Response

CAN NEUROSCIENCE PROVIDE A COMPLETE ACCOUNT OF HUMAN NATURE?: A REPLY TO ROGER SPERRY

by James W. Jones

Abstract. In a recent *Zygon* article (June 1991), Roger Sperry argues for the unification of science and religion based on the principle of emergent causation within the central nervous system. After illustrating Sperry's position with some current experiments, I suggest that his conclusions exceed his argument and the findings of contemporary neuroscience and propose instead a pluralistic, rather than unified, approach to the relations between religion and science necessitated by the incompleteness inherent in any strictly neurological account of human nature.

Keywords: human nature; mind-brain relationship; philosophy of mind; religion and science.

In a recent and significant essay in *Zygon,* Roger Sperry (1991) joins other neuroscientists who embraced a reductionistic understanding of the mind-brain relationship at the start of their careers and later repudiated it as incompatible with the findings of their science. Karl Lashley devoted his life to searching for the specific location of discrete memories and, failing to find them, concluded that memory is a property of the entire cortical system (1950). Sir Charles Sherrington, Wilder Penfield, and Sir John Eccles, after studying neurology from a reductionistic paradigm, became convinced dualists. In a similar spirit, Sperry writes, "I have come around almost full circle today to reject the type of truth science traditionally stood for, along with its dominant central tenet that everything in our universe, including the human psyche, can be accounted for

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[*Zygon,* vol. 27, no. 2 (June 1992).]
 ISSN 0591-2385

in terms entirely physical—that science has absolutely no need for recourse to conscious mental or spiritual forces" (1991, 238).

ROGER SPERRY'S VISION

The spiritual forces of which Sperry speaks ("mind, spirit, beliefs, values") emerge out of the higher levels of neurological organization which have evolved in the human brain, appearing "in the causal chain of brain activity at upper (i.e., cognitive) levels of brain processing in the form of irreducible emergent properties . . . [which] interact on a holistic, 'functionalist,' basis at their own cognitive level in brain integration" (1991, 243).

This is possible because organizations develop properties that their individual components lack. A sentence is made up of words and words made up of letters, but a sentence is more than a loose collection of letters. A sentence requires a certain kind of organization and a reader. Also, rules governing the construction, decoding, and translating of sentences cannot be reduced to rules for individual letters. In thermodynamics, statements about temperature can never, without loss of information, be translated into statements about molecular motion: aggregates display temperature; individual molecules do not. Likewise, the brain as a system displays properties beyond those of individual neurons.

The brain does this without requiring any additional components beyond the mechanisms of neural anatomy and physiology. While colleagues like Penfield and Eccles embrace dualism, Sperry rejects "dualistic supernatural beliefs such as unembodied minds or spirits" (1991, 242). The behavior of a collection of elements can be governed by the relationships among the elements rather than the parts in isolation. The idea that the behavior of an ensemble may derive from its organization removes the need to find a single, direct cause for every event and also the need to posit some nonphysical force as the cause of the system's behavior. Sperry maintains that human beings are creatures of biology and chemistry while agreeing with Penfield and Eccles on the reality of consciousness and choice (phenomena which an earlier reductionism treated as illusory since they could not be found in the cerebral hardware). But Sperry locates their reality in properties which arise out of neural organization rather than in some nonphysical realm, for the mind-brain system is "governed by novel emergent properties of its own as a whole" (1991, 246).

Primary among these emergent properties is the active agency of consciousness which "must causally program the patterns of neuronal firing" (1991, 244). Subjectivity, then, is "no longer a mere impotent epiphenomenon of brain activity. It becomes a powerful impelling force in its own right" (1991, 239). Consciousness can no longer be treated as simply the result of more primary physical processes. Subjective states have become causal agents which can influence as well as be influenced by the material world. "The shift from a noncausal to a causal view of consciousness [asserts] that subjective awareness counts and makes a real difference in the physical world" (1991, 239). Conscious agency emerges out of neuronal organization and then exercises control over it.

This emergent power of consciousness demands a revised model of causality which "combines traditional bottom-up with emergent top-down causation in a 'reciprocal' or 'doubly determinate' form of hierarchic control" (1991, 243). In this reciprocal determinism, conscious choices "exert a concomitant supervenient form of downward control over their constituent neurocellular activities" (1991, 243).

