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COMMENTARY

EMERGENCE AND THE MIND

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Abstract—This commentary deals with the mind–body problem from the point of view of a general systems theory. It starts by elucidating the notions of thing, property, state and process. In particular it shows how the concept of a state space can be used to represent the states and changes of state of a concrete thing such as the central nervous system. Next the concepts of emergence and of level are discussed. An emergent property is defined as a property possessed by a system but not by its components. The notion of level and the peculiar relation existing between levels are clarified, only to show later on that the mental cannot be regarded as a level on a par with the physical or the social. The upshot is a rationalist and naturalist pluralism.

The second half of the paper expounds and examines the various versions of psychoneural monism and dualism. Dualism is found unclear, at variance with the general framework of science, and untestable. Eliminative materialism and reductive materialism are rejected for ignoring the peculiar (emergent) properties of the central nervous system. A variety of psychoneural monism called emergentist materialism is found the most acceptable because of its compatibility with our present knowledge and because of its heuristic power. However, it is emphasized that emergentist materialism is still largely a programmatic hypothesis in search of detailed theories, in particular mathematical ones, of the various emergent functions of the central nervous system and its subsystems.

THE PROBLEM AND ITS SETTING

THIS commentary deals with the so-called mind–body problem. This is the set of questions about the nature of the mental and its relations to the bodily. For example, are mind and body two separate substances? If so, how are they held together in the living organism? These questions are rather difficult to answer. However, I submit that the difficulty is not wholly intrinsic but has been compounded by hurdles such as the following. Firstly, several doctrines concerning the mind–body problem have some ideological bias or other—and ideologies are not particularly interested in fostering conceptual clarity and empirical investigation. Secondly, the very formulation of the mind–body problem employs certain concepts, such as those of substance, emergent property, state and event, which are far from clear. (These concepts occur in all sciences and are therefore elucidated by none: they belong in the branch of philosophy known as ontology or metaphysics.) In fact it is pointless to engage in an argument about whether or not there are mental states that are not brain states, or whether mental events have causal efficacy, unless one can make some sense of the very expressions 'mental state' and 'mental event', which in turn contain the philosophical concepts of state, event and mind. Let us therefore start by trying to clarify these and a few other ontological concepts that occur in the discussions on the mind–body problem. (For a detailed mathematical treatment of these concepts see BUNGE, 1977*a*.)

A thing, or concrete object, may be characterized as whatever can join (or associate with) another thing to form a third thing. On the other hand two concepts cannot always join to form a third concept, e.g. 'purple number' is not a concept although 'purple' and 'number' are. But things have of course many other properties in addition to that of joining to form other things. For instance, they can interact and get together, forming tightly knit complex things, i.e. systems; they can move about, change in kind, and so forth. We may then assume that every thing, no matter how simple it may look, has a large number n of properties. (We are here referring to general properties such as that of moving, not to particular properties such as that of moving from here to there with such and such an instantaneous velocity relative to a given frame.)

Now, every thing property can be conceptualized as (or represented by) a function in the mathematical sense of the term and, in principle, by a real valued function. And the n functions representing the properties of a concrete thing can be collected together into a single function in conformity with:

Definition 1

Let each of the n properties of a concrete thing be represented by a real valued function F_i of time, with $1 \leq i \leq n$. Then

(i) $\mathbb{F} = \langle F_1, F_2, \ldots, F_n \rangle$: $T \rightarrow \mathbb{R}^n$ is called the *state function* of the given thing;

Abbreviation: CNS, central nervous system.

(ii) the value $s = \mathbb{F}(t)$ of $\mathbb{F}$ at time t is called the *state* of the given thing at t;

(iii) the ordered pair $\langle s, s' \rangle$ of values of $\mathbb{F}$ at times t and t' respectively is called an *event* occurring in the thing concerned between t and t';

(iv) the sequence of states joining two states s and s' of a given thing is called the *process* leading from s to s', or the *history* of the thing between t and t'.

Note that we have not been talking about properties, states or changes in themselves: every property is a property of (possessed by) some thing or other; likewise every state is a state of some thing, and every change of state is a change of or in some thing or other. Thus physical states are states of physical things; chemical states, states of chemical systems; biological states, states of organisms; social states, states of social systems; and so on. This manner of speaking, which is entrenched in modern science and which ignores the Platonic forms hovering above things, will prove of decisive importance in our discussion of the mind–body problem.

