

## Roger W. Sperry's Monist Interactionism

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Sperry has proposed a solution to the mind-body problem that is both physical monist and, surprisingly for many readers, interactionist. This combination, among other features of his position, has resulted in puzzlement and misunderstanding. Objections to Sperry's conception have sometimes been based on a failure to grasp what he has been proposing. In the interests of making clear and defending the monist interactionist position, this article considers seven objections that have been made to it in the literature.

### Introduction: "Progress on Mind-Body Problem"

This bold heading appears at an extremely prominent location: in the lecture Sperry (1982) gave upon accepting a Nobel Prize in Physiology and Medicine. He stated that a most important indirect result of his research on commissurotomy is "a revised concept of the nature of consciousness and its fundamental relation to brain processing" (p. 1226). My purpose is to examine in the light of published objections this proposal that Sperry (1964, 1965, 1966, 1969, 1970a, 1970b, 1976a, 1976b, 1977a, 1977b, 1978, 1980, 1982, 1985) has defended for two decades (cf. Natsoulas, 1974, 1981). From Sperry's characterization of his conception as interactionist, one may gather the proposed relation is, in part at least, a mutual relation of cause and effect. The designation *monist interactionism* is appropriate (cf. Searle, 1980, pp. 455-456) since the proposal is, also, a species of physical monism—a distinctive kind of physical monism, however, which shares commitment to certain important truths with dualist interactionism (Sperry, 1976a, p. 14; Sperry, 1980, p. 201).

Many people consider Sperry's solution to be inconsistent, because it blends together features of opposed solutions. They find such statements as the following incoherent: "A conceptual explanatory model for psychoneural interaction is provided, stated in terms acceptable to neuroscience without violating the monistic principles of scientific explanation" (Sperry, 1977b, p. 119). As will be seen, Sperry's proposal was a source of puzzlement and misunder-

standing for several readers who discussed it in print. It must be admitted: Sperry's interpretation of the mind-body relation is not free of problems; some of these will be evident here. But sometimes these problems are not those problems (purportedly) exposed by the critics. Moreover, I believe Sperry has provided us with a generally correct (meaning correct for the most part) version of physical monism, which manages to find a place in the world of facts for the existence and efficacy of the mental.

The place of the mental, according to the psychobiologist Sperry, is absolutely crucial. Consequently, I expect his conception to be, once understood, very attractive to psychologists. It contains biological justification for the level of analysis where most of us function as scientists, namely, the level of perceptual experiences, feelings, thoughts, emotions, desires, intentions, and the like:

Behavior on these terms is still causal and deterministic but at a cognitive and conative, mental (rather than mechanistic or physiological) level. . . . [The] current theory . . . allows one to determine one's own actions according to one's own subjective wants, personal judgment, perspectives, cognitive aims, emotional biases, and other mental inclinations. (Sperry, 1977a, pp. 240-241)

That is, to explain the behavior of the human being as a whole, the brain's function requires description at the level (*pace* dualists) of brain-occurrences of the mental kind. The mental categories will always be part of the scientific explanation of behavior because they succeed in carving this part of nature (i.e., our higher-order brain-activity) at the joints (cf. Searle, 1983, p. 262), or if they do not so succeed, at least the mental categories represent the level of higher-order analysis of brain-function with the greatest promise for explaining the behavior of the human being as such.

### First Objection:

#### **"Completely Unclear How Conscious Emergent Properties 'Direct' Individual Nerve Impulses"**

Savage's (1976) objection pertains to the relation Sperry (1969) proposed between mental and nonmental occurrences. The objection addressed one aspect of this relation: how a mental occurrence could influence individual nerve impulses that, *ex hypothesi*, constitute the mental occurrence. Besides arguing for "downward causation," Sperry held that processes that are mental also function causally *at their own level* of organization. As Searle (1983) stated more generally, in arguing a similar view, there are "different levels of description of a substance where the phenomena at each of the different levels function causally" (p. 268; cf. Sperry, 1982, p. 1226). By first considering Sperry's conception of *intralevel* mind-body interaction, a context is provided next for Savage's objection (and other issues in subsequent sections).