What was formerly viewed as incompatible is now reconciled as the model of reciprocal ("top-down" and "bottom-up") causality and brings together the subjective reality of consciousness with the findings of physical science. "The new holistic emergent downward-control reasoning provided a legitimate, rationally sound way to circumvent the logic of conventional microchain causation without violating the empiric principles of science" (1991, 244).

A revised model of causation carries with it a vision of human nature which, according to Sperry, combines the most important features of previous religious and scientific theories.

> The shift of mental qualities from noncausal to a causal status demanded basic revisions in our prior materialist/behaviorist convictions. Brain function could no longer be thought to be fully explainable in terms of its chemistry or molecular biology. The higher organizational network properties must also be included as irreducible control agents. Instead of excluding mind and spirit, this view retains all the rich subjective qualities as integral and ineliminable functional agents—not, of course, in any disembodied, free floating, or ethereal form but as wholistic properties in upper-level brain processing. The long-banned subjective states and qualities are put up front—in the driver's seat as it were—as a crowning achievement of evolution. (1991, 244)

Beyond articulating a new scientific paradigm, Sperry emphasizes the importance of values and beliefs. The existence of "top-down causality" means that "the subjective value-belief system of the brain (is) a powerful intrinsic force that, above any other, shapes human culture" (1991, 238). Choice matters! And so do the values and beliefs on which those choices are made. Much of his article is taken up with arguing for a new, "holistic" ethic derived from science and applicable to the momentous decisions we face as a species.

Ethics, Sperry's overriding focus in his article, will not be my main concern here. Rather I will concentrate on the religious and philosophical aspects of Sperry's position, for that is where his conclusions seem most to exceed his argument and the findings of contemporary neuroscience. Sperry is proposing a grand vision which overcomes the historic conflict between religion and science and provides a complete account of human nature and its place in the cosmos. Emergent causation means that "incompatible objective-vs.-subjective frameworks of the past are reconciled in a unifying, intermediate position that departs from previously accepted philosophic dichotomies. . . . Features from both sides of the old dichotomy—the mental and the physical, fact and value, subjective and objective, freedom and determinism—are blended, without contradiction, within a single, consistent worldview synthesis" (1991, 242).

Sperry has clearly and powerfully expressed the ways in which current neuroscientific findings push us past the reductive materialism of prior physical science. But has he, or can he, provide such a unified vision on the basis of neuroscience alone?

Crucial Experiments

In this article Sperry states his position but does not elaborate on its foundation in contemporary research. To fill out the argument and provide a basis for my position, I want to briefly review three areas of study which bear directly on the relationship between consciousness and the brain. Any discussion of this issue must incorporate them in some way.

Biofeedback and Self-regulation. A quick survey of the literature on biofeedback and self-regulation reveals that by forming mental images, people can learn to develop conscious control over the following: the functioning of their central nervous system by regulating their own brain waves; their peripheral nervous system by changing their heartbeat and respiration rates; the mediation of conscious experience by overruling their pain centers; physiological functioning by, for example, raising and lowering their levels of white blood cells (Basmajian 1980; Green and Green 1977).

Clearly the body, especially the brain, influences the mind—a blow to the head certainly affects consciousness. But it is equally true that the mind controls the body. And it is far from clear how a purely internal, mental action—like forming an image in the mind—can affect brain functioning or physiological activities. Such images bear no structural similarity to the affected physiological processes: I once taught a youngster to control the pain in his arm by imagining his mind as the control room of a spaceship with dials and switches and picturing himself turning down the dial connected to the pain.

Biofeedback results illustrate Sperry's "principle of emergent causation" (1991, 245) by which the mind influences the body as much as the body regulates the mind: by a purely mental act, such as producing an image, a person can control cerebral and peripheral physiology. (For an accessible review of the clinical literature on the use of mental imagery, see Jaffe 1980; also Green 1984.)

Penfield. An early explorer and mapper of the brain, the neurosurgeon Wilder Penfield carried out extensive electric stimulation experiments in which he discovered that patients could relive, and not just remember, earlier experiences. He also discovered that electric stimulation could cause, say, the patient's arm to move but that patients who were fully conscious on the operating table while their brains were being touched by the electrode would report, "You did that, I didn't," as their arm lifted.