Now, the state function $\mathbb{F}$ describing the states and changes of state of a thing is not *a priori*: it is determined by the laws possessed by the thing. In other words, there are laws that restrict the possible forms of $\mathbb{F}$. These laws may take the form of mere restrictions on the range of $\mathbb{F}$, or of algebraic relations among the components of $\mathbb{F}$, or of differential equations satisfied by them, or what have you. By virtue of such restrictions, the tip of $\mathbb{F}$ spans not the totality of its codomain $\mathbb{R}^n$ but only a subset of it. This subset of the set of all logically possible states of the thing will be called the *state space* of the latter or, more precisely, its *lawful state space*. We designate it $S_{\mathbb{L}}(x)$, where $\mathbb{L}$ is the set of laws possessed ('obeyed') by thing x. (See Fig. 1.)

So much for the concepts of thing, property, state and process. Let us now take a closer look at properties of a particular kind, namely emergent properties. They are of special interest to the neuroscientist who, while acknowledging that feeling, recalling, imagining and reasoning are emergent properties of the brain, would like to explain them in terms of events occurring in certain subsystems of it.

RESULTANTS, EMERGENTS AND LEVELS

Temperature and entropy are properties of an atomic aggregate, not possessed by any of its atomic components. Likewise the capacity to self-duplicate is a property of deoxyribonucleic acid molecules that none of their components (i.e. the nucleotides) possesses. These are examples of emergent properties, or properties characterizing a system as a whole and which the system components do not have. Emergence is conspicuous at all levels and *a fortiori* between levels. This much seems clear.

What are not clear at all are the various notions of emergence and level. There are several reasons for this. One is that most rationalist philosophers are radical reductionists and so have claimed that emergence is a myth. Another is that most emergentist philosophers are irrationalists and so have held that there is nothing to be explained: that emergence is as mysterious as it is real. A third reason for the obscurity of the notion is that scientists are forever trying to explain emergence and, when they succeed, give the impression that they have explained it away. But of course things and their properties, even if radically new, do not go away just because scientists succeed in understanding them or philosophers pretend that they do not exist to begin with. We had therefore better face the task of elucidating first the elusive notion of emergence.

We shall be concerned with complex things, in particular with systems, i.e. things the components of which are linked or coupled to one another. The properties of a complex thing are called *bulk* or *global* properties because they are possessed by the thing as a whole. Now, bulk properties are of two kinds: resultant and emergent. Energy is a resultant property for it is possessed by every part of a thing. On the other hand having a certain structure, being stable, being alive, and thinking are emergent or nonhereditary properties for they are possessed by no component of the whole concerned. More precisely, we make:

Definition 2

Let P be a property of a complex thing x other than the composition of x. Then

(i) P is *resultant* or *hereditary* if P is a property of some components of x;

(ii) otherwise, i.e. if no component of x possesses P, P is *emergent*, *collective*, *systemic* or *gestalt*.

(Composition does not count because it is a universal property and because even a mere heap has a composition.)

What holds for properties holds also, of course, for their carriers. Thus a resultant thing (or just *resultant*) is one the properties of which are possessed also by some of its components. And an emergent thing (or just *emergent*) is one possessing properties that none of its components possesses. Note that emergence is relative. Thus the ability to think is an emergent property of the primate brain relative to its component neurons, but it is a resultant property of the primate because it is possessed by one of the latter's components, namely its brain.

Radical monism, in particular mechanism, assumes all properties to be resultant or hereditary, hence explainable by straight reduction, as happens to be the case with the total energy and the total electric charge of a body. Radical pluralism, on the other hand, holds that there are emergent properties (an ontological hypothesis) and moreover that none of these is explainable in terms of the components and their links (an epistemological hypothesis). We take neither of these stands.

