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6 Mental Phenomena as Causal Determinants in Brain Function

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The central concepts concerning consciousness that I shall try to defend have already been presented in some detail (Sperry, 1952, 1964, 1965). Accordingly, I shall review them only in brief outline, devoting the bulk of the discussion to various peripheral aspects and implications that previously have had less emphasis. At the outset let me make it clear that when I refer to consciousness I mean that kind of experience that is lost when one faints or sinks into a coma. It is the subjective experience that is lacking during dreamless sleep, that may be obliterated by a blow on the head, by anoxia, or by pressure on the inner walls of the third ventricle during brain surgery. On the positive side we can include as conscious events the various sensations elicitable by a local electric current applied to the unanesthetized brain, or the pain of a phantom amputated limb, as well as most of our waking subjective experience, including self-consciousness.

I want to emphasize, however, that I shall not be concerned particularly with *self*-consciousness any more than with the conscious-

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ness of other selves, or with that of external objects, situations and events; *self*-consciousness is a separate story in itself. Nor shall I be trying to define different forms of consciousness, nor intermediate states between full awareness and the *sub*conscious or the *un*conscious. My arguments can all be referred to some clearly accepted and simple example of conscious experience, like seeing red, or hearing a musical tone, or feeling pain. The problem is difficult enough in its simplest and clearest formulation without introducing the confusion of borderline states. I assume that, if we can find an answer to the mind–brain problem in its simplest form, we shall then be able to apply the basic concepts to its more complex aspects.

For the sake of further clarification, let me specify that I shall address myself throughout to the problem of the nature of consciousness and the mind–brain relation as it presents *in other people's brains* primarily, rather than in my own brain. This, it is hoped, will avoid various logical entanglements that otherwise arise. This starting move is based, of course, on the assumption that other people's brains do have consciousness much like my own. Those who are not willing to accept this assumption have, I suspect, a separate problem all their own. I am not trying by this step to avoid entirely questions concerning the privacy of conscious experience. A number of different approaches to this important privacy, or first-person, property of consciousness are recognized, and I will try to outline later, in context, the explanation to which my own position leads.

Perhaps the quickest way to center in on our current interpretation is to compare it broadly with others. We can start by saying that ours does not belong among positions based on dualism, epiphenomenalism, or other parallelisms. We can bypass as well the radical behaviorist refusal to consider the problem, and various sophistries and epistemological gymnastics that would make it just a pseudoproblem or explain it away as unimportant or nonexistent. We can also bypass the traditional materialism of the hard-core reductionistic and dialectic varieties. Our position does not accord either with the interpretation of subjective experience as just an inner aspect of the one material brain process. It is further distinguishable from the so-called "identity theory," that version of materialism which holds that mental phenomena are *identical* with the neural events. This view does not correlate consciousness with language particularly. Finally, it is in disagreement with the position known as panpsychism in which rocks and trees and all things in the universe are held to possess consciousness of some sort.

AN EMERGENT THEORY

On the positive side our present view can be classified broadly as an "emergent" theory of mind that needs to be distinguished from other emergent theories advanced previously, mainly by the Gestalt school in psychology. It differs from these in several respects: first, the phenomena of subjective experience are not thought to be derived from electrical field forces or volume-conduction effects, or any metaneuronal by-product of cerebral activity. Our view relies on orthodox neural-circuit and related physiological properties (Sperry, 1952; 1953; Sperry & Miner, 1955). Second, there is no assumption of the need for an isomorphic or topological correspondence between the events of perceptual experience and corresponding events in the brain. I have conceived the mental properties to be *functional* derivatives that get their meaning from the way in which the brain circuits and related processes operate and interact, rather than in terms of isomorphic correlations (Sperry, 1952). Reference to "spatiotemporal patterning" of brain activity is safe as far as it goes, but this term fails to connote the operational derivation of the conscious properties that I have tried to emphasize. Third, the conscious subjective properties in our present view are interpreted to have causal potency in regulating the course of brain events; that is, the mental forces or properties exert a regulative control influence in brain physiology. The subjective conscious experience on these terms becomes an integral part of the brain process, rather than a correlated phenomenon as conceived by Köhler (Köhler and Held, 1949) and others. The mental events are *causes* rather than *correlates*. In this respect our view can be said to involve a form of mental interactionism, except that there is no implication of dualism or other parallelism in the traditional sense. The mental forces are direct causal emergents of the brain process.

