory apparatus by the describable wave patterns impinging on my ears. All these and more are components—but something more than this constitutes the symphony. This something more is not mystical. Musicians call it structure.

I do not consider the mystery of the symphony the more (nor the less) mysterious for the fact that one very crucial element in the structure of its reproduction is a piece of light cardboard shaped in a cone, whose crucial characteristics are difficult to pin down. I do not invoke the epithet "mentalist" at the British Industries Corporation, nor call them less competent engineers because they say:

> Your own ear is the best judge of the ability of a speaker system to recreate the emotional impact of the original muscial performance. Technical details can not be expected to answer the question "Does it sound natural?" Each person must listen and judge for himself (British Industries Corporation 1962, p. 77).

I merely validate their experience with my own—which if possible includes running pure tones, harmonics, and complex sounds through portions of the equipment, to satisfy my desire for minimal distortion. But I also listen to the symphony. And, in the same way, I also unashamedly listen to my own introspections and to verbal reports of others, as well as to the records of instrumental behavior and to the responses of neurons, to build my multilevel monistic structure of the neuropsychological apparatus.

And your reply, rightly, may well be, "Bully for you, but why should I accept your view of the universe and the way it ought to be constructed?" Or, to put it another way, can the search for constants or invariants in the exact natural sciences be properly extended to include the problems faced by the social disciplines? As a *neuro*psychologist my answer is a resounding yes. I would not deny Eve her root biological entity, her identity and unity. Yet the many faces shown by the social Eve are nonetheless real for their evanescence. Physics has gracefully accepted the principles of complementarity and of indeterminacy: one way of looking at the natural world complements, not necessarily supplements, another; what at one level of analysis appears structurally stable and ordered may, at another level, reveal a goodly amount of chaos—and structure is often shown to emerge from the very probabilities that describe the amount of this chaos.

THE ISOMERIC RELATIONSHIP BETWEEN BODY AND MIND

Are matters so utterly different in the biological-social science enterprise which comes to a focus in neuropsychology? If the answer were a simple "no" it should have been given easily by now. Wherein lies the difficulty? I believe that the complication lies in the fact that the behavioral, biological-social scientist interested in the mind-body problem finds his universe to be a mirror image of the universe constructed by the physical scientist who deals with the same problem. And it should not come as a surprise when each of these isomers, the one produced by the physicist and the one produced by the behavioral scientist, on occasion displays properties that differ considerably from one another, much as do optical isomers in organic chemistry.

I believe these images are mirrors because of differences in the direction generally pursued from each investigator's effective starting point, his own observation. The physical scientist, for the most part, constructs his universe by ever more refined analysis of systems of input variables, that is, sensory stimuli to which he reacts. The form of the reaction (cathode-ray tube, solid-state device, chromatography, or galvanometer) is unimportant, except that it provides a sufficiently broad communicative base. Constancies are gradually retrieved from manipulations and observations of these input variables under a variety of conditions. As these constants achieve stability, the "correctness" of the views that produced them is asserted: the physical universe is properly described.

In the social disciplines the direction pursued is often just the reverse. Analysis is made of *action* systems (cf. Parsons & Bales 1953). The exact nature of the input to the actor (including the observing scientist) is of little consequence, provided it has sufficient communicative base; the effect of action on the system is the subject of analysis. It matters little (perhaps because the cause is usually multiple and/or indeterminable) if a currency is deflated because of fear of inflation, depression, personal whim, or misguided economic theory. The effects of deflation can be studied, are knowable. And once known, the action becomes corrective; the resulting stabilization, constancy, is interpreted as evidence for the "correctness" of the action that produced the correction. Appropriate norms for the social universe become established.

One striking difference between the two images thus formed is immediately apparent. The physicist's macroscopic universe is the more stable predictable one: "It does not hurt the moon to look at it" (Eddington 1958, p. 227). For the most part, it is as he moves to ever more microscopic worlds that uncertainties are asserted. The scientist concerned with social matters finds it just the other way round: it seemingly does little harm to the man to look at him; but seriously look at his family, his friendships, or his political-economic systems and what you had started out to look at changes with the looking. Here indeterminacy comes to plague the macrostructure; it is in the stabilities of microanalysis that the mirage of safety appears.

The philosopher of science and the neuropsychologist, interested as they must be in the mind-brain problem, stand by necessity squarely between these two mirror images. If they deny the evidence that there are two images by showing interest in only one, or by denying the "reality" of the other, they are in dangerous waters and liable to shipwreck in the strong currents of mentalism, physicalism, and dualism. Their searches for the one "real" world and its mirror image may well be interminable, since an alternative possibility is equally likely to be a correct one.