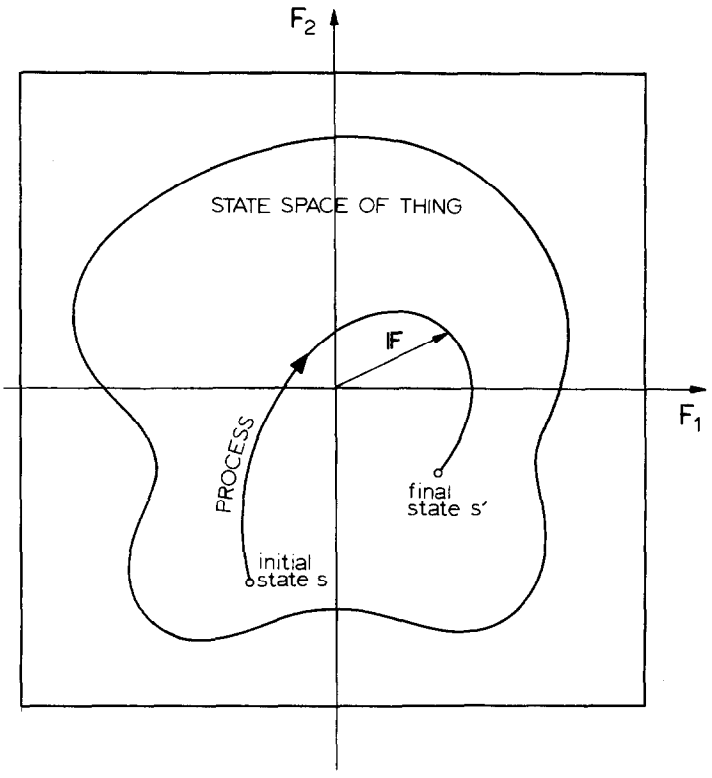

FIG. 1. The states and changes of state of a thing (e.g. neuron, neuronal circuit, subsystem of the CNS or entire CNS are representable in the state space of the latter, which is the space spanned by its state function—the ordered n-tuple of functions representing its various properties. (On the other hand according to eliminative and reductive materialism of the radical sort, i.e. mechanism, the states of any thing should be representable as points in spacetime.) In the diagram only two properties, represented by functions F_1 and F_2 (or rather their ranges), are shown. Actually any realistic model of a complex thing will involve a state function with many more components. So, try to imagine the state of a thing as the tip of a vector in an n-dimensional state space.

We recognize the fact of emergence but assume that every emergent can be accounted for in terms of a system's components and the couplings among them. For example, refraction is not a bulk property of transparent bodies: it is an emergent property relative to the atomic (or molecular) components of such bodies, for none of those components possesses the property of refrangibility. Yet this emergent property of the whole is explained by electrodynamics in terms of the electrical properties of atoms (or molecules) and light. However, this explanation is not reductive in a simple sense, as it does not consist in attributing refrangibility to individual atoms: it is reductive in consisting in the deduction of the formula for refractive power from premises concerning the interaction between electromagnetic waves and atomic lattices.

What holds for physical systems holds *a fortiori* for chemical, biochemical, biological and social systems. For example, enzymatic catalysis is an emergent property of biochemical systems, sexuality an emergent property of some biosystems, and social cohesion an emergent property of sociosystems. However, these are not unintelligible properties: they can be and are being explained. (That no scientific explanation is likely to be definitive is beside the point.)

The foregoing assumptions can be compressed into two postulates, one ontological or concerning reality, the other epistemological or concerning our knowledge of reality. Here is the *emergence postulate*:

Postulate 1. Some of the properties of every system are emergent.

And here is the *rationality postulate*:

Postulate 2. Every emergent property of a system can be explained in terms of properties of its components and of the couplings amongst these.

These two postulates constitute the kernel of what may be called *rational emergentism*, a doctrine differing from both the irrationalist emergentism of the holists and the rationalist flattening (or leveling) by the mechanists, energetists and idealists.

The last ontological concept we must handle before turning to the mind–body problem is that of level, particularly in view of the popular assumption that the mental constitutes a higher level than the biological one. First the intuitive idea.

Most biologists seem to agree that things, and in particular things of concern to biology, are found not

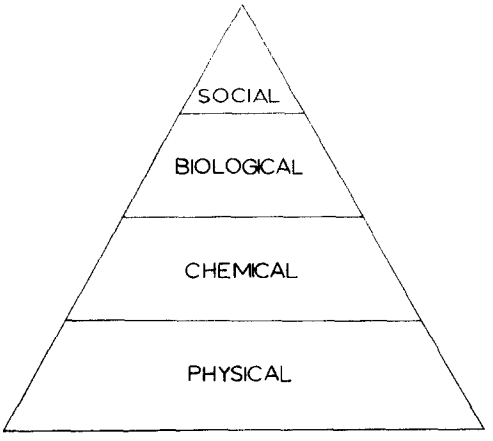

FIG. 2. The pyramid of levels of organization of the world. Each higher level consists of systems built with components belonging to the immediately prior level. And each level splits into sublevels. For example the biological level can be subdivided into the cell, organ, organism, population and ecosystem sublevels. The pyramid suggests not subordination or excellence, but only that the higher a level the more dependent and the less populated it is.

pell-mell but rather in levels, and that these in turn constitute a sort of pyramid. Thus one speaks of the atomic level and the molecular one, of the cellular level and the organal one, etc. And one assumes that the systems at any given higher level are composed of things belonging to the immediately preceding level (see Fig. 2). This suggests making:

Definition 3

Let L be a family nonempty sets L_i of things, with $1 \leq i \leq n$. Then if L_i and L_j are members of L, then L_i *precedes* L_j if and only if each member of L_j is composed exclusively of things in L_i.