How could that be explained? The person was not only aware of the movement of the arm but also that they had not willed that movement. A part of the person appeared to stand outside watching. Try as he might, Penfield could not find any place where electric stimulation produced this experience of self-awareness; no local electric contact could result in the sensations of will, choice, or self-reflection. Such experiences may be tethered to the brain, but if so, they are linked in a different way than those which can be directly accessed by activating the brain. The mind-brain system appears organized in a hierarchical way in which there is direct action (moving the arm) and awareness of the action (noticing my arm is moving) and also awareness of the awareness (this is not my act but yours). The first two are directly linked to neurônal activity; Penfield's findings suggest that the third may not be.

In his book *The Mystery of the Mind* (1975), Penfield reflects on these results. He began his work in neurology insisting on the reduction of the mind to the brain. But as the consequence of these findings, Penfield ended his career insisting that the person is composed of two elements—a physical brain and a nonphysical, self-aware mind. The relation between them is like the computer and the programmer. The programmer can only express himself through the computer, but he exists independently of the machine. Likewise with the mind and the brain.

Kornhuber and Libet. Penfield's early electric stimulation protocol has been extended with some interesting results. H. H. Kornhuber had subjects arbitrarily, randomly move their finger while connected to an E.E.G. All external stimulation was removed. The E.E.G. revealed a gradual buildup of electric activity in the brain that occurs before the finger moves. Kornhuber calls this a "readiness potential." This readiness potential starts developing all over the brain and gradually intensifies onto the motor cortex before the finger moves. There is no clearly detectable antecedent to this diffuse readiness potential—although perhaps better instrumentation would find one. As of now, there is no single neuronal "cause" for even the simple act of moving a finger, but rather the whole brain begins to mobilize itself prior to the action. The question of what "causes" that mobilization remains unanswered (Kornhuber's research is reviewed in Popper and Eccles 1977).

The question of neuronal causation is even more confounded by Benjamin Libet's research. Libet found that if the appropriate somatosensory cortex is electrically stimulated, the subject reports feeling a pain in the hand on the opposite side of the body. A single, quick stimulation to the brain produces no felt sensation. Half a second of stimulation to the brain is required for the subject to feel a sensation (which is felt in the hand, not in the brain); below that threshold of electric activity in the brain nothing is felt (Libet 1967).

However, if the skin on the finger is stimulated, one very weak stimulation produces a conscious sensation. In an elaborate series of experiments that involved stimulating the skin and the cortex in a variety of sequences, Libet established that a single electric impulse applied to the skin does not produce enough electric activity to cross the threshold required for conscious experience, yet there is a conscious sensation. Also, stimulating the cortex requires a 0.5 second delay before there is any sensation, but stimulating the skin produces an immediate response.

Any simple cause-effect relation between neuronal activity and consciousness is called into question. Causality requires temporality. Yet here is the "effect" (conscious awareness) happening before the postulated "cause" (sufficient neuronal activity). Libet proposes that with the onset of sufficient cortical activity, the brain projects the sensation backward 0.5 seconds to the moment of stimulation; there is no known neuronal mechanism, however, that produces such effects.

Libet's research depends on the assumption that cortical stimulation produces the same neuronal and experiential effects as peripheral stimulation, and so comparisons are possible and the subject's reports of timing and sequence are reasonably reliable. Both of these assumptions are not beyond challenge (Churchland 1981), although they are often employed in neurophysiological research (reviewed by Libet 1981).

Perhaps Libet's theory of temporal displacement is part of the larger problem of how inputs from the nervous system are converted into conscious experience (a suggestion Libet himself makes, 1981). For example, in the area of visual processing, a series of discrete still pictures is converted into a continual moving picture, and a flat configuration of neurons is transformed into a three-dimensional visual image. While the various brain centers connected with this process are currently being mapped, the actual process by which neuronal firing becomes conscious experience is far from understood.

Clearly these three sets of findings support Sperry's rejection of the earlier ("bottom-up") reductionism which hoped to find a specific neuronal event as the direct cause of every thought or mental act and to translate statements about thoughts completely into statements about neuronal activity (Maranto 1984). They are also compatible with a dualist position, a fact which Eccles, Popper, Penfield, and other advocates of this position are quick to point out. Eccles (Popper and Eccles 1977, 364–65) argues that Libet's (and Kornhuber's) results support a dualistic position and the existence of a semi-autonomous mind which becomes aware of the stimuli immediately. But Eccles invokes the "mind" as a *deus ex machina* which can explain whatever gaps occur in current neurological research (a critique of Eccles's arguments for dualism can be found in Dennett 1979).

