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On

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Unpacking Some Dualities Inherent in a Mind/Brain Dualism

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INTRODUCTION

In this world of appearances, there is no question but that human mental experience can be sharply distinguished from that which is experienced. The issue has been labelled 'intentionality' (or intentional existence) by Brentano (1973) and has given rise to inferences about the nature of reality (Chisholm 1960). The question is often phrased: are my perceptions (my phenomenal experiences) the really 'real' or does the content of those perceptions make up the 'real' world? My phenomenal experiences are mental, the world as it appears to me is material. I can give primacy to my experience and become a phenomenologist or I can give primacy to the contents of the experience and become a materialist. But, I can also give primacy to neither and attest to the dual nature of reality.

Materialism and phenomenology run into difficulty only when each attempts to deny the other. As long as only primacy is at stake, either view can be made consistent. After all, our experiences are primary and empiricism is not inimical to a real material world. And we do appear to be experiencing something(s), so our experiences may well become organized by those real somethings.

However, by accepting such a moderate position with regard to mind and matter we immediately come up against a set of dualistic problems. Are the contents of perception in any way organized by the experience of the perceiver? Is that experience in turn organized by brain function, sensory input and the energies impinging on the senses? Would a complete description of brain function of an organism also be a description of the experience of that organism? If so, aren't the material descriptions of brain, senses, energies sufficient? Or at least, do the descriptions of experience add anything to the material descrip-

tions? Could not the inverse be equally true: what do the descriptions of brain, senses and energies materially add to what we so richly experience?

I believe that today there are answers to these questions where only a few years ago there were not. These answers come from 'unpacking' conceptual confusions and demonstrating where each conceptualization captures a *part* of a truthful whole.

First, a semantic analysis shows that descriptors of brain, senses and energy sources are derived from an analysis of experience into components. The components are organismic and environmental (biological and physical or social) and each component can be subdivided farther into subcomponents until the quantum and nuclear levels of analysis are reached. This procedure of analysis downward in a hierarchy of systems is the ordinary way of descriptive science. Within systems, causes and effects are traced. When discrepancies are found statistical principles are adduced and probabilities invoked. Scientists have become adept and comfortable with such procedures.

Mental language stems from different considerations. As in the case of descriptive science, mental terms take their origin in experience. Now, however, experience is validated consensually. First, experience in one sensory mode is compared with that obtained in another. Then, validation proceeds by comparison of one's experience with that of another. A little girl points to a horse. Up to now mother has allowed her to say 'cow' whenever any animal is pointed to. But the time has come to be more precise and the experience of horse becomes validly different from that of cow. Mental language is derived from such upward validations in a hierarchy of systems.

Elsewhere (Pribram 1965) I have detailed the differences in scientific approach which this upward- or outward-look entails. It is certainly not limited to psychology. When Einstein enunciated his special and general theories of relativity he was looking upward in the set of hierarchically arranged physical systems. The resultant relativistic views are as applicable to mental conceptualizations as they are to physical. It is these relativisms which existentialists and phenomenologists constantly struggle to formulate into some coherent principles. My own belief is that they will be successful only to the extent that they develop the techniques of structural analysis. But structural analyses often depend on enactment to clarify the complexities involved. Abhorrent as the computer and other engineering devices may be to philosophers and psychologists of the existential-phenomenal persuasion, these tools may turn out to be of great service to their mode of inquiry.

If the above analysis is correct, then a dualism of sorts can be entertained as valid. First, a caution however. This form of dualism is concerned with the everyday domain of appearances—of ordinary experiences. Commencing with such ordinary experiences two modes of conceptualization have developed. One mode operates downward in a hierarchy of systems, analyzing experience into components and establishing hierarchical and cause-effect relationships between these components. The other operates upward toward other organisms to attain consensual validation of experiences by comparing and sharing them.

Thus two mirror images—two optical isomers, as it were—are constructed from experience. One we call material and the other mental. Just as optical isomers in chemistry have differing biological properties though they have identical components and arrangements, so the mental and material conceptualizations have different properties even though they initially arise from the selfsame experiences.