In symbols:

$$L_i < L_j =_{df} \forall x(x \epsilon L_j \Rightarrow \mathscr{C}(x) \subset L_i)$$

where $\mathscr{C}$ is the composition function. ($\mathscr{C}$ maps the set of things into the power set of the latter, in such a way that if x is a thing then $\mathscr{C}(x)$ = the set of parts of x.) In short, $\langle L, < \rangle$ is a partially ordered set.

Note two points. The first is that a level is not a thing but a set and therefore a concept, though certainly not an idle one. (Hence levels cannot act upon one another. In particular the higher levels cannot command or even obey the lower ones.) Second, the relation between levels is neither the part–whole relation nor the set inclusion relation, but a *sui generis* relation definable in terms of the composition function, which in turn is definable in terms of the part–whole relation.

The concept of a level occurs in the *levels hypothesis*, or

Postulate 3. Every thing belongs to some level or other.

This is sometimes called the *hierarchical principle*—incorrectly so because there is nothing sacred (*hieros*) about the level structure of the world and because the relation between levels is not one of command (*archein*) but the one of precedence. According to the above definition, one level precedes another just in case it supplies the components for the systems in the next highest level.

Now, the components of a system are also its precursors in an evolutionary process. Thus amino acids are at the same time the components and the precursors of proteins, and cells both compose a multicellular organism and give rise to it. (On the other hand according to holism the whole precedes its parts and controls them.) One may wish to generalize stating

Postulate 4. Every complex thing belonging to a given level has self-assembled from things of the preceding level.

To put it metaphorically: higher levels emerge out of lower ones in a natural process of self-assembly. Consequently radical novelties emerge out of previously existing things. Therefore emergence and levels, far from forming a static order, are features of an evolutionary process. And, according to our assumption, this process is natural or spontaneous: notice the term 'self' in Postulate 4.

Postulates 1, 2 and 3 form the nucleus of rationalist pluralism. Postulate 4 renders this ontology dynamicist and naturalist (instead of supernaturalist). In fact the whole thing is a sort of generalization of the theory of evolution.

What has all this to do with the mind–body problem? Much, for the mental may be conceived of as an emergent relative to the physiological. But the mind may be so conceived in either of two different ways: as an emergent *entity* or as an emergent *property* of entities of a certain kind—say vertebrates. In the first case one might wish to claim that *minds* constitute a level of their own: this would be the thesis of psychoneural dualism embedded in an overall pluralistic ontology. In the second case one would certainly hold that *organisms* endowed with mental abilities form a new level relative to mindless organisms: this would be the thesis of psychoneural unity embedded in the pluralistic ontology sketched earlier. Let us look at this problem more closely.

MONISM AND DUALISM IN THE MATTER OF MIND

There are two classes of solution to the mind–body problem: psychoneural monism and psychoneural dualism. And each of these classes contains at least five different doctrines: see Table 1, where 'φ' stands for *body* (or *the organic*) and 'ψ' for *mind* (or *the mental*). (Cf. ARMSTRONG, 1968; BORST, 1970; FEIGL, 1967; FEYERABEND & MAXWELL, 1966; HEBB, 1949; HOOK, 1960; KOESTLER & SMYTHIES, 1969; O'CONNOR, 1969; PLACE, 1956; ROSENBLUETH, 1970; SMART, 1959.) Let

us examine them briefly, starting with the main varieties of psychoneural dualism.

We need not consider the independence thesis D1, as both introspection and neuroscience tell us that the bodily and the mental—whatever the latter may be—are interdependent. As for the parallelism or synchronization thesis D2, upheld by the Gestalt school, it begs the question instead of answering it, for what we want to know is precisely the mechanism responsible for the 'parallel sequences' of mental and physiological states. To say that mental events have neural 'correlates' is fine but not very informative unless one states what a mental event is and the nature of its 'correlation' with its neural 'correlate'. For these reasons D2 is vague to the point of being confirmable by all possible empirical data. Hence D2 is not a scientific hypothesis.

On the dualist side we are then left with either of the thesis acknowledging one substance's acting upon the other. However, in this case too only the physical is supposed to be knowable, whereas the mental is left in the dark or, at best, in the care of philosophy or even theology. We do indeed understand what it is for a given neuron, or neuron assembly, to be in such and such a state: a state of a thing is always an ordered n-tuple of the n properties we care to assign to it. (Cf. The first section in this commentary.) And we understand what is a neural event or process, namely a change in the state of a neural unit neuron or neuron assembly). Consequently we know what it is for one neural unit (neuron or neuron assembly) to act upon another: A acts on B if the states of B when it is connected with A are not the same as those of β when it is not so connected. In short we have some idea of neural functions (states, events, processes). Recall Fig. 1.