Individual nerve-impulses occur as part of large "circuit-system configurations" that derive their structure as processes, in part, from built-in neural circuitry designed by evolution for adaptational purposes. These molar brain-processes vary in their higher-order properties depending on (a) the anatomical circuit of which they are an activation, (b) the configurational properties of the preceding activation of the identical circuit, and (c) "the context" in which a molar brain-process occurs of other circuit-systems' configurations of neural activity. At this level, molar processes operate causally as "entities," each as a reproducible unit with predictable effects. That a molar "entitative" brain-process is internally organized in a specific way has implications for how it enters into interaction with other such processes. Patterns of activity in one or more circuits lawfully determine how other circuits are activated as a unit and how their own circuits are subsequently affected by patterns of activity in other circuits. For this reason, Sperry described as playing causal roles *the pattern-properties themselves*. Typically, an entitative, brain process made possible by a certain built-in circuit is *causally a different process* depending on its variable dynamic configurational properties. According to Sperry, some of these molar brain-processes literally *are* mental occurrences, and interact with other molar processes that may not possess the kind of organization whose dynamic pattern-properties are mental (Sperry, 1976b, p. 168). Their mutual interaction brings into existence further effects at their own level, including "volitional responses" (Sperry, 1969, p. 533). Both kinds of molar processes are purely physical; both have only physical properties, including "dynamic holistic properties."

Savage (1976) began by pointing out that individual nerve-impulses must determine the pattern of activity at the crucial level in a circuit, and such determination cannot be causal since a molar process is simply a pattern of impulses. Moreover, interlevel determination amounts simply to such constitution. It is completely unclear, therefore, how pattern-properties of molar process might "direct" individual impulses. Responding to Sperry's (1969) analogy of how a wheel carries downhill molecules and atoms composing it, or how a stream of water determines where a drop goes, Savage (1976) stated, "Drops of water are not 'carried along' by the local eddy. They and their actions on one another *constitute* the local eddy" (p. 130).

But what happens to part of a wheel rolling downhill depends on the whole wheel's fate unless the part breaks off. In many instances, parts of a wheel do not reach bottom because they do not stay connected to the rest of the wheel. If, analogously, whether and when and how often a certain nerve-impulse occurs depends on the pattern of which it is a part, then it is unclear what Savage required when he asked how configurational properties could affect particular nerve-impulses. Still, Sperry can call attention to "the flow pattern of excitation" (Sperry, 1969, p. 539) and the structure over time of

the process to which an impulse contributes. Think of the stages of a process and how later stages are determined by earlier stages. An impulse's part in a molar process should not be imagined spatially; the process does not consist only of what goes on in the circuit at the instant when the impulse occurs.

As part of a flow-pattern, the same nerve-impulse occurs and perhaps recurs in a particular circuit-system configuration of neural activity. Since the impulse is part of a larger temporal pattern, its "fate" (i.e., whether and when and in what contextual relationship it occurs) depends on the character of the molar temporal "entity" taking place in the anatomical circuit to which the respective neuron belongs (Sperry, 1980, p. 201). A pattern of activity to which it contributes in time precedes the individual impulse in its circuit. As this pattern varies, due to stimulatory or internal factors, the same impulse may enter into it at different points and more or less frequently. (Similarly, as is well recognized, the nerve-impulse's effects depend on other neural activities that occur along with it.) Mental properties can affect particular impulses because mental properties belong to the organized neural context in which the impulses occur. Think not only of which neurons' activity caused the activity of other neurons, but also of the arrangement in time of the activity of the latter neurons and how this arrangement came to be produced.