I urge that this is the origin of dualism and accounts for it. The duality expressed is of conceptual procedures, not of any basic duality in nature. As we

shall see below, there are other dualities that are more basic but these are *not* the ones that have become the staple of those arguing for dualism.

CONSTRUCTIONAL REALISM

Before proceeding with a critique of current dualisms, it may be helpful to describe alternative views. Most of these fall under the rubric of 'monism' which states simply that the truly basic components of the universe are neither material nor mental but neutral. The dematerialization of matter at the level of analysis that concerns modern physics and which has been reviewed above supports such a 'neutral monism' (see e.g., Bertrand Russell 1948). Critical philosophers (e.g., Feigl) steeped in linguistic analysis developed this monistic view by suggesting that the 'mental' and 'material' are simply different ways of talking about the same processes. Thus 'mind' and 'brain' come to stand for separate linguistic systems, covering different aspects of a basic commonality. The problem has been to find a neutral language to describe the commonality without being either mental or material in its connotations.

I have taken this 'dual aspects' view a step further by proposing that each aspect is not only characterized linguistically but is in fact a separate 'realization' or 'embodiment' (Pribram 1971*a*). Further, I have proposed that what becomes embodied is 'structure'. Thus, in essence, I have stood the critical philosopher's approach on its head: the enduring 'neutral' component of the universe is characterized as linguistic—or mathematical, musical, cultural, etc.—and is essentially structural. The dual aspects are dual realizations—which, in fact, may be multiple—of the fundamental structure: thus a symphony can be realized in the playing at a concert, in the musical score, on a record or on a tape and thence through a high-fidelity audio system at home.

'Mind' and 'brain' stand for two such classes of realization, each achieved, as described above, by proceeding in a different direction in the hierarchy of conceptual and realized systems. Both mental phenomena and material objects are realizations and therefore realities. Both classes of reality are con-structions from underlying 'structures' which it is the task of science to specify in as neutral a language as possible (neutral, i.e., with respect to connotations that would suggest that the 'structures' belong in one or the other class). I have elsewhere noted the relationship of such a constructional realism to critical realism, pragmatism and neo-Kantian rationalism (Pribram 1965, 1971*a*, 1971*b*)

MIND AS EMERGENT OR AS ACTOR: THE POPPER-ECCLES DILEMMA

The views expressed thus far have provided a coherent *theory* which accounts for dualistic views but transcends them by showing them to arise from procedural differences which separately *realize* a common structure. That structure is neutrally described in mathematical and information processing (or similar) terms, terms which cannot readily be characterized as either material or mental.

This *theory* is considerably different from more classical dualistic views which hold to a fundamental separation between mental and material. I believe that there is considerable merit to these views in that they pose questions which are not addressed by the constructional realism proposed above. I do not agree with the dualistic solution (or rather non-solutions) given by unreconstructed dualists, however, and will detail an alternative in the last section of this paper. But first, let us examine one recent document which states the case for one form of classical dualism in comprehensive fashion. The document is *The Self and Its Brain* by Popper and Eccles.

The Self and Its Brain embodies in its format the views of its authors. The book is divided into two major portions: Popper deals with the philosophy of

mind: Eccles describes the neurophysiology of brain. In keeping with the interactionist tone of the volume, there is a third section made up of discourse between Popper and Eccles—a sort of question and answer period. The interaction is somewhat stilted and one-sided—the discourse deals much more often with mind than with brain. But even this defect is, I feel, in keeping with the authors' philosophy: in their system, mind gently—'with a cognitive caress' as Eccles once put it to me—influences, biases, brain function. Popper is not quite so gentle as Eccles, however, and I tend to agree with him. After all, 'the pen *is* mightier than the sword': there is nothing gentle about the way I am moved by music, a spouse's anger, etc. Perhaps this basic disagreement between Eccles and Popper and their attempt to deal with it 'gently' has led to the somewhat artificial tone of the interchange. I am sorry about this because I feel that the format of two views and an interchange between them is potentially powerful—I suggested it once to Arthur Koestler, but he chose to go it alone and produced *The Ghost in the Machine*.