But these ideas—common to all sciences—are not transferable to the mental 'substance'. If they are, nobody has shown how. In particular, attention, memory and ideation have not been shown to be properties or changes of properties of a mental substance (mind, soul or spirit). In sum, the concepts of mental state, event and process do not fit within the general framework of contemporary science unless they are construed in neural terms, i.e. as, respectively, a state of the brain or an event or process in a brain. This is one of the reasons for dualism's inability to go beyond the stage of verbal and metaphorical formulations. This is why there is not a single dualistic model—in particular a mathematical model—in physiological psychology.

In short, interactionism is just as imprecise as parallelism—which is to be expected of a popular, i.e. nonscientific, view. (Recall that ordinary knowledge is largely popular superstition.) And, not being a precise hypothesis, it can hardly be put to empirical tests. Moreover even if parallelism and interactionism were to be formulated in a precise manner, it might not be possible to decide between them on the strength of empirical data. Indeed, it would seem that every psychological experience and every psychophysiological experiment could be interpreted (or misinterpreted) either in parallelist or in interactionist terms, since neural events are simultaneous with their mental 'correlates'.

We are led to the conclusion that the two main variants of psychoneural dualism, namely parallelism and interactionism, though conceptually different, are equally fuzzy and are empirically equivalent in so far as they accord (much too easily!) with the same empirical data. For these reasons dualism is not scientifically viable. It is barren double talk and, as Spinoza characterized it, a disguise for our ignorance. We are then left with psychoneural monism as the only scientifically and philosophically viable alternative.

But, as shown in Table 1, psychoneural monism is a whole class of doctrines. Let us start with M1 or subjectivism. We can write it off without further ado because it is incompatible with physics, chemistry, molecular biology and social science, all of which are busy hypothesizing and manipulating unobservables such as atoms, ecosystems and societies. Moreover, all of these disciplines are supposed to abide by the scientific approach, which includes objectivity. As for neutral monism, it has yet to be formulated clearly and in agreement with the natural sciences.

TABLE 1. TEN VIEWS ON THE MIND–BODY PROBLEM

Psychoneural monism	Psychoneural dualism
M1 Everything is ψ (*phenomenalism, idealism*).	D1 φ and ψ are independent.
M2 φ and ψ are so many aspects or manifestations of a single entity (*neutral monism*).	D2 $\varphi \parallel \psi$, i.e. φ and ψ are parallel (*psychophysical parallelism*).
M3 Nothing is ψ (*eliminative materialism*).	D3 $\varphi \rightarrow \psi$, i.e. φ affects (or even secretes) ψ (*epiphenomenalism*).
M4 The mind is corporeal (*reductive materialism*).	D4 $\psi \rightarrow \varphi$, i.e. ψ affects (e.g. controls) φ (*mentalism*).
M5 ψ is a collection of emergent functions of φ (*emergentist materialism*).	D5 $\varphi \leftrightarrow \psi$, i.e. φ and ψ interact (*interactionism*).

φ, *body* (or *the organic*); ψ, *mind* (or *the mental*).

Even the least obscure and mystical of its versions, namely Ostwald's energetism, is vague. (Moreoever it rests on the mistaken reification of energy, which is actually a property of physical objects not a thing.) We may therefore dismiss M1 and M2, and examine materialism.

We distinguish three kinds of materialism, to wit, eliminative, reductive and emergentist. (Recall Table 1.) Eliminative materialism holds that there is no such thing as the mental: that everything is material. There are two different versions of this thesis: the ancient thesis that all subjective phenomena are composed of particles, and the modern thesis that there are only neural facts (states, events, processes). Neither of these theses is capable of distinguishing between appearance and reality, i.e. between facts as perceived by a sentient being (i.e. phenomena) and facts as they are independently of the organism. Nor does eliminative materialism distinguish between *Homo sapiens* and its nearest cousin the amazing chimpanzee, so similar at the cellular level and yet so different at the organismic level. In short, eliminative materialism can be eliminated.

The thesis of reductive materialism may be formulated thus: 'Every mental state (or event or process) is a state (or event or process) of the central nervous system. Therefore the mental is no different from the physical.' While I have no quarrel with the premise, I submit that the conclusion is a *non sequitur*. But before arguing for emergence let us examine this argument of the reductive materialists. It is an argument from analogy with other macrofacts rather than an independent examination of the models and the empirical evidence in physiological psychology. Let us dwell on it for a while.

Reductive materialists claim that the body–mind relation is just a particular case of the macroscopic–atomic relation, and that in both cases it is one of epistemological *and* ontological reduction. While I agree with the first contention, I disagree with half of the second, namely concerning the ontological reduction of the mental to the neural. The first thesis seems rather plausible: however localized some or even all mental facts may be, they always involve a large number of neurons, not to speak of blood cells and other non-neuronal components of the nervous system. As for the reducibility thesis, let us discuss it in the light of the stock-in-trade example of the reductionists, namely the alleged reduction of water to water molecules.