### Second Objection: "Not Part of the Physical Universe"

Had Hebb (1980) been commenting on Bergmann's (1956; Addis, 1982; cf. Natsoulas, 1984b) psychophysiological parallelism and Eccles's (1973, 1974, 1976a, 1976b; Popper and Eccles, 1977) dualist interactionism, his characterization of the mental on their behalf as *extraphysical* would have been correct. However, Hebb was discussing Sperry's position along with Eccles's, and was assuming that the interactionist dimension they share suffices to equate their views in other ways as well—notwithstanding Hebb's quotation from Sperry (1970b) concerning the mental's being "inseparable from the brain process and its structural constraints" (p. 136). The quotation began a little before the latter, where Sperry stated that the mental is an "emergent" property of brain-excitation. This much Hebb considered a "slippery" idea that included the separateness of the mental from the physical. If Hebb had continued the quotation to the end of the paragraph, Sperry's explicit opposition to anything "disembodied" or "supernatural" would have been evident. Although the mental properties are "holistic, configurational, gestalt, encompassing, and entitative," they are *nothing more (or less) than or different from* "dynamic . . . properties of the cerebral circuitry in action" (Sperry, 1970b, p. 137). This would seem to force one to distinguish Sperry's mind-body solution from Eccles's and to come separately to terms with it. Reading to the end of Sperry's

(1970b) chapter yields a picture of his position entirely consistent with the picture I am developing here.

Noting Hebb's misinterpretation of Sperry is less important than trying to understand what about Sperry's or Hebb's point of view, or both, may explain the lack of communication. Hebb's discussion appears in a chapter where he argued that false neurological ideas have a distorting effect on psychological and philosophical thought. I want to add that, conversely, some philosophical thought may prevent recognition of alternative views of brain-processing. Hebb (1980) was well aware of this danger; in his preface, he wrote that ideas about the nature of mind, self-knowledge, determinism, and freedom of thought and action may affect one's psychological research even when one is unaware that they do. Trying to understand Hebb's reaction to Sperry along these lines, we must ask what caused Hebb to group Sperry with Eccles as deserving of the following critical question: "What meaning is there in saying that emergent consciousness is not simply an aspect or property of the physical brain and its activity, as magnetism is a physical property of moving electrons" (Hebb, 1980, p. 42)? After all, Sperry has stated again and again that mental molar brain-processes have special physical pattern-properties that distinguish them as mental.

For Hebb, *interactionism therefore dualism* was a necessary implication. In a later article, Hebb (1981) stated there are only two important kinds of theory of the mental, namely, materialistic monism and interactive dualism: "Other formulations can be disregarded for scientific purposes" (p. 2421). Interactionism necessarily means "conflict with conservation of mass-energy." Thus, if Sperry's view is a species of interactionism, it must be dualistic. There is no other possibility. It is instructive to ask why. Since there was, probably, a very great deal of agreement between Sperry and Hebb (and Uttal, 1978, and Smart, 1981; see below) about psychology and science, why did the physical monist Hebb not arrive at Sperry's position himself, let alone recognize it? In a moment, I shall come to an answer that derives from Hebb's reasoned rejection of an ability that Sperry, among many others, believed us to have.

A kind of scientific realism holds our everyday perceptions are fraught with systematic error. Obviously, the standard for error, in this view, is not our extremely successful behavioral adaptation to our habitat. The basis for depreciating what our perceptual systems provide is the theoretical judgment of science concerning the environment's true properties. Now, Hebb does not seem to have been this kind of scientific realist (cf. Natsoulas, 1983d). But he did turn a similar kind of scientific realism *on the mind itself* and our knowledge of it. Accordingly, what common sense and the first-person perspective tell us about our mind has no special authority; the whole of our purportedly direct knowledge of the mental is in fact inferential. This

"knowledge" is tantamount to a collection or system of explanations, which we apply to ourselves and others, for a certain part of what we indeed observe (including our behavior): "The mind is known theoretically, by inference from observation of the physical world" (Hebb, 1981, p. 420). Therefore, scientific knowledge of the mind is in all cases potentially better than self-knowledge.