Douglas Hofstadter and Daniel Dennett (1981) agree with Sperry that the mind-brain is a unified system; they, too, speak of "reciprocal determinism" and "top-down/bottom-up causality" (1981, 197). For Hofstadter and Dennett the basic unit of understanding is neither ideas nor neurons but states of a system. Thoughts, feelings, images are parts of the same system as neuronal firings and the movement of neurotransmitters are; no one part causes the other in some linear way; rather, all occur together as part of a unified process. The state of the system changes, a neuron fires, a thought or image occurs, and, most likely, a behavior happens. These are not three or four discrete realities causally linked in some sequence, but rather the exact same phenomena seen through three or four different frames of reference. Thus, the vexing question of causality and the attendant problem of temporal sequence is simply eliminated.

For example, what Kornhuber is observing in his "readiness potential" is not the neuronal cause of the "decision" to move the finger, but rather simply the state of the system shifting, which involves both a buildup of electric activity in the motor areas and the "decision" to wiggle a finger. There is no answer to the question of what causes the buildup of the readiness potential in either an individual neuron or the brain as a whole other than the shifting configuration of the entire system. There is no hypothetical infinite regress of neuronal firings causing neuronal firings. This model also removes the need to think of either the "mind" or the "brain" as the independent variable. A brain lesion can be described as affecting mental functioning or a mental image can be described as regulating brain waves, but both are really examples of the reciprocal interactions of a single system.

The crucial issue for this model remains the kind of self-awareness Penfield describes. Dennett and Hofstadter, who have carried this model as far as anyone, refer to this level of information processing as a "hyperloop" which goes beyond simple feedback (1981, 191-201). Feedback is another way of speaking of reciprocal causation. A thermostat can maintain a constant temperature because a switch is thrown when the temperature rises above or falls below a preset level. A heating or cooling machine is activated until the temperature returns to the preset level. The thermostat is an example of feedback, but few would suggest that it is an example of self-awareness. It governs the behavior of the heating-cooling mechanisms in a building and so exhibits a rudimentary awareness of temperature, but it is not in turn aware of what it is doing. One might construct a thermostat with a tie to the outside of the building so it could also regulate its own settings depending on the weather or the season. But—and this is the crucial question—can more complex feedback loops sum up to a state of self-awareness, or does it require a quantum leap from simple feedback, no matter how complex, to consciousness?

Even the most complex thermostat involves only simple feedback. A more complex example might be a computer connected to a camera and equipped with a voice synthesizer. When pointed at itself, it might say, "I am seeing myself." Again, is that an analogue for human self-awareness? Probably not. The computer-camera-voice-module senses itself but is not aware that it is sensing itself. It would be like one of Penfield's patients watching his arm move and saying, "I see my arm move," but not being aware of who or what was causing the movement. In Hofstadter and Dennett's terms, awareness involves not just a feedback loop but a "hyperloop" whereby feedback is given about the feedback and so they agree that such a computer-camera would not be an adequate model of consciousness (1981, 261). Like Sperry, they are convinced, however, that this hyperloop can be understood as an emergent property of the brain's organization. To a discussion of that point we will turn next.

Is the Systemic Model a Sufficient Account of Consciousness?

What does it mean to call something a system's property? At least two conditions must be present. A^1 can be said to be a property of system A if: (1) A^1 cannot exist without A, and (2) A^1 has something in common with A. This would clearly describe the relation between words and letters: a word is a system of letters and the word cannot exist without the letters, and both the letters and the word are linguistic, often written, forms. Or the relation between a cell and its chemicals: a cell is a system of chemicals and the cell cannot exist apart from the chemicals, and the cell and the chemicals that make it up are both composed of atoms and molecules. All these analogies involve systems composed of similar entities (words, cells, musical chords, etc.—even the ant colony in Hofstadter's famous "ant fugue" [Hofstadter and Dennett 1981, 149–91] is only composed of ants).

However, if we say that consciousness is a system of neurons, we run into immediate problems.

1. The claim that consciousness cannot exist apart from the brain is one of the things that such a model was supposed to demonstrate. An argument that begins by assuming this tenet may be simply circular and end up by concluding what it has already taken for granted. However, we might grant that consciousness may not exist apart from the brain in order to go on and explore the logic of this model. We must beware of using this model, however, to argue that consciousness cannot be separate from the brain since this model seems to depend on precisely this claim.