The microreductionists claim that water is just H_2O, which in turn they claim to be nothing but an aggregate of two hydrogen atoms and one oxygen atom. This they take to be a paradigm of microreduction. Epistemologically maybe so. (And I hope so, although as a matter of fact there exists no adequate theory of liquids, and *a fortiori* none has been deduced from quantum mechanics.) But the thesis of ontological reduction is obviously false. Indeed, to state that the *composition* of a body of water is a set of H_2O molecules is not to state that the former is nothing but the latter, any more than to say that the composition of a human society is a bunch of persons is to say that a society is nothing more than the set of its members. And this for the following reasons. First, a thing is not a set (which the composition of a thing is). Second, a body of water is a system, hence something with a structure, not only a composition. And that structure includes the hydrogen bonds among H_2O molecules. The result is a system with emergent properties such as fluidity, viscosity, transparency and others, which its molecular components lack. Surely one can (hope to) understand all of these emergent properties in terms of those of the water molecules and their interactions. That is, one can (hope to) 'reduce' the macroscopic properties of water to the properties of its microcomponents. But such an explanation—which has yet to be provided—does not accompany an ontological reduction: explained fluidity is still fluidity. Likewise explained vision is still vision, explained imagination is still imagination, and explained consciousness is still consciousness. Therefore ontological reductionism is just as untenable in the matter of mind as it was found to be in the matter of matter. (Cf. The second section in this commentary.) This leaves us with psychoneural monism of the emergentist kind. Let us take a closer look at it.

EMERGENTIST PSYCHONEURAL MONISM

In this section we shall examine the strengths and the weaknesses of emergentist psychoneural monism, or M5 in Table 1. This view boils down to

Postulate 5. (i) All mental states, events and processes are states of, or events and processes in, the central nervous systems of vertebrates;

(ii) these states, events and processes are emergent relative to those of the cellular components of the CNS;

(iii) the so-called psychophysical relations are interactions between different subsystems of the CNS, or between them and other components of the organism.

The first clause is the thesis of psychoneural monism of the materialist kind. The second clause is the emergence thesis. It states that mental facts are both organismic or biological, i.e. involve entire assemblies of interconnected cells. The third clause is a monistic version of the parallelist and interactionist myths.

If one accepts the above postulate then one can talk about *mental phenomena* without jumping out of the biological level: the mentalistic vocabulary originally coined by religion and dualistic philosophies begins to make, or is hoped to make, neurological sense. (Equivalently: psychology becomes a neuroscience.) In particular it now becomes possible to speak of *parallel sequences* of events, e.g. of processes in the visual system and in the motor system, or in the language system and in the cardiovascular system.

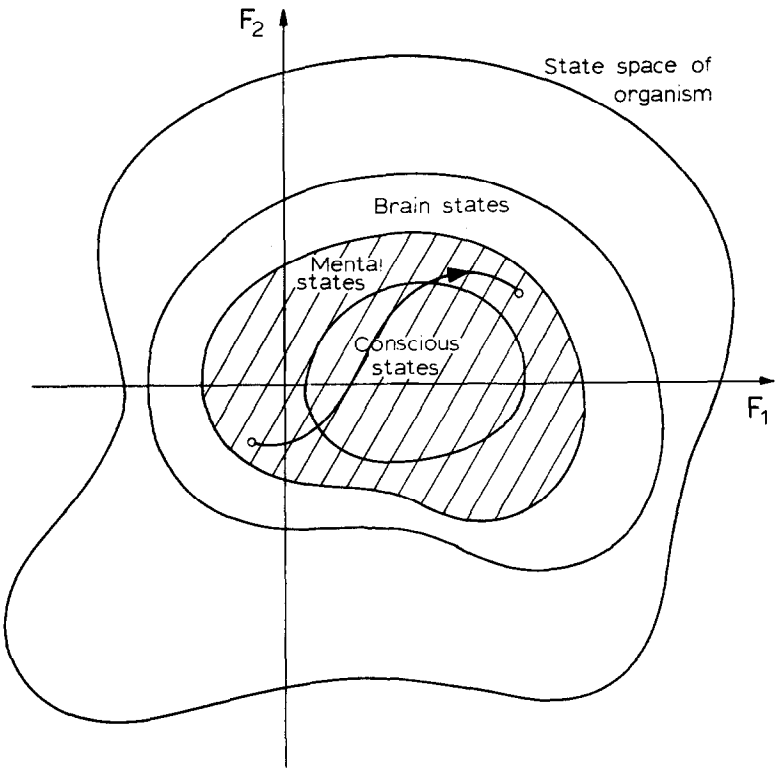

FIG. 3. Mental states form a subset of the collection of all brain states, which in turn are included in the set of possible states of the whole organism. Awareness (or the self) is conjectured to be a distinguished subset of the mental states and therefore a subset of the totality of organic states. The arc of curve represents a mental process, such as recollecting an experience, which is partly conscious. The diagram is programmatic: we still have to identify the properties represented by the blanks F_1 and F_2 in the state function of the CNS.