What does bring power to the format of *The Self and Its Brain* is the book itself. Popper's interactionism depends on the products of mind—its contents, becoming manifest in the physical world. The physical world in turn influences the brain through the senses. Books are prime examples—and *The Self and Its Brain* is a prime example of a book (a medium) being in format what its contents are meant to convey.

But here we experience in reality the dissonance expressed in the dialogue between Popper and Eccles. Popper's books and other contents of mind constitute his World III. World III interacts with the brain (which is part of the physical world—World I) through the senses (e.g., p. 449). The interaction is clearcut. By contrast, Eccles has mind selecting *from the* sensory input, organizing the functions of the associated cortex especially that of the dominant speech producing hemisphere:

> In these further stages the different sensory modalities project to common areas in the polymodal areas. In these areas... wide ranging information is processed. How is it selected... and put together?... It is proposed that the self-conscious mind plays through the whole (polymodal) liason brain in a selective and unifying manner... somewhat like a searchlight. Or better, a multiple scanning and probing device that reads out from and selects.... [P. 163.]

Thus mind operates on brain directly for Eccles and indirectly through World III for Popper. For Popper mind is an emergent (e.g., p. 127) and the problem is how emergents can interact with their substrate. He worries about 'downward causation of the higher level acting on the lower level' and comes to the conclusion that 'the emergence of hierarchical levels or layers, and of an interaction between them, depends upon a fundamental indeterminism of the physical universe. Each level is open to causal influences coming from lower *and* higher levels' (p. 35). For Eccles, mind is a given entity that organizes brain function and is organized in turn by World III acting through the senses. For Eccles, mind pre and postdates brain but needs cortex of a special sort in order to make a liaison.

To me, Popper's position is the easier starting point. As we shall see, however, there is some merit to Eccles' view, as well. What Popper has done is split what ordinarily is called 'mental' into two Worlds: World II and World III. World II is the mental state; World III is composed of the contents of that state. Both World II and World III are emergents of complex brain organization. World III is a product of World II. World II is completely mental but World III can be, in part at least, material (e.g., the book).

I believe this division and the resultant attempts at interactionism to be unnecessarily awkward. I prefer to begin with the idea that mental states are the result of an interaction between an organism and its environment, in particular between an organism's brain and its social environment. This position is derived from behaviourism (see Popper's discussion of Ryle, pp. 104-107) but goes beyond it in that it admits the ghosts in the machine, admits them to be as real as the machine itself. Images, experiences, intentions, plans, expectations, joys and sorrows are not excised from the 'real' world but are prime manifestations of that world (see the 'subjective behaviourism' of Miller, Galanter and Pribram 1960). They are not necessarily the primary or only manifestations, however, as the phenomenologists or even the empiricists would have it. Eccles and Popper, as dualists, rightly decry such overemphases on primacy—but often come up with confusing statements regarding causation from the interactionist stance. Thus Popper (p. 514) talks of illusions which have a mental origin as in wish fulfillment. Freud's treatment in the 'Project' (1895) has wish fulfillment and its illusions come about by very specific brain processes (see Pribram and Gill 1976), more in keeping with Popper's overall emergent property position.

By contrast, the proofs of an existence of a reality beyond our senses are clearly reviewed by Popper (pp. 104-108) and I hold with him and with psychologists such as Gibson (1950) that there are invariants in the relationship between organism and environment that provide strong proofs of stable organizations in that environment.

Note that the interaction that I espouse is between organism and its environment. Note also that such interaction does not deny the emergence of mental properties. However, the emergence can stem either from biological evolution which has produced novel brain organizations that result in linguistic capacities, or from cultural evolution which can produce new linguistic modes such as writing and printing (see Pribram, 'Language in a Sociobiological Frame', 1976*a*).

Popper, by contrast, addresses the interaction between mental and material. And, although he reviews the problems faced by materialism because of the insights obtained in the new physics, he fails to see that these insights apply as well to a dualism which still holds dear the separation of mind and matter. I wonder: Are forces 'material'? Are light 'waves' waving in vacuo 'material'? Are quarks with their charm and flavours 'material'? As Wigner (1969) so aptly states, modern physics is based on 'relationships between observations not relationships between observables'. But is not this the self-same definition which characterizes modern scientific psychology?