The problem can be grasped, however, if it is dealt with in terms of isomeric forms of the same event universe—isomers differing in that their structures mirror each other. Put another way, the problem resolves itself into a meshing of the descriptive and the normative sciences. The suggestion is that structure in descriptive science ordinarily emerges from the analysis of the relations between systems and their subsystems; that in the normative sciences, it is largely the other way round: structure emerges when the relation between a system and its "supersystem" is studied.

If this view is correct, we should find normative statements about the nature of the physical world when these are constructed from the examination of relations between a set of systems and a higher order system. Is not relativity just this sort of statement? This is not a social scientist speaking about the "criterion problem":

> The modest observer . . . [is] faced with the task of choosing between a number of frames of space with nothing to guide his choice. They are different in the sense that they frame the material objects of the world, including the observer himself, differently; but they are indistinguishable in the sense that the world as framed in one space conducts itself according to precisely the same laws as the world framed in another space. Owing to the accident of having been born on a particular planet our observer has hitherto unthinkingly adopted

> one of the frames; but he realises that this is no ground for obstinately asserting that it must be the right frame. Which is the right frame?
>
> At this juncture Einstein comes forward with a suggestion—"You are seeking a frame of space which you call the *right* frame. In what does its *rightness* consist?"
>
> You are standing with a label in your hand before a row of packages all precisely similar. You are worried because there is nothing to help you to decide which of the packages it should be attached to. Look at the label and see what is written on it. Nothing. "Right" as applied to frames of space is a blank label. It implies that there is something distinguishing a right frame from a wrong frame; but when we ask what is the distinguishing property, the only answer we receive is "Rightness," which does not make the meaning clearer or convince us that there is a meaning (Eddington 1958, p. 20).

Obversely, we should find descriptive statements about the nature of the social world when these derive from a study of the relations between a system and its subsystems. Doesn't the following passage fit this requirement?

> Role behavior depends first of all on the role positions that society establishes; that is, certain ways of behaving toward others are defined by different positions (Hilgard 1962, p. 482).

Aren't statements about roles unambiguously descriptive?

Attention to structure has left the neuropsychologist, perhaps a bit dizzily, contemplating two mirror images of a universe. By looking to the right, he has profited greatly from the researches of his neurobiological colleagues in matters concerning a variety of brain processes such as those involved in perception and in memory storage mechanisms. Is there any substantial insight to be reaped from a look to the left?

HOLOGRAMS AND TRANSFORMATIONS

Recent discoveries in the brain sciences augur yet another approach to the mind-brain problem that is utterly different from the behavioristic and structural. This approach directly addresses the wholistic aspects of phenomenal-existential psychology and has a great deal in common with that of the mystics, the depth psychology of Carl Jung (1960), and the more recent transpersonal conceptualizations (see, for example, Tart 1977). It is also kin to the views expressed by philosophers such as Leibnitz in the *Monadology* and by Whitehead in his process cosmology

(1958). This approach centers on holography as providing a set of concepts which clearly distinguish the wholistic and structural views that presently confound not only existential-phenomenal psychology but other scientific endeavors as well. Such concepts have been espoused by many modern physicists to explain observations made at the quantum and nuclear levels of inquiry: David Bohm (1971, 1973) and Wigner (1969) to name two of the foremost.

Holography was initially seen as a powerful metaphor to explain the distributed nature of memory traces in the brain (Pribram 1966). Clinical or experimental lesions of neural tissue do not remove specific memories: Lashley (1960) in his paper on the search for the engram despaired of comprehending the biological basis of memory organization because of this resilience of learned behavior to brain damage. But a hologram has just these properties: a holographic store, the photographic film, can be injured or cut up into small pieces and an image can still be reconstructed from any of the pieces—thus the name "hologram": every part contains sufficient information to characterize the whole.

Holograms are blurred records of images and objects. Each point of light is spread over the entire film as is every adjacent point. However, the blur is an orderly one and the set of mathematical expressions that define the blur (such as the Fourier transform) are often called spread functions.A good way to conceptualize the nature of the spread is to visualize the concentric circles of ripples made by a pebble thrown onto the smooth surface of a pond. Throw in two pebbles and the spreading concentric circles will cross each other and create interference patterns; throw in a handful of pebbles and when the interference patterns are at their maximum, take a photograph of the surface of the pond. That photograph is a hologram.