2. A more serious problem exists: The second assumption points out that this systemic model of the mind depends upon an "identity theory"—that mind and brain are really identical—which itself has serious logical difficulties. In what sense can thoughts and neurons be said to be identical? Practically none. Consider:

a) Neurons and other components of the central nervous system, like all physical entities, are always described in the categories of space and time. Thoughts are never described, except perhaps under poetic license, in terms of their mass, energy coefficient or width.

b) I may make a claim about the neurons in my brain—their number, density, organization, or development—and be mistaken about it. As philosophers have pointed out for centuries, I cannot be mistaken about the ideas or sensations I have in my mind. If I say I feel a pain in my foot, I cannot be mistaken about feeling such a sensation, even if I do not have a foot.

All of this is so obvious that it is a little silly to repeat it except that it seems to be a fatal blow to the identity theory on which the systemic model of consciousness rests. If thoughts and neurons are neither described in the same categories nor governed by the same logic of explanation, in what sense can they possibly be identical? And if thoughts and neurons are not at least basically similar, in what sense can thoughts be understood as a property of a system of neurons? Certainly not in the same sense that a word can be understood as a system of letters or a cell as a system of chemicals. (An oft-cited critique of this identity theory on which the system's model appears to depend can be found in Nagel 1974; the main arguments against it are also reviewed in Robinson 1982; and an extended critique is carried out by Watkins 1982 and Poulten 1973.)

Put most starkly, a thought is not a thing. As philosophers have noted for centuries, the sensation of seeing red is not reducible to or translatable into statements about wavelengths, rods and cones, or neuronal processing (Robinson 1976). No description of physics or neurology can lead to the experience of redness. So how can the same system be composed of both physical and nonphysical components? I am not saying it is impossible, but one of the claimed advantages of the systemic model in contrast to dualism is that it removes the dilemma of specifying how mind and brain, spirit and matter, interact. Renaming consciousness as a system's property may not account for it without some way of specifying how two such different things as thoughts and brains can be aspects of a single system.

The system's model is supposed to be simpler than its competitors, but it is not clear in what sense this simplicity is a virtue if it provides no explanation of the process that most needs explaining—the transition from neuronal states to conscious states. As fervently as the proponents of this model might hope otherwise, it is not clear that just calling consciousness an emergent systems property removes the need (which dualism also has) to provide a theoretical bridge between brains and thoughts.

3. And there is another difficulty. One of the advantages of this model is that it supposedly does away with the problem of temporal

sequence and causality which has bedeviled earlier accounts of brains and minds (Hofstadter and Dennett make this point repeatedly in advocating this model, see for example 1981, 193–220). However, the issue of temporality and causality may not be as easily dismissed as they imply. Consider the following thought experiment, based on Penfield's research. It is probably not possible in practice, but it is easy enough to visualize.

Suppose you are on an operating table with your brain exposed, and a series of cameras and screens allow you to observe your own brain functioning. You notice the color red in the corner of the room, and at the same time you become aware of the neuronal discharge that represents the visual experience of seeing red. And you realize that the neuronal activity in the visual cortex is connected to the experience of seeing red. And simultaneously you notice the neuronal discharge that represents drawing the connection between the previous occipital activity and the experience of redness. And then—or simultaneously?—you see the neuronal correlate of drawing the conclusion that the previous neuronal activity represents drawing the conclusion about the experience of redness. And of course there would have to be a neuronal correlate of that conclusion, but again, where in the sequence would you see it? And where would you see the neuronal correlate of seeing it?

Why is this so confusing? Because you are watching your brain record the experience of watching your brain record the experience, ad infinitum. You see the brain configuration change as you think new thoughts, but what do you see that goes with the recognition that you are watching the brain configuration change as you think new thoughts? What neuronal activity would you observe that goes with the awareness of your awareness?