It also makes good scientific sense to speak of *psychosomatic interactions*, because these are now construed as reciprocal actions between different subsystems of one and the same organism, such as the neocortex and the sympathetic nervous system. For example, rather than say that love can color our reasonings, we may say that the right brain hemisphere affects the left one, and that sex hormones can act upon the cell assemblies that do the thinking. In short, ironic as it may sound, the dualistic modes of speech, which encapsulate our undigested introspective experience and which are but metaphorical and vague in the context of psychoneural dualism, become literal and precise in the context of emergentist materialism. The latter salvages whatever can be salvaged from the dualist myth.

Emergentist monism has many attractive features, the most important of which are that (i) it squares with the natural sciences by postulating that mental facts, far from being affections of an immaterial substance, are states of, or events and processes in, concrete organisms, whence (ii) they can be investigated through the normal procedures of science—a feature which turns psychology into a natural science instead of a supernatural one.

Emergentist materialism holds then splendid promise and moreover has already rendered distinguished service by being the driving force behind physiological psychology. However, it has one important shortcoming, namely that it is still immature. In fact emergentist materialism is not a *theory* proper, i.e. a hypothetical-deductive system containing precisely formulated and detailed hypotheses accounting for a wide range of psychoneural facts. It is instead a *programmatic hypothesis*—one both scientific and philosophical—in search of scientific theories embodying it. So much so that emergentist materialism can be summed up in a single sentence, to wit: *Mental states form a subset (albeit a very distinguished one) of brain states* (which in turn are a subset of the state space of the whole organism). This, however suggestive, is so little as to be representable in simple diagram: see Fig. 3. (Dualism on the other hand cannot be diagrammed at all, except metaphorically, so it is even poorer.)

What is needed for implementing the program of emergentist materialism, i.e. for developing it into a mature scientific enterprise? Obviously, not more undigested data. What we do need are two different though complementary batches of theories: (i) *ex-*

tremely general theories (not just stray hypotheses or programs) of the mental conceived of as a collection of functions of the CNS; and (ii) *specific* theories accounting for the functioning of the various subsystems of the CNS.

The general theories of psychoneural activity would belong to the intersection of ontology and psychology, while the specific theories of the psychoneural would be the exclusive property of physiological psychology. And all of them should be stated in precise terms, i.e. should be mathematical in form.

It may be argued that the preceding plea for intensifying theoretical work in the fields of psychophilosophy and physiopsychology are impertinent because there is no dearth of theories in both fields. Let us see about that.

Certainly, much has been written about the so-called *identity theory* over the past two and a half millenia. But none of the 'theories' of the psychoneural that agree with the materialist hypothesis are *theories* proper, i.e. hypothetical–deductive systems, let alone mathematical ones. They are instead single and stray hypotheses. And they are verbal and often verbose. (This may be one of the reasons that most mathematical psychologists have not been attracted to materialism.) In other words we still do not have a general materialist theory of the mind.

As for specific theories in physiological psychology, there is no doubt that many have been proposed, particularly over the past quarter of a century and largely thanks to Hebb's influence (HEBB 1949; MILNER, 1970; BINDRA, 1976). However, (a) there are too few of them, (b) those which are close to experiment are for the most part verbal, and (c) those which are mathematical are usually far removed from experiment. (Moreover most theories in mathematical psychology are either (a) neobehavioristic learning theories disregarding the CNS or (b) information–theoretic theories regarding the CNS as a computer rather than a biosystem. Both skip chemistry and biology.)

So much for the shortcomings of emergentist materialism in its infancy. However many and grave these may be, the emergentist materialist philosophy of mind seems to be the best we have, and this for the following reasons:

1. Because it eschews the mysterious mental substance without thereby denying the mental, emergentist materialism *is compatible with the scientific approach* far more than either dualism or eliminative and reductive materialism.

2. Emergentist materialism is *free from the fuzziness* that characterizes dualism with its talk of 'correlations' between the mental and the physical relations that dualists do not care to clarify, perhaps because they cannot.

3. Unlike dualism, emergentist materialism is *consistent with the general concepts of state and event* that can be gleaned from all the sciences. (On the other hand according to dualism mental states would be the *only* states that fail to be states of some thing, and mental events would be the *only* events that fail to be changes of state of some thing – this being why dualism agrees more closely with theology than with science.)