Because the spread of ripples, waves, can be precisely specified, it is possible to recreate the location of impact of each pebble by performing the inverse of the mathematical operation (the spread function) that described the creation of interference patterns. The procedure is similar to that performed by NASA when an orbiting camera is taking a photograph of the surface of Venus or Mars. The photograph is a blur but because the speed of the camera relative to the planet is known, that speed can be subtracted out and a clear image obtained.

Holograms thus provide a ready instrument for spreading—distributing—information which can easily be retrieved by performing the inverse of the transform by which the hologram is constructed. In fact, when Fourier transforms are used, the same mathematical equation describes the initial transform and its inverse. Thus by repeating the *same* procedure an image of an object is obtained.

Why bother with these transformations? What are the attributes of holograms that make them so useful? There are many, but the most important for understanding brain function are (1) the readiness with which images can be reconstructed from a distributed store; (2) the resistance of a distributed store to injury; (3) a fantastic advantage in computing power—practically instantaneous cross and autocorrelations are possible (this is why in X-ray tomography calculations are made in the Fourier domain); (4) a tremendous increase in storage capacity—recently a billion bits of retrievable information has been stored in a cubic centimeter of holographic memory; (5) the fact that images constructed from one part of the hologram are recognizably similar to those constructed from another (translational invariance); (6) the facility for associating two "images" in the holographic store and retrieving both in the absence of one—that is, when only one of the previously associated images is present, illumination of it and the hologram will reconstruct the other, as is the case in associative recall.

It is here that contact with physics is made. David Bohm (1971, 1973) has pointed out that the discrepancies in conceptualization that lead to the complementarity between particles and waves arise because, since Galileo, we have relied almost exclusively on lenses for our views of the physical macro and micro universe. He asks, what if we looked at the world through gratings which produce holograms—that is, took seriously the frequency domain as a possible organization of the universe? Lenses focus, they objectify, particularize, and individuate. Holograms are the result of processes which spread, distribute energy and provide for a wholistic organization in which each part represents the whole and the whole implies each part. Bohm calls the lens view of reality the explicate, and the holographic view the implicate order.

If brain and the physical universe are seen to share this implicate holographic order, then each portion of the order, each organism, for instance, must in some sense represent the whole universe. In turn, the universe must imply each organism, each of us. Physicists have been drawing such conclusions for a half century (see, for example, Capra 1975) but they are new to biologists and experimental psychologists. Such conclusions are extremely difficult to comprehend and therefore frightening. In addition, they sound so much like those described by mystics on the basis of their transcendental experiences that hard-headed scientists are apt to shy away from formulations that are derived from an enterprise so totally different and foreign to the ordinary scientific method.

Still, the facts must be explained and the holographic explanation is a powerful one. A good deal of this power comes from its precision. For the first time a wholistic conceptualization can be made as rigorously and mathematically precise as a particularistic one. For psychology such precision is a necessity, since its data are so varied. As noted above, behaviorism provides precision by searching for causes. Existential-phenomenal psychologies, if they are to attain precision, must enact for reasonable structures that explicate experience. Holographic, that is, holistic psychology depends on discovering *transformations* for its precision. By specifying the transfer functions involved in moving from one state to another, the holistic approach is made as scientifically respectable as any other. Explicitly adding structure and transformation to the search for causes is long overdue and imperative if scientific conceptualizations are to deal with the richness of problems raised by the advances in scientific technology. But this added richness raises new issues which were obscured by the earlier more restricted approaches.

A NEW DUALITY: THE WORLD OF APPEARANCES VERSUS THE FREQUENCY DOMAIN

The point was made in the introductory sections of this paper that the Cartesian dualism of mental versus material holds only for the ordinary world of appearances: the world described by Euclidean geometry and Newtonian mechanics. An explanation of dualism was given in terms of procedural differences in approaching the hierarchy of systems that can be discerned in this world of appearances. This explanation was developed into a theory, a multiple-aspects constructional realism. But certain questions raised by a more classical dualistic position are left unanswered by the explanations given in terms of a constructional realism.

What are these questions? The classical causal and the structuralist views of the relationship between brain and mind are entirely different—and in a fundamental sense, opposite. If the reductionist considers mind at all, he thinks of it as an emergent from brain functioning. By contrast, structuralists, and especially existential-phenomenologists, if they consider brain, have it operated *upon* by mind.