I do not, of course, deny the distinction between observation and observable—the problem of intentionality (see e.g., Searle). What I do claim is that the distinction no longer distinguishes what we call the physical from what we call the psychological sciences. I do not deny reality to an *appearance* of the material world as in Newtonian mechanics or in Gibsonian perceptual psychology. Nor do I deny that one can distinguish between these appearances and other realities and also between physical reality and psychological reality. But for me realities are constructed, often painfully and painstakingly. Appearances are one such reality, the perceptual reality beyond which lie others.

I am sitting quietly writing this commentary. I am moving in a complex trajectory around the earth's axis, the sun, and within our galaxy. Both statements reflect a reality—the one my perceptual reality—the reality of appearance; the other, my physical reality based on the observations and calculations of innumerable scientists. Which reality is 'objective' and which 'subjective'? Which is based solely on the interaction of material observables and which is based on mental operations such as calculation and observation?

Popper's invention of World III attempts to cope with these questions but I believe the invention does not go far enough. The issue is not material versus mental but how we construct a material reality and how we construct one that is apparently mental.

Elsewhere (Pribram 1976*b*) I have argued that the way Popper—and Eccles—describe the interaction of mind and brain is akin to a colloquial use of the concept force. We say that gravity pulls us to the earth. However, the concept 'gravity' was derived from studying the interactions of masses in motion. Gravity is by definition an interaction term—gravity would not 'exist' were there no 'us' to be attracted to the earth. We then reify 'gravity' and have it pull us—and appearances certainly confirm this way of conceiving forces, that they are being 'produced' by one body and operating on another. Popper develops his thesis of World III being 'produced' by World II in this spirit. May 'The Force' be with him.

What I see good in the World II, World III division is that it attempts to portray the same issue that I have in mind when I discuss structure and its realization. In a sense what I call 'structure' is what Popper and also Eccles call 'mind'. The difficulty is, however, that my 'structures' are derived, as are all other *concepts*, from the interaction of organism and environment. 'Structure' can therefore be inherent in environment, and in material, physical environments (such as the structure of a symphony being embodied in a printed score or a magnetic tape). This would make my formulation akin to Whitehead's or Wigner's—a form of panpsychism. But, in agreement with Eccles, I am not wholly willing to go that far at the moment. Rather, I prefer to hold the line by stating that *structures transcend both the physical and mental realities in which they become realized*.

There is thus an important difference between a constructional realism such as I propose and the dualist (trialist)—interactionism espoused by Eccles and Popper. In a constructional scheme the precise place of brain mechanisms can be specified. The sensory and brain perceptual mechanisms that are used to construct the Newtonian reality of appearances; the cognitive 'intrinsic' (my term for Eccles' 'liaison') brain mechanisms that are necessary to the formulation of quantum and nuclear physics; the connative motor brain mechanisms that organize intention and plan; the emergence of feelings from the neurochemical organizations of the brain—all can be fitted into their precise and proper place in the scheme (see e.g., Pribram 1971*a*). There is no global 'mind' that has to make mysterious contact with global 'brain'. Many mysteries are still there—e.g., how emergents do come about and how they are so utterly different from their substrate—to name only one. But issues become scientific and manageable within the broader context of philosophic inquiry.

THERE IS A BRAIN IN THE MIND/BRAIN PROBLEM

One example is in the order of such manageability and the precision with which the problems can be stated. I take this example from my own work because Eccles reviews it and criticizes it in his part of the book. The problem relates to both perception and memory. The issue is how sensory input becomes encoded in the brain cortex. Eccles puts the problem in the following way:

> What neural events are in liason with the self-conscious mind both for giving and receiving.... We reject the hypothesis that the agent is the field potential generated by the neural events. The original postulate of the gestalt school was based on finding that a massive visual input such as a large illuminated circle resulted in some topologically equivalent potential field in the visual cortex, even a closed loop! This crude hypothesis need not be further considered. However a more refined version has recently been proposed by Pribram (1971) in his postulate of micro-potential fields. It is assumed that these fields

provide a more subtle cortical response than the impulse generation by neurones. However, this field potential theory involves a tremendous loss of information because hundreds of thousands of neurones would be contributing to a micro-potential fields across a small zone of the cerebral cortex. All the finer grain of neuronal activity would be lost in this most inefficient task of generating a minute electrical potential by current flow in the ohmic resistance provided by the extracellular medium. In addition we have the further problem that there would have to be some homunculus to read out the potentials in all their patterned array! The assumed feedback from micro-potential fields onto the firing frequencies of neurones would be of negligible influence because the currents would be extremely small.