When I initially stated this view in 1965 one had to search a long way in philosophy, and especially in science, to find anyone who would put into writing that mental forces or events are capable of causing physical changes in an organism's behavior or its neurophysiology. With rare exceptions writings in behavioral science dealing with perception, imagery, emotion, cognition, and various other mental phenomena were very cautiously phrased to conform with prevailing materialist–behaviorist doctrine. Care was taken to be sure that the subjective phenomena should not be implied to be more than passive correlates or inner aspects of brain events, and especially to avoid any implication that the mental phenomena might interact causally with the

physical brain process. Those few who did subscribe earlier to the theory of psychophysical interaction were such extreme dualists that little heed was paid them in behavioral science. Once we could show how mental events can causally influence neural events in a compromise formulation that does not violate the principles of scientific explanation, the long-standing resistance to mental–physical interaction began to decline. It is only since then that mental imagery, for example, has been able to gain popular acceptance as an explanatory construct. Today it becomes increasingly difficult to differentiate some of the closely related positions on these matters, and one must go back to the "pre-'65" versions in order to make clear distinctions.

COMPARISON WITH IDENTITY THEORY

Our "emergent interactionist" position was described as a compromise between dualistic mentalism and pre-'65 materialism, indicating that it would not be difficult to stretch either mentalism or materialism, including identity theory, to encompass the emergent interpretation. I say this despite the declaration of Feigl (1967) that,

> If future scientific research should lead to the adoption of one or another form of emergentism (or—horrible dictu!—dualistic interactionism), then most of my reflections will be reduced to the status of a logical (I hope not illogical!) exercise within the frame of an untenable presupposition.

I was unable to find in pre-'65 identity theory anything to distinguish the conscious from the many nonconscious properties that seem to comprise the subsystems of any given neural event, nor did I find a distinction between neural events that involve consciousness and those that lack consciousness, as in the cerebellum or spinal cord. In general the term "neural events," as this term had been used thus far in science and philosophy, hardly included the holistic conscious properties that I think of as the mental properties of the brain process. These special mental properties have not been described objectively as yet in any form. They are holistic configurational properties that have yet to be discovered. We predict that, once they have been discovered and understood, they will be best conceived of as being different from and more than the neural events of which they are composed.

In our own view, colors, sounds, sights, taste, smell, pain, and all the other phenomena of the world of inner mental experience are given due recognition as phenomena in their own right. Rather than being identical to the neural events, as is generally understood, they are emergents of these events. To say that the mental experience is identical to the brain process is analogous, in our interpretation, to saying that the physiological brain process is itself identical to the chemical events that compose it, or that these chemical events are in turn identical to their atomistic and electron–proton events, etc. It is like saying that the upcoming ninth wave at Laguna is nothing but another uplift and fall of H_2O and other molecules.

I take the stand that wholes and their properties are real phenomena, and that these and their causal potency are just as important as the properties of the parts to which the reductionist position likes to give prior, or even sole, recognition. This is to say, that the relationships of the parts to each other in time and space are of critical importance in causation and in determining the nature and properties of all entities. It is a pragmatic interpretation of what is real and meaningful.

In trying to see that the pattern properties are just as real and important as are the properties of the parts, it may help to recognize that the properties of the parts are themselves in turn holistic properties of subsystems at a different level. The reductionist approach that would always explain the whole in terms of the parts leads to an infinite regress in which eventually everything is held to be explainable in terms of essentially nothing. Let me repeat that the thing to remember in this connection is that, in the causal interplay between systems and their surroundings, the spatial and the temporal relationships of the constituent parts of a system have in themselves important causal efficacy over and above the properties of the parts *per se*.

Even a pile of stones (Wimsatt, 1971) will be a very different entity with very different properties depending on how the given set of stones happens to be piled together. When hit by a car or jiggled by an earthquake, different patterns of the whole may exhibit properties that supersede those of the parts in determining the causal consequences. There is no way in which the relationships of the parts in space and time for any given entity can be reduced to the properties of the parts alone.

A SIMPLE APPROACH

The way in which mental phenomena are conceived to control the brain's physiology can be understood very simply in terms of the

chain of command in the brain's hierarchy of causal controls (Sperry, 1965). It is easy to see that the forces operating at subatomic and subnuclear levels within brain cells are molecule-bound, and are superseded by the encompassing configurational properties of the brain molecules in which the subatomic elements are embedded; that is, the nuclear and other subatomic elements are pushed and hauled about in chemical interactions by the enveloping molecular properties. In the same way the properties of the brain molecules are enveloped by the dynamics of cellular organization, and the properties of the brain cells are in turn superseded by the larger network properties of the circuit systems in which they are embedded.