I believe that the analysis provided earlier in this paper may help "unpack" this issue. Note that when one looks downward in the hierarchy of systems that compose the ordinary world of appearances, essentially reductive analyses are engaged. To take account of new properties that arise when components become organized into higher-order, more complex structures, "emergence" is proposed—actually, the proposal is essentially descriptive of what is observed. By contrast, the upward look in the hierarchy as in the phenomenal and existential approaches simply takes these "emergents" as the fundamental achievements of observations. The question therefore arises as to what might be the place of brain in the compass of such observations if the reductive approach is to be eschewed. The phenomenal-existential psychologist is thus currently impaled on the horns of a dilemma: He can espouse some sort of reductionism as a part of his philosophy or he needs to deal with a brainless persona.

But consider now the brain as a frequency analyzer and the general characteristics of the frequency domain. These characteristics have been appreciated fully only recently: The recording of patterns of wave fronts by holography has provided a visible artifact whose properties can be readily conceptualized. And recall that by way of transformation and inverse transformation the brain and phenomenal domains are reciprocal.

Consider further the fact that in the holographic domain space and time are enfolded. Only the density of occurrences is manifest. These densities can be recorded as wave number or in scattering matrices representing n-dimensional (Hilberth) domains as has been done in quantum physics. What is important here is that holography has become a window through which we are able to conceptualize a universe totally different from that which characterizes the world of appearances.

As noted above, most of our conceptions of the physical world depend on what we can observe through lenses. Lenses focus, objectify, and draw boundaries between parts. Lenses particularize. Holograms, by contrast, are distributive, boundaryless, and holistic. Thus there are two reciprocal orders: as Bohm calls them, an explicate and an implicate. The explicate order gives an account in terms of particles, objects, and images. The implicate order, still poorly cognized, begins with densities of the fluctuating properties of wave forms.

Bohm (1976) and other physicists (see, for example, the review by Capra, 1975) have become excited by the similarity of conceptualizations of the implicate order and those described by mystics who have experienced a variety of religious and other "paranormal" phenomena. The lack of spatial and temporal boundaries, the holographic characteristic that the whole is represented in every part, the transformational and even metamorphosing character of shifting from explicate to implicate order, are all beyond ordinary human experiencing which is apparently limited to the everyday explicate Euclidean, Newtonian universe to which we have become accustomed.

It is probably not an accident that holograms were a mathematical invention (by Dennis Gabor, who received the Nobel Prize for the discovery) which used a form of mathematics—the integral calculus—invented by Leibnitz who also came to a vision of the implicate order. Leibnitz's monadology is holographic, his monads are distributed, "windowless" forms, each of which is representative of the whole. Substitute the term "lensless" for "windowless" and the description of a monad and a hologram are identical.

Thus, the view of existential-phenomenal psychologists of a distributed mind operating in some seemingly mysterious way in or on brainy organisms acting-in-the-world can be explicated by a highly rigorous, mathematical formulation. The fact that the brain is, among other things, a frequency analyzer, that it encodes information in a distributed fashion akin to that which characterizes a hologram also means that the structural boundaries that characterize the ordinary limits of "brain," and so on, are transcended. The mystery is resolved not by taking an interactionist stance, but by recognizing the transformational nature of the implicate domain.

CONCLUSION

In concluding, I will attempt to summarize succinctly my position as developed in this paper. The essay began by accepting a dualistic view of everyday experience: We humans can clearly distinguish between the process of experiencing and the contents of that experience. This led in the centuries since Descartes to the view that the process of experiencing is mental, while the contents of the experience, if not themselves material, are at least indicators of a material, physical world. The essay then went on to show that modern physicists working at both the microphysical quantum and nuclear level and at the macrophysical "universe" level have called into question the material basis of matter. Matter is constituted of energy which in several forms interacts to produce that which we normally experience in ordinary perception. Normal experience is characterized by Euclidean geometry and Newtonian mechanics. Thus the material nature of matter is limited to the ordinary world of experience, unless one wants to adopt the bias that energy is material since it can be converted to matter as indicated by Einstein's equation $e = mc^2$. But then why would we have to call such a transformation a conversion? Does not such a materialist bias cloud rather than clarify the fact that we as yet do not know how to properly characterize various energy forms? And by this question I do *not* wish to suggest that they be characterized as mental.

Beginning from the other end of the mental/material dichotomy, we ran into a similar limitation on its usefulness. Information and information processing, as when a computer is programmed or a brain is informed by sensory signals, was shown to involve minute amounts of energy that could organize or reorganize larger-scale systems. The configurations which energy systems display rather than their raw amount were shown to be critical. Are such figural changes to be conceived as mental or material when they involve languages, cultures, and so on? Once again, a limit is reached where the mental/material distinction becomes useless.