It also follows that what people take on a firsthand basis to be evident truths about the efficacy of mental occurrences are no more than inferential judgments to make sense of perceptually observed states of affairs in our body, behavior, and environment. The strong and reliable influence of the mental that Sperry and everyday thought claim on a noninferential basis is not accessible to us directly (contrast Feigl, 1981, p. 345). Therefore, the purported first-person detections of the mental's causal efficacy are no real challenge to mind-body positions and cannot be appealed to as grounds for interactionism.

In contrast, Sperry (e.g., 1970a) began from "the common intuitive impression that conscious phenomena are both real and operationally useful" (p. 586), and held on to this impression as a truth about the mind:

The causal sequence of brain events leading to and determining a given voluntary act or decision no longer is conceived to be restricted to a series of neurophysiochemical activities . . . . This introduces new degrees and qualities of freedom into the brain's decision-making process. . . . For example, one's subjective desire to do this or that . . . may now, per se, influence the progression of brain events as directive causal factors. (Sperry, 1976a, pp. 14-15)

Based on the direct access Hebb rejected, Sperry accepted the claims of common sense as literally as Searle (1983): "There really are such things as . . . mental phenomena which cannot be reduced to something else or eliminated by some kind of re-definition. There really are pains, tickles, and itches, beliefs, fears, hopes, desires, perceptual experiences, experiences of acting, thoughts, feelings, and all the rest" (p. 262). Sperry accepted the daily evidence of mind-body interaction, and strongly believed it could be explained (not explained away) in terms of brain-function at the proper (mental) level of analysis without introducing extraphysical properties or occurrences to do the job.

Hebb based his rejection of immediate knowledge of one's mind on two main grounds: (a) "Introspection is not the simple direct observation that it may seem . . . . Theory somehow contaminates it" (Hebb, 1981, p. 2419). Indeed, direct awarenesses are commonsensical in the concepts they apply to mental occurrences. While this leaves room for much improvement (e.g., subtle distinctions among feelings), it does not follow from the (unavoidable) fact of "theoretical contamination" that direct (reflective) awareness does not contain useful information allowing us to make adaptations that take our mental occurrences into account.

(b) Hebb insisted the nervous system has no way to know itself directly, its own processes and contents (cf. Skinner, 1974; Natsoulas, 1983c, 1985). Its sense receptors and sense organs are directed upon the environment and body outside the nervous system. And no other way exists than the sensory to become observationally aware of anything. But we do have the possible mechanism of molar brain-process interaction. One of Sperry's (1969) entitative brain-processes could be produced by another one and be an awareness of the first: "The brain process must be able to detect and to react to the pattern properties of its own excitation. It must detect the overall qualities of different kinds and different species of cerebral processes" (p. 534). It remains to be seen how the brain is directly aware of its own processes and contents. Our ignorance about brain-function is no argument against an ability we so often put to use—as when, for example, we stop trying to see a certain object in the environment upon becoming directly aware that we are, finally, experiencing it visually (for further discussion, see Natsoulas, 1977, 1983a, 1983b; cf. Natsoulas, 1970, 1973, 1978).

**Third Objection:  
"Action of Brain Processes on Brain Processes Without  
Intervention of Alterations in Physical Environment"**

This is how Uttal (1978) characterized Sperry's (1969, 1970a) mental-physical interactions, which he assessed as implicitly dualistic; physical processes cannot interact as Sperry believed they do in the brain. This seems the point Uttal tried to get across by referring to the physical environment's nonintervention. Is there really something dualistic about the causality Sperry assigned to brain processes with mental properties? Although Sperry's statements sometimes evoke imagery of actions by an inner conscious agent, the meaning of none of them requires postulating such an agent. Consider the two articles on which Uttal based his criticism. In one (Sperry, 1970a), we find the phrase "actively govern" for how mental occurrences affect the flow-pattern of neural excitation; this was also called "direct causal influence." Any temptation to read into these phrases an extraphysical kind of causation meets strong discouragement from Sperry's (1970a) statements that what exercises control is no more than "an integral dynamic property of brain activity" (p. 588) and "determinism still holds in the sense that all decisions are caused" (p. 590).