We must believe that there is an essential functional meaning in all the discrete neuronal interactions in spatiotemporal patterns, otherwise there would be a great loss of information. In this context, we must consider the organization of the cortical neurones in the anatomical and physiological entity that is called a module (chapter E1, Figs. E1-5 and 6). In the first place it is inconceivable that the self-conscious mind is in liason with single nerve cells or single nerve fibers as has been proposed by Barlow (1972). These neuronal units as individuals are far too unreliable and ineffective. In our present understanding of the mode of operation of neural machinery we emphasize ensembles of neurones (many hundreds) acting in some collusive patterned array. Only in such assemblages can there be reliability and effectiveness. As described in chapter E1 the modules of the cerebral cortex (Figs. 5 and 6) are such ensembles of neurones. The module has to some degree a collective life of its own with as many as 10,000 neurones of diverse types and with a functional arrangement of feed-forward and feedback excitation and inhibition. As yet we have little knowledge of the inner dynamic life of a module, but we may conjecture that, with its complexly organized and intensely active properties, it could be a component of the physical world (World 1) that is open to the self-conscious mind (World 2) both for receiving from and for giving to. We can further propose that not all modules in the cerebral cortex have this transcendent property of being 'open' to World 2, and thus being the World 1 components of the interface. By definition there would be restriction to the modules of the liaison brain, and only then when they are in the correct level of activity. Each module may be likened to a radio transmitter-receiver unit. Szentagothai has suggested that the module may be thought of as an integrated microcircuit of electronics, only vastly more complicated. [Pp. 365-66.]

In this account Eccles is a bit naughty. *Languages of the Brain* (Pribram 1971*b*) which he quotes contains whole sections—e.g., pp. 126-31 and pp. 324-27 devoted to what are there labelled as 'logic modules'. The structure of such modules is presented in much greater detail than Eccles has done in *The Self and Its Brain* or anywhere else. Furthermore, the precise operation of the modules has been simulated by computer on several occasions in Pribram's laboratory (Spinelli 1966; Phelps 1974; Bridgeman 1971; Pribram, Nuwer and Baron 1974).

But there is more. Eccles criticizes Pribram in the first of the two paragraphs quoted above as follows: 'The assumed feedback from micropotential fields onto the firing frequencies of neurones would be of negligible influence because the currents would be extremely small'. In the following paragraph he uses these same currents (which, as clearly defined in *Languages of the Brain*, are the depolarizations and especially the hyperpolarizations that occur at synapses and within dendritic fields) to 'emphasize ensembles of neurones (many hundreds) acting in some collusive patterned array . . . with as many as 10,000 neurones of diverse types and with a functional arrangement of feed-forward and feedback excitation and inhibition'. This excitation and inhibition is for the most part carried out in axonless (Golgi Type II) 'local circuit' neurons (Rakic 1976) which depend on the very 'micropotentials' that Eccles criticized in the earlier passage. It is becoming more and more clear that processing in the brain, processing within local neuronal circuits is proceeding by way of local electrotonic and chemical communications that characterize dendrodendritic interactions—

rather than via the action potential mode so characteristic of long sensory and motor pathways (see e.g., Schmitt et al 1976).

Shepherd (1974) and Rall (1970) have presented voluminous neurophysiological evidence on the functional organization of these local microcircuits—evidence on which Pribram based his proposal of microstructures. What then is the actual difference between Eccles' microcircuits and Pribram's microstructures except that Pribram has clearly specified the graded response characteristics of the patterning that produce the functional arrangements within microstructures (or microcircuits) while Eccles fails to do so and takes umbrage in 'the self and its mind' operating a 'radio transmitter or receiver' (the brain modules).