At the apex of the brain's organizational hierarchy are found the large cerebral processes that mediate mental activity. These large cerebral events as entities have their own dynamics and associated properties that causally determine their interactions. These top-level systems' properties supersede those of the various subsystems they embody.

Only *some* of the dynamic holistic properties that emerge in the higher levels of cerebral activity are conscious phenomena. Many others are not, even though the unconscious activities may in some cases be equally or more complex. Complexity alone is not, in our scheme, the source of the conscious qualities (Sperry, 1966). It is the operational function rather than the complexity of any given cerebral process that determines its conscious effect.

In this respect my interpretation differs from that of Teilhard de Chardin (1959). Consciousness in my view is strictly a property of brain circuits specifically designed to produce the particular conscious effects obtained from different brain regions. On these terms I see no way in which the consciousness of individuals could become coalesced into a megaconscious experience of humanity as a whole, nor any way in which the consciousness of one brain could influence that of another by a metaphysical route.

As is the case for most, or all, part–whole relationships, a mutual interdependence is recognized to exist between the neural events and the emergent mental phenomena. In other words, the brain physiology determines the mental effects and the mental phenomena in turn have causal influence on the neurophysiology. The interjection of subjective mental experience into the causal sequence of decision making on these terms brings a compromise, not only between materialism and mentalism, but also between the positions of determinism and free will. Determinism of this kind, in which subjective experience is included as a causal agent in brain function, allows degrees of freedom in

any voluntary choice far above that envisaged in traditional materialism or atomistic determinism.

I have tried to tie these general principles to the example of subjective pain as it is referred to an amputated limb (Sperry, 1965). For present purposes let us make it more specifically the pain of a phantom left foot that is produced by stimulation of a sore toe in the opposite hindfoot in one of our experimental "sensory nerve cross" rats. These are rats in which the right hindfoot has become reinnervated by foreign nerves that originally had supplied the left foot (Sperry, 1943). The switch in nerve connections from left to right foot is brought about by surgical cross-union of the sciatic nerve and its branches from left to right leg in the fourth week after birth as a test of central nervous plasticity and the functional interchangeability of nerve connections. Occasionally the animals will "instinctively" chew off the denervated insensitive foot on the left, and there is also a tendency for cutaneous trophic sores to develop in the right foot while it is being reinnervated. Such a sore on the right foot heals very slowly, despite antibiotics, because these rats walk around on three legs protectively holding up the wrong foot from which the pain seems to come and thereby putting additional pressure and trauma on the sore right foot. Occasionally, as the result of an extra-hard impact or abrasion to the right foot, the rat may yip or squeak and will turn to lick, not at the sore right foot, but at the uninjured left foot when it is there, or otherwise at the amputation stump.

I choose this example to emphasize, among other things, my assumption that conscious experience is not restricted to the human species. Self-consciousness is another matter, of course, and may well be limited mainly to man with some beginnings in the higher subhuman forms. The experimental rat's false reference of pain to the amputated left foot persists throughout life, and this example thus serves to reinforce our view that the basic circuit properties responsible for conscious experience are largely determined genetically (Sperry, 1969). They may have evolved initially around sensory functions and/or around a primitive awareness with positive and negative reinforcement functions.

The main point to be brought out with this example is the contention that the animal's responses in protectively holding up the wrong foot and in yipping and licking the wrong foot are caused directly in brain function by the subjective pain property itself, rather than by the physiology of the nerve impulses or by the chemical, atomistic, or other subunit features of the brain process. The pain sensation is considered to be a real emergent phenomenon in itself.

Although built of neural events, and possibly of glial events as well, the pain sensation as a larger whole is not itself the same as the constituent neural and glial events. Nor is the subjective pain to be viewed as a mere parallel correlate of the brain process. Rather, I look upon it as a real dynamic entity in the brain activity that has an important causal role as a phenomenon itself in the stimulus–response sequence. In other words, a full objective account of the whole stimulus–response process would not be complete without including the pain as such. Although our neurophysiology is not yet sufficiently advanced to give an adequate description of the neural composition of the pain phenomenon, or of other conscious events, one assumes that this will be possible eventually as our knowledge of brain mechanisms continues to advance.