4. Unlike dualism, emergentist materialism *fosters interaction between psychology and the other sciences*, in particular neuroscience, and this precisely because it regards mental events as special biological events.

5. Unlike dualism, which digs an unbridgeable chasm between man and beast, emergentist materialism *jibes with evolutionary biology*, which—by exhibiting the gradual development of the mental faculties along certain lineages – refutes the superstition that only Man has been endowed with a mind.

6. Unlike dualism, which postulates an unchanging mind, emergentist materialism *accords with developmental psychology and neurophysiology*, which exhibit the gradual maturation of the brain.

None of the rivals of emergentist materialism can boast of so many and important supports, direct and indirect, scientific and philosophical. Therefore it is worth while to try and implement the program of emergentist materialism, i.e. to attempt to build theories of various degrees of generality, mathematical in form and agreeing with the known facts, that construe the mind as a distinguished subset of the set of neural states and events.

CONCLUSION: PSYCHONEURAL MONISM *CUM* OVERALL PLURALISM

The first half of this paper argues for the reality of emergence and even for the plurality of levels: in fact it sketches a pluralist ontology. The second half defends a version of psychoneural monism. Contradiction? Not at all, for we take the mental to occur only at the organismic level: we assume that neurons are mindless as are populations, in particular, societies. So we assert that organisms endowed with mental abilities constitute a level of their own, which can be called that of psychosystems. But we do not affirm that minds constitute a level of their own—and this simply because there are no disembodied minds. In short, in our ontology minds do not constitute a supraorganic level because they form no level at all.

To repeat the same idea in different words: One can hold that the mind is emergent relative to the physical without reifying the former. That is, one can hold that the mind is not a thing composed of lower level things—let alone a thing composed of no things whatever—but a collection of functions of neuron assemblies, that individual neurons do not possess. (The brain and some of its subsystems can mind i.e. be in mental states—but the mind cannot mind even its own business because it has no more an independent existence than does mass alongside bodies or history separately from people. Only the functioning—minding—brain can mind its business.) And so emergentist materialism is seen to be compatible with overall pluralism.

Our espousing emergentist materialism does not require affirming that it has in fact solved the mind–body problem. It has not. But it is working on it: witness the progress of physiological psychology. Moreover we submit that emergentist materialism is the only philosophy of mind that enables a breakthrough in the scientific investigation of the mind–body (or rather brain–rest-of-the-body) problem. In fact it is the only one that enjoys the support of all the life sciences, that does not promote a quixotic reductionism, and that defends neuroscience against obstruction by obsolete philosophies and ideologies.

Finally, three caveats are in order. The first is that to espouse emergentist materialism is not to deny subjective experience or even to disallow employing introspection as a tool in the scientific investigation of the mental. To espouse emergentist materialism is to favor the understanding of subjectivity in neural terms, and to encourage the control of subjectivity instead of allowing the latter to control the course of research. (In particular, hunches got by introspection must be regarded not as self-evident but as hypotheses to be subjected to objective tests.)

Second caveat: Emergentist materialism does not require one to investigate the mental in exactly the same way as one would investigate earthquakes or infections. Indeed the psychologist is the luckiest of scientists in that he can tap a number of sources: he can learn from neurophysiology as it deals with the levels of the neuronal circuit, the brain subsystem (e.g. the brain stem), and the entire CNS; he can learn from introspection and the study of behavior, from neurosurgery and psychiatry, from comparative zoology and the study of cultures. He can command, then, many sources of hypotheses and data and just as many ways of checking his hypotheses. In this regard, then, the study of the psyche is unique. (It is not unique in its being subject to the standard canons of scientific research.)

Third and last caveat: To explain the mental in terms of the neural is not to rule out that the mental is a set of emergent functions of the brain, any more than explaining the formation of a liquid vortex rules out that it possesses properties beyond the properties of the individual atoms that take part in it. In other words, the ideal of rationality is consistent with pluralism: to explain is not necessarily to explain away. Besides, the explanation of emergence is anything but straightforward: it is a matter not of deducing consequences from a theory concerning some lower level, but of suitably enriching the latter with new assumptions and data. Thus the theory of neurons does not entail the theory of neuronal circuits, nor does the latter entail the theory of the reticular formation, and so on. (For the logic of reduction see BUNGE, 1977*b*.) A psychophysiological theory, though concerned with some of the physical or chemical processes in the CNS, deals not just with them but also with a distinguished subset of biological processes going on in neural assemblies, namely those processes that are commonly called mental. To explain the mind in depth is to know it, not to ignore it. And to know something is to have adequate theories about it.

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