So much for the neurophysiology. The question is, of course, what does this neurophysiology gain us with respect to the mind-body problem? Pribram has suggested that the neuronal microstructure, the microcircuitry, is encoding *periodic* activity, that sensory transduction of environmental energy results in patterns of neural activation in the *frequency* domain. Eccles is not averse to this when he suggests that microcircuits act much as 'radio transmitter-receivers'. Radios operate on periodic information—they are tuned to transmit and receive frequences.

The initial evidence for neural encoding in the frequency domain was presented in *Languages of the Brain* (1971, Chap. 8). Since that publication, evidence continues to pour in. Ohm (1843) and Helmholtz (1863) had originally suggested that the auditory system operates as a frequency analyzer. Bekesy (1957) showed that the skin and the somatosensory mechanism behave in a similar fashion. But the most dramatic evidence concerns the visual system. More and more evidence is accumulating (e.g., Campbell and Robson 1968; Movshon et al 1978*a*, 1978*b*, 1978*c*; De Valois et al 1978*a*, 1978*b*; Pribram et al submitted) to show that visual spatial processing is accomplished in the frequency domain—the eye analyzes the periodic fluctuations of the intensity of light over space.

In the engineering sciences such processing in the frequency domain is called optical information processing (if done with lens systems) or image processing (if performed with computers) or holography (if storage on photographic film is employed). It is holography that first called my attention to the attributes of the frequency domain (Pribram 1966). In a hologram (the photographic film that stores the microstructure of periodic changes of light and dark over space) the information about forms in space becomes distributed. One of the most difficult problems of neuroscience has been to explain the fact that local lesions in the brain do not selectively impair one or another memory trace. Similarly, in a hologram restricted damage does not disrupt the stored information because it has become distributed.

In essence the information becomes blurred over the entire extent of the holographic film, but in such a precise fashion that it can be deblurred by performing the inverse procedure. Thus image reconstruction (or construction) from the stored frequency domain is simple—actually, applying the same transform that produced the store will also decode it into an image. In short, contrary to what Eccles states to be a problem with Pribram's theory, the evidence that the brain encodes information in the frequency domain indicates that no 'homunculus' is needed to read out the memory trace. Either an input from the senses or from some central source such as Popper's suggestion that the pain, pleasure expectation and attention mechanisms might be responsible (see Pribram and McGuinness 1975, for evidence) will activate the frequency encoded memory trace to produce an image. No 'self conscious mind' is sitting there as Eccles suggests, biasing the functions of the association cortex. Rather, as

Popper claims, self conscious mind is best conceived as an emergent property of a particular specifiable brain organization.

For the mind-brain problem, this mechanism has direct relevance. Note that storage takes place in the frequency domain. Images as such are not stored nor are they 'localized' in the brain. Rather, by virtue of the operation of the local brain circuitry, usually with the aid of sensory input from the environment, images, mental events emerge, are constructed. The images are produced, constructed—they are ghosts resulting from the operations of the machine (brain).

A similar mechanism on the motor side can account for intentional behaviour. The evidence that such a mechanism exists is presented in *Languages of the Brain* (1971) and elsewhere (e.g., Pribram 1976c; submitted). Much of my laboratory research has been involved in demonstrating that brain function is active, not passive in its interactions with environment and in elucidating the mechanisms involved in this active aspect of mind. This research has shown that the intrinsic cortex and limbic formations of the forebrain actively organize sensory input, etc.

Suffice it here to say that I believe the discovery that certain operations of the brain can be best-understood in terms of processing in the frequency domain is as important to the mind-brain problem as was the discovery of quantum and nuclear physics that ultimately the appearances of matter may be immaterial.

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

The point was made earlier in this paper that the 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 embodiment constructional realism. But it was also stated that certain questions raised by a more classical dualistic position were left unanswered by the explanations given in terms of a constructional realism.

What are these questions? Recall that Popper and Eccles propose entirely different—and in a fundamental sense, opposite—views of how mind and brain interact. Popper has mind an emergent from brain functioning, Eccles has mind operating *on* the intrinsic 'liason' formations of brain cortex. Still these authors managed to publish a book together. They must have both felt *some* affinity for the other's views. What is it that they may have sensed to be in common, what deep feeling did they fail to articulate adequately in their volume?