Next the issue of dualism was analyzed on its own ground—that is, within the purviews of ordinary experience. Here dualism was found to be based on mirror image views constituted by different analytic procedures. Looking downward from one's experience into the hierarchy of components that constitute that experience, the reductive materialistic view held by most scientists is found. This reductive view is ordinarily balanced by the recognition that novel properties "emerge" when specific configurations of components are formed.

Looking upward from one's experiences involves validating the experience with that of others. Experienced "phenomena" are described and compared. Emphasis is on the existence of the experience per se, its existential nature—and when precision is attempted, the emphasis is on the structural relationships among phenomena. Consensual validation, enactment and structural analysis of relationships constitute the tool of inquiry, not separation into parts causally related to one another as in reductive sciences. Thus the language of phenomenology, existentialism, and structuralism is "mental," since it is experience per se that constitutes the focus of interest.

Recognition of the procedural difference that is responsible for dualism in the ordinary world of experience allows one to transcend this dualism without denying its usefulness to deal with the problems of that ordinary world. I proposed that dualism can be transcended by carefully combining the techniques and results of both the reductive and the phenomenal approaches to inquiry. By making structure the central, enduring, single quality of a pluralistic monism, both reductive entities and phenomena were seen as *realizations* of identical structures derived from a more basic existential given.

Once this constructional realism was formulated it had to face another issue, however. True, dualism had not been denied, it had simply been shown to operate in a limited sphere. But by transcending dualism with a structural monism, the very spirit of what dualists believe in and are trying to articulate was violated. A constructional realism does not deal with the issue that phenomenal-existential views depend on some version of reductionism if they are to take the material universe into consideration—or else they are caught in the web of a mental universe independent of, or interacting in some mysterious way with, the material.

The final proposal of the paper meets the requirement of this aspect of daulism. Brain physiologists have shown the nervous system to be, among other things, a frequency analyzer. Further input apparently becomes distributed and stored in the frequency domain in the manner of a holographic record. This domain is readily entered and exited through transfer functions that invert one domain (for example, the ordinary) to its reciprocal (the holistic). And physicists have suggested that a holographic-like order might well characterize the microstructure of the physical world. In the reciprocal (holistic) domain, space and time become enfolded; only density of occurrences are represented.

Descriptions of this domain and other similar orders that account for the observations of modern physics have been shown to be remarkably similar to descriptions of paranormal and mystical experience and religious thought. I proposed therefore that the duality between the normal everyday domain of appearances and the frequency-transform domain captures the spirit of dualism and accounts in a scientific and precise mathematical fashion for what has hitherto been incomprehensible.

Constructional realism thus deals with a number of dualities of which two are especially significant for unpacking the issues involved in a mind/brain dualism: (1) a procedural duality that faces upward and downward in the hierarchy of systems discerned in the ordinary world of appearances; and (2) a transformational duality that apposes the ordinary world of appearances to that viewed through the window of the frequency-transform domain which is characterized by descriptions akin to those describing the experience of mystics which form the basis of religious thought.

Other dualities may well be discovered to underlie as yet inarticulated premises of dualism. What appears clear at the moment is that a dualism based on the distinction between mental and material is too limited to deal with the very issues that is poses. Other dualities can articulate answers to the problems raised by these issues and deal not only with their substance but with their spirit. Further, these dualities can be specified by scientifically sound procedures and mathematically precise formulations. Finally, recognition of these dualities stems directly from discoveries in the physical, information, and behavioral sciences. Thus the often-made argument that the results of scientific research have no bearing on philosophically framed issues has been shown to be wrong. In fact, what has been shown is that *only* through the results of scientific research can philosophical issues, even at the ontological level, be refreshed.

POSTSCRIPT

The participants of this conference have addressed problems which in many ways have a direct bearing on my own presentation. Their contributions confirm my feeling that we are in the midst of a paradigm shift (using Kuhn's overworked phrase) not only in psychology but in science as a whole. Charles Cofer noted that the overinvolvement of experimental psychology with the Newtonian reflex-arc, stimulusresponse mechanism ceased around 1960 when a cognitive psychology based on the similarity between human plans and computer programs became evident. In my own history, it was the failure of operant conditioning to account for (rather than merely describing the environmental contingencies for) the chaining of responses that led to *Plans and the Structure of Behavior*. The serial ordering of behavior is a central problem in psychology, as Lashley had clearly pointed out, and explanation became imperative in our own work on the relationship between frontal-lobe function and the classical alternation task.