THE BISECTED BRAIN AND UNITY OF CONSCIOUSNESS

Philosophy has been concerned with the "unity of consciousness" in connection with problems relating to the nature of the self, the person, and personal identity. In our "split-brain" studies of the past two decades (Sperry, 1961, 1966, 1968, 1970*a*, 1973), the surgically separated hemispheres of animals and man have been shown to perceive, learn, and remember independently, each hemisphere evidently cut off from the conscious experience of the other. In man the language-dominant hemisphere further reports verbally that it is not consciously aware of the concomitant or immediately preceding mental performances of the disconnected partner hemisphere. These test performances of which the speaking hemisphere remains unaware obviously involve perception, comprehension, and in some cases nonverbal memory, reasoning, and concept formation of different kinds depending on the nature of the test task. In these and in many other respects, the split-brain animal and man behave as if each of the separated hemispheres had a mind of its own.

This division by surgery of the normally unified realm of conscious awareness into two distinct domains of conscious experience that exist in parallel, and in some cases have content that is mutually contradictory, has been subject to several different philosophical interpretations. One line of reasoning concludes that each hemisphere of the brain must have a mind of its own, not only after surgery but also in the normal intact state as well; that is, the normal individual is interpreted to be a compound of two persons, one based in each

hemisphere (Bogen, 1969; Puccetti, 1973). A contrasting interpretation says that only one, the language-dominant hemisphere, remains conscious (Eccles, 1970), and thus the unity of consciousness is preserved. It is inferred that the disconnected minor hemisphere operates like an automaton or complex computer. Another view holds that consciousness is not centered in either right or left hemisphere, but in some unified metaorganizing system (MacKay, 1966), presumably in the intact brain stem. There are additional variations on these main themes (Nagel, 1971).

The state of our progress in understanding the nature of consciousness is nicely illustrated in the diversity of positions seriously supported here and currently among our colleagues. At least one of our conferees (like Whitehead, Waddington, and others) maintains that rocks have consciousness (Globus, 1973). In other words, panpsychism still lives! At the other extreme, another of our members would deny conscious experience, not only to rocks and plants, but even to the minor hemisphere of the human brain (Eccles, 1970). Others claim that each of us in the normal state operates with two distinct right and left domains of conscious awareness.

My own inclination is to see consciousness as being unified in the normal brain but largely divided in the bisected brain, depending on the depth and extent of the surgery, and depending also on the nature and level of the particular conscious process in question. I would credit the neocommissures with a unifying role in conscious activity under normal conditions that in effect serves to tie the conscious function of the hemispheres together across the midline into a single unified process. The callosal activity thus becomes part of the conscious event. The fiber systems uniting right and left hemispheres are viewed as being not essentially different in their relation to consciousness from those uniting front and back or other areas within the same hemisphere. I know of no evidence as yet that says we must exclude white-matter neural events from consciousness, or, in other words, that conscious effects are confined to grey-matter dynamics. This interpretation does not exclude the possibility that the conscious processes in left and right hemispheres may function separately in the undivided brain under exceptional conditions, and particularly where pathology tends to depress commissural function.

Surgical separation of the hemispheres, especially the deeper bisections we perform in animals, I have interpreted as resulting in the creation of two distinct domains of consciousness. This says nothing about *self*-consciousness. It remains to be determined how much, if any, self-consciousness is present in the disconnected minor hemi-

components with, other brain processes that do not reach conscious awareness. The holistic properties are not to be conceived in simple spatial, volume, or dimension terms but rather in terms of nerve-network and cerebral-circuit interactions, the emergent dynamics of which have yet to be elucidated, especially for the upper, conscious levels of brain function.

Normally, with the neocommissures intact, neural events in right and left upper arms of our schematized Y substrate of consciousness become merged into a unified conscious brain process. The criterion for unity is an operational one; that is, the right and left components, coalesced through commissural communication, function in brain dynamics as a unit. This is illustrated in the unified visual perception of a stimulus figure flashed tachistoscopically half in the left and half in the right visual half-fields. In the normal brain the right and left hemispheric components combine and function as a unit in the causal sequence of cerebral control. In the divided brain, on the other hand, each hemispheric component gets its own separate causal effect as a distinct entity.