The sequence of observing one's own brain might be diagramed as follows, where *C.S.* stands for a cortical state and *C.E.* stands for a conscious experience:

$C.S.^1 > C.E.^1$ (I see my brain)

[$C.S.^1 > C.E.^1$ (I see my brain)] > [$C.S.^2 > C.E.^2$ (I am aware that I am seeing my brain)]

{[$C.S.^1 > C.E.^1$ (I see my brain)] > [$C.S.^2 > C.E.^2$ (I am aware that I am seeing my brain)]} > {$C.S.^3 > C.E.^3$ (I am aware that I am seeing my brain and the connection of that awareness to my brain)}

{[$C.S.^1 > C.E.^1$ (I see my brain)] > [$C.S.^2 > C.E.^2$ (I am aware that I am seeing my brain)]} > {$C.S.^3 > C.E.^3$ (I am aware that I am seeing my brain and the connection of that awareness to my brain)} > $C.S.^4 > C.E.^4$ (I am aware that I am seeing my brain and seeing the connection of that awareness to my brain and seeing the connection of seeing that awareness of my brain to my brain)

The point is not so much that this is an infinite regress of causes which might hypothetically be stopped by invoking the state of the system in the way that Hofstadter and Dennett suggest. Rather this is potentially an infinite regress (or progress?) of hierarchies in which each new level encompasses the one (or ones) which came before it. A series of linear causes might be halted by reframing them as sequential configurations of a system. But it is harder to imagine mapping an increasing (hypothetically infinite) series of hierarchies onto the shifting linear configurations of neuronal activities when one of those hierarchies represents an awareness of those shifting configurations of neuronal activities and another hierarchy represents an awareness of that awareness of those shifting configurations. What is the state of the system that goes with observing that state of the system?

The systems model, in fact, may not do away with the paradoxical relation between cortical states and conscious experiences, especially when the conscious experience in question is of the cortical state that goes with that conscious experience of that cortical state. Hofstadter and Dennett are masters at evocatively describing consciousness with full attention to all of its paradoxes and complexities, but it is not clear how their "descriptions" can function as "explanations," nor how far the invocation of "complexity" (Hofstadter and Dennett) or "emergent causality" (Sperry) can go in explaining consciousness in the absence of some theory that more explicitly links the nature of consciousness to the nature of neurons.

Where does this leave Sperry's attempt to create a unified account of human nature based on neuroscience?

THREE TYPES OF INCOMPLETENESS

Sperry's work seems incomplete on at least three counts.

Goedel's Incompleteness. The thought experiment involving the possible neurology of our awareness of our awareness brings to light another aspect of this problem. Essential to human consciousness is that self-reflexiveness which makes conscious accounts of consciousness (like Sperry's) possible. The mathematician and philosopher Kurt Goedel demonstrated that formal systems of reasonable complexity cannot validate all their assumptions and claims and are thus "incomplete" in that sense. His investigations included claims within a formal system which referred to that system itself, thus involving him in the problem of self-reflexiveness and leading him to conclude that there is an inherent incompleteness in any account involving self-reflexiveness. In diagraming my thought experiment regarding the observation of the brain state that goes with observing that brain state, I created a set of Goedelian sentences (Findlay 1952), suggesting a possible incompleteness in every description of consciousness.

The application of Goedel's theorem to the problem of consciousness has a controversial history, much of it centering around a paper by J. Lucas in which he argues that Goedel's theorem makes a consistent materialistic philosophy of mind impossible (a position Goedel himself may have held) and thus supports a kind of dualism, almost by default (a discussion of the controversy and critique of Lucas can be found in Hofstadter and Dennett 1981, especially 276–83). While covering much of the same ground as Lucas, my discussion is not necessarily designed to argue for dualism, but rather only for incompleteness. A similar conclusion (that all accounts of consciousness are bound to be incomplete) but from a very different standpoint, can be found in McGinn (1989) and also Robinson (1976).

Experimental Incompleteness. Contemporary neuroscience has uncovered areas of incompleteness in the investigation of brain functioning—Penfield's failure to access or localize self-awareness for example, or Libet's focus on the transformation of neuronal activity into conscious experience. These may be resolved by further investigation. They may also reflect an incompleteness inherent in the subject under study.

There is a paradox in neuroscience: the primary instrument for studying the mind-brain is the mind-brain. Does that make neuroscience different from, say, physics or chemistry? It would probably be misleading to say that physics consists of electrons studying electrons or chemistry consists of chemicals studying chemicals, but it is not misleading to say that neuroscience consists of the brain studying the brain. The study of consciousness may contain a limitation that can never be completely resolved, since we are using the brain to study the brain and using the categories of cognitive processing to study the categories of cognitive processing.