In the other article (Sperry, 1969), "a directive role in determining the flow pattern of cerebral excitation" (p. 533) will start readers wondering whether something dualistic has not just gone by. The source of this feeling undoubtedly lies in Sperry's position, though not in his purported dualism. Its source must be the causal import he attributed to occurrences of which we

may have direct (reflective) awareness. It is, for many, simply startling to find a contemporary psychobiologist of Sperry's accomplishments stating that the kind of happening people report on a privileged first-person basis (i.e., by means of a kind of access to the mind that modern psychology has rejected as unreliable) is a brain-occurrence possessing an especially significant causal efficacy.

This could explain, though it may not, why Uttal (1978) characterized as he did the dualism he sensed in Sperry's view: "Even if one considers this to be an action of brain processes on brain processes, such an action of mind on mind, without the intervention of alterations in the physical environment, would essentially be a dualistic concept" (p. 71). We can be sure Uttal noted the extraordinary causal role Sperry gave the mental, for Uttal saw similarities between Sperry's effects of the mental and those proposed in psychosomatic medicine, behavior therapy, and biofeedback. But we cannot be sure why Uttal mentioned the physical environment in his criticism. Perhaps he got the impression that Sperry was downplaying to an extreme something crucial to the collective experience of this century's psychologists, namely, the control of behavior by stimulation. The implicit point contra Sperry may be somewhat along the lines of one often heard from Skinner (e.g., 1974) to the effect that attempts to account for behavior in terms of feelings and other conscious content divert the psychologist from the real causal action to behavior, particularly the part of this action that is the psychologists' special province, namely, the environmental conditions (historical and present) that increase or decrease the probability of a behavior's occurrence (cf. Natsoulas, 1983c, 1985).

After all, Sperry's (1969, 1970a) account did not ignore the physical environment's influence. Quite naturally, nearly all of Sperry's discussion pertained to the mental's influence on the flow of brain-excitation, for that was his special contribution, the dimension about which he had something unusual to say. But notice, he closed the first of the two articles with "a revision in traditional stimulus-response concepts of central nervous control" (p. 535). According to his conception of brain-function, there is an ongoing central process that may be focused on one or another modality. The special sensory input for the attended modality (as well as centrally generated input from other circuits) gets incorporated into the ongoing process by altering its dynamic pattern-properties in ways that depend on the input's characteristics. Sperry described the ongoing process as "exquisitely responsive" in this regard. The effects of sensory input on awareness and behavior depend on how the input perturbs the continuous central process preceding its arrival (which may already be perturbed, of course, by previous inputs).

Sperry (1969) stated, "The present view places greater emphasis on the central processes and their specialized organizational features that create out of



neural excitation the higher order phenomena of mental experiences" (p. 535). This greater emphasis does not amount to proposing a new kind of (non-physical) causality or the nonintervention of the physical environment in brain-activity and motor output. Instead, Sperry's mind-body solution is controversial because it includes what he often called "inner or subjective experience" among the causes of behavior. This is a kind of occurrence that many psychologists believe to lie outside the main action to behavior (while the main action consists of processes that cannot be conscious). In contrast, Sperry has mental phenomena in there making a difference, interacting with nonmental molar processes at the top of the command-hierarchy of levels of control in neural-regulation systems.

The most intriguing of Sperry's many statements on monist interactionism was one that claimed the mental molar brain-occurrences to be the central organizational focus for a great deal of the interaction that takes place at the highest control-level of the nervous system. While there are nonmental brain-processes at work at the most molar level of operation, their function was viewed by Sperry (1977b) as largely involved in their relation to mental occurrences: "Most higher brain processing . . . can be viewed as being designed for, and directed toward, the generation, maintenance, or expression of aspects of conscious awareness" (p. 122). Certainly, this is enough, without dualism, to raise psychological eyebrows. It will be difficult to assimilate Sperry's view to a rather ordinary mind-brain identity theory.

#### **Fourth Objection: "No Hypothesis About Neural Mechanisms