The cognitive orientation in psychology remained incomplete in the 1960s, however. It was not until the 1970s that psychologists became deeply interested in the images that guide plans. In *Plans and the Structure of Behavior*, Image and Plan were intimately interwoven in a hierarchy of TOTE (Test-Operate-Test-Exit) units in which the tests were accomplished by Imaging. In *Languages of the Brain*, published in 1971, I therefore took as great pains to outline a neurophysiology for *Images* as one for *Plan*.

Just as the computer program had furnished an appropriate and useful metaphor for Plans, the hologram in its optical instantiation in information processing became the metaphor for Image. In *Languages of the Brain* and further during the 1970s the metaphor was developed into a model both in the research laboratory and by theory construction. (I use the term theory to denote a statement of the knowable which is as yet not explicitly known). The most striking theoretical aspect of holography is its transformational character in which image and representation stand in reciprocal relationship with each other, despite their apparent gross dissimilarity. Joseph Rychlak in his paper discussed structures akin to programs but returned repeatedly to the dialectic as a model. I wonder whether it would be feasible and appropriate to unconfound these two approaches in his analysis: the structural and the transformational (dialectic)?

Karl Weick's delightful address on "Psychology as Gloss" underlines and expands my own views expressed as an upward or outward look in a hierarchically arranged set of knowledge systems. Such an outbound science must depend on consensual validations that establish norms, glossaries, as noted in my paper. Weick's "reflections" on the virtues and vices of glossing add immeasurably to my rather sparse insights.

Sandra Scarr also detailed for us the consequences of such an outward reach, but in the realm of behavioral genetics. She pitted a reductive Mendelian genetics against a Darwinian view of biology which has much in common with the existential-phenomenal psychologies I addressed in my paper. The central theme of these views is "final causes" (as opposed to the proximal efficient causality of reductive approaches). But such final causes are, as Waddington suggested, teleonomic or homeorhetic and are thus generated by events rather than generating them. In engineering terminology such processes are termed "feedforward, open loop" (helical) in contrast to the better known self-stabilizing homeostatic feedback, causal loops.

This thought brings me directly to Roger Brown who on an earlier occasion gently criticized *Plans and the Structure of Behavior* for its homeostatic flavor. For a decade I wrestled with the problem of providing a model for a *biased* homeostat which would be truly homeorhetic. A solution was achieved just as *Languages of the Brain* went to press: A parallel processing of input into two independent "tests" converted the TOTE from a feedback into a feedforward process. (For an independent development of this model see Sommerhoff 1974). Thus the test portion of the TOTE, its Imaging process, takes on added significance.

Roger Brown's highly instructive contribution distinguished for us two types of categorizing: formal and natural. Both seemed to me to depend on some initial identification of a prototype—an identification that could be made most readily through cross- and autocorrelation. The frequency domain is of course especially suited for this type of computation—that is why the fast Fourier transform is so abundantly used in the computer sciences. A brain cortex that encodes in the frequency domain (that is, holographically) serves the categorizing process admirably.

Further, the distinction between formal and natural categories may well be related to the difference in function between the posterior cortical convexity and the frontolimbic forebrain. The posterior cortical convexity is involved in discrimination, placing boundaries on categories by virtue of differences. On the other hand, the frontolimbic forebrain flexibly organizes the redundant aspects of episodes pragmatically according to contextual need and circumstance.

Finally, I turn to George Albee's presentation which challenged us to heed our social responsibilities. Without question, the development of our science makes it imperative to come to a resolution of the mind/brain dichotomy which now divides psychology and psychiatry into the psychotherapists and organicists, the social and the physiological, and so on. I believe that the systems analysis of this issue developed in my paper goes a long way toward helping to understand the conceptual origins of these divisions. (These conceptual origins were abetted by historical ones: The psychological disciplines grew out of philosophy and education, while psychiatry is rooted in biology and medicine.)

But really innovative insights that were hard to conceive of even a decade ago have emerged from the holographic model of brain function. These converge onto models developed in quantum physics to reassert the spiritual nature of man. Thus, any comprehensive science of the future—and especially any psychological science—must come to grips with such spiritual issues as values and responsibility—not only because these are critically important in and of themselves, as Albee has reviewed for us, but because they form an intrinsic part of the contents of our understanding.

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