This may parallel the dispute in physics about the "collapse of the wave function" in which experimental phenomena set limits on our knowledge of the subatomic domain in Heisenberg's "uncertainty principle." Schrödinger, Wigner, Jeans, and others suggest that the "uncertainty principle" not only puts an inevitable limitation on our knowledge of the physical world, but also points to the irreducible nature of consciousness, which has become an indispensable component in the experiments of quantum mechanics (this issue is discussed in Jones 1984 and Morowitz 1981). Likewise, some gaps in our current neurological knowledge of consciousness may well be filled by further investigation; others may reflect intrinsic and abiding limitations on the field.

Theoretical Incompleteness. The issue of incompleteness is as much a philosophy-of-science issue as a neurological one. I have argued elsewhere (Jones 1981) that, as a matter of logic, no scientific theory can or will ever be complete. It is not a criticism of any neuroscientific model to say that it is not a complete account, for all theories are incomplete in several senses—for example, selectivity must limit a theory's range and scope.

To use the analogy of a painting: I can give a complete description of the chemistry of the pigments, but is that a complete account of Picasso's *Guernica?* Obviously not. Many aspects of the work are not touched by such a discussion. Each field-dependent analysis may be complete on its own terms but cover only certain aspects of the painting. (The analogy is discussed in more depth and detail in Jones 1981.)

IMPLICATIONS FOR SPERRY'S PROJECT

What are the implications of these different types of incompleteness for Sperry's unifying "macromental paradigm"?

In his drive for conceptual unification based in science, the current state of empirical investigation remains his sole criterion of what is real. Since they can now be placed within an empirically derived framework, values and beliefs and moral choices are acceptable. On the other hand, "new age" beliefs such as "reincarnation . . . mental telepathy, all occultisms . . . and anything else not accepted in mainstream science are ruled out" (1991, 255). I have no desire either to defend "new age trends" or to suggest that religions can or should believe propositions directly contradicted by science.

On the other hand, "empiric verification" may not provide the only vision of what is real. Science does not say that science is the only valid way to envision the world; such a claim is hardly an empirical one. The standing incompleteness—in the senses previously discussed—within all current (and I think future) neurological theories leaves room for multiple models of consciousness. No neurological account can be used to preclude a theological one (the epistemic pluralism implicit here is discussed in relation to a similar issue in Jones 1986 and defended in Jones 1981).

As there are for the metaphorical painting, there can be a variety of accounts of human consciousness and human nature. Each may be relatively complete within itself and sufficient for its own purposes, but none is *the* complete and sufficient account. Neuroscience is ideally suited to explain such aspects of human life as neurotransmitter function or the biochemistry of memory but may be less well adapted to discuss the full range of consciousness, purpose, and choice. There may still be aspects of human experience that escape the net of "mainstream science."

There is no reason to think that religious and neuroscientific accounts of consciousness can or must map onto each other or be reducible to each other, any more than discussions of the aesthetics of a painting map onto its chemistry. The aesthetics of the painting are not governed by the molecular structure of the pigments (many different aesthetic and not-so-aesthetic paintings can be produced from exactly the same pigments). Rather, the aesthetic form might be said to use the pigments for its purposes.

Likewise, there is no reason that any theology of the human spirit should map onto the neuroarchitecture of the human brain. While it is true that we do not experience the human spirit apart from the human brain, just as we do not experience the harmony of a painting apart from the color of its pigments, discussions of the human spirit need not necessarily conform to descriptions of the human brain. To insist otherwise is to commit, in Stephen Toulmin's words, "a serious logical blunder" (quoted in Jones 1981, 39).

In summary, Sperry illustrates the way in which a theory based on genuinely new systems properties emerging at higher levels of organization may incorporate religious concerns and even be implicitly theological. Stunning examples of the theological use of such a systems perspective can be found in Rolston (1987), and examples of contemporary neuroscientific models serving as fruitful sources for theological analogies in Ashbrook (1989a, 1989b). Religion need no longer be incompatible with science; rather, some theological claims may now receive empirical verification. But the drive for a unitary world view obscures the inherent incompleteness in all human theorizing, especially concerning as paradoxical a phenomenon as self-awareness.

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Author's note. During 1989 I conducted an undergraduate honors seminar at Rutgers University which covered many of these issues. I want to express my appreciation to those students whose questions and comments contributed to my understanding of this topic. Also, an earlier version of this paper was submitted to *Zygon*, and I appreciate the valuable comments of the reviewers and editors.

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