PRIVACY OF SUBJECTIVE EXPERIENCE

The objective description of pain or of other conscious phenomena is not expected to be the same as the subjective description. The reason, however, that an observer's understanding and description of another's subjective experience differs from the subjective experience itself is not so much because this involves a second-order representation of a representation (Globus, 1973), but for a more basic reason involving the nature of the causal relationships involved. The conscious subjective qualities, as I conceive them, derive from the selective operational interactions of brain events in a matrix of brain activity (Sperry, 1952, 1969). The only way an observer brain would be able to interact with and thereby experience the subjective qualities of another brain would be through an intimate communication into the interior of the observed brain that would enable it to react to the internal operational effects and internal relations of the observed brain. An observer relation is not enough; the second brain must be in an intimately involved relation with the internal operations of the first brain. Reasoning from our split-brain findings in animals and human patients, I have used the example of a corpus-callosum-type of intercommunication system in this connection (Sperry, 1969) to illustrate the kind of interaction that is required.

Just as it is possible to describe and understand the workings of an internal-combustion engine without being directly involved in the internal explosions, temperatures, and pressures, so it should be possible in principle to describe and understand in objective terms the phenomena of subjective experience. These descriptions are not yet, however, available. Essentially I was only predicting that, when these objective descriptions are eventually achieved, they will be found to be expressible in terms of emergent holistic properties of high-order cerebral processes, and further that these emergent phenomena will be seen to play a potent causal role in brain function that cannot be accounted for in terms merely of the neurophysiologic and neurochemical events as these are traditionally conceived.

In arriving at an objective understanding of the mental phenomena it will be helpful to keep the subjective qualities in mind and not be misled into thinking of these emergents of neural events as being "nothing but" or "identical to" the neural events themselves. A neural event, or, preferably, a brain event or brain process, is many things: it includes the physiology of nerve-impulse traffic, the underlying chemistry, plus all sorts of subatomic low- and high-energy physical phenomena. While these may be the stuff of neural events, they are not, as I see it, the conscious phenomena. The latter are distinct causal properties that emerge only at upper levels of the brain hierarchy and with certain special types of cerebral events, unique as far as we know and yet to be discovered—hardly to be identified with what has heretofore been termed the neural events.

Although it is not difficult, as indicated (Sperry, 1970*b*), to stretch the materialist or mentalist approaches of 10 years ago to incorporate these emergent interaction concepts, it is important to recognize the various differences involved. These differences have important consequences in other areas of philosophy that deal with determinism and free will (Sperry, 1964, 1965), with the concept of causation (Pols, 1971), and with the whole field of human values and the relation of scientific explanation to value judgment (Sperry, 1972). Value theory has been rather neglected in philosophy of late but could take on new importance on our present terms, especially in view of the critical significance of human value priorities in the context of mounting crisis problems.

Our interpretation of the phenomena of inner experience as causal control agents in cerebral function yields a picture of scientific determinism somewhat different from either the materialist or mentalist views. Introduction of mental phenomena into the causal sequence of brain function means, among other things, that values of all kinds, even aesthetic, spiritual and irrational, must now be recognized as

positive causal factors in human decision making—as must all other components of the world of inner subjective experience. The degrees and kinds of freedom thereby introduced into the causal sequence of volitional choice can be seen to set the human brain apart, by comparison, above all other known systems, at an apex post in the deterministic universe of science. Considered broadly, our present interpretation goes far to restore to human nature the personal dignity, freedom of choice, inner creativity, and other humanistic attributes of which it has long been deprived by the behavioristic and materialistic movement in the brain-behavior sciences. By uniting the subjective mental phenomena with the objective cerebral events within a single monistic continuum in the brain, it serves also to bridge in principle the long standing gap between science and the humanities.

Our current interpretation leads to a unifying concept of mind, brain, and man in nature and points to a "this world" framework for human values—a framework within which science can operate. Subjective values become objective causal agents operating in the physical brain, and through the brain onto the surrounding world. As the brain process comes to be understood objectively, all mental phenomena, including the generation of values, can be treated as objective causal agents in human decision making. The origins, directive potency, and the consequences of values all become amenable, in principle, to objective scientific investigation and analysis. This applies at all levels, from that of the pleasure–pain centers and other reinforcement systems of the brain on up through the forces that mold priorities at the societal, national, and international plane. A separate science of values becomes theoretically feasible, and a matter of top priority today considering the critical control role played by the human value factor in determining world crisis conditions.

Some of the main implications can be seen to derive from the fact that conscious experience in this view is given an operational causal role in objective models of cerebral function, and thus a reason for being and for having been evolved. This is not true for the materialistic or various parallelistic interpretations in which the brain would function just as well in terms of the neural events whether or not neural events had subjective properties.

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