I believe that the analysis provided earlier in this paper may help 'unpack' this issue. Note than 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. The upward look in the hierarchy as in the phenomenal and existential approaches simply takes these 'emergents' as the fundamental achievements of observations. Constructional realism is this sort of theory, and as noted above, I believe Popper is attempting to achieve a similar end by his construction of a World III.

Eccles by contrast is holding out for a very different sort of formulation. He insists that mind transcends brain function in that mind operates upon brain, not

because mind emerges from the functioning of the brain. As noted above, articulated in this fashion, Eccles' formulation makes no scientific sense.

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.

Essentially space and time become enfolded in the holographic domain. This accounts for translational invariance, the fact that transformation into the ordinary domain can be accomplished from *any* part of the encoded record. In the holographic record information becomes distributed, spread over the entire surface of a photographic film or brain module much as the waves produced by throwing a pebble into a pond spread to its edges. Several such waves initiated by several pebbles will interact or 'interfere' and the record of these interference patterns constitutes the hologram. If a moving picture were made of the origin and development of the interference patterns, the movie could be reversed and the image of the pebbles striking the pond could be recovered. Image reconstruction by holography accomplishes much the same effect by an operation that performs an inverse transform on the record. Thus image (and object) and holographic record are transforms of each other and the transformations involved are readily reversible.

Consider further the fact that in the holographic domain space and time are collapsed. Only the density of occurrences is manifest. These densities can be recorded as wave number or in scattering matrices representing n-dimensional (Hilbert) 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.

David Bohm (1971, 1973) has pointed out that 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. Bohm refers to our lens-given ordinary perceptions and conceptions as explicate and those that are holographic-like as implicate. Thus there are at least two discernible orders in the universe—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 e.g., 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 religions and other 'paranormal' phenomena. The lack of spatial and temporal boundaries, the holographic characteristic that the whole is represented in every part, the transformational character of shifting from explicate to implicate order, are all beyond ordinary human experiencing which is apparently limited to the everyday explicate Euclidian, 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.

To summarize this section, I propose that Eccles' suggestion of a distributed 'mind' operating in some 'as yet mysterious' way on brain can be supported 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' etc. are transcended. The 'mystery' is resolved not by taking the interactionist stance that Eccles has taken and which is appropriate to Popper's formulation, 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. Modern physicists working at both the microphysical quantum and nuclear level and at the macrophysical 'universe' level have, however, called into question the material basis of matter (Bohm 1971, 1973; Wigner 1969). 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 such 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 run 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, has been shown to involve minute amounts of energy that can organize or reorganize larger scale systems. The configurations which energy systems display rather than the raw amount of energy they consume has been shown to be critical (Brillouin 1962; Weizsacker 1974). Are such figural changes to be conceived as mental or material when they involve languages, cultures, etc.? Once again, a limit is reached where the mental/material distinction becomes useless.

However, the issue of dualism can be analyzed on its own ground—i.e., within the purviews of ordinary experience. Here dualism is 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. This is the view proposed by Popper in *The Self and Its Brain*.

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. As shown, Eccles attempted such articulation by suggesting what seems to be a rather naive interactionism: mind operating on the association areas of the brain—its intrinsic, 'liason' cortex. A constructional realism does not deal with the issue that is being posed by Eccles' formulation: a 'mental' universe 'independent' of—though 'interacting in some mysterious way'—with the material.

The final proposal of the paper meets the requirement of this aspect of dualism. 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. And physicists have suggested that a holographic-like order might well characterize the microstructure of the physical world. In the frequency 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.

Structural realism thus deals with a number of dualities which are especially significant for unpacking the issues involved in a mind/brain dualism: (1) a dualism based on the distinction between a material and a mental universe is found too limited to deal with the very issues it poses; (2) a procedural duality that faces upward and downward in a hierarchy of knowledge systems can be discerned in the ordinary world of appearances and accounts for separate mental and objective realizations of experience (3). An additional distinction can be made which captures the spirit of dualism: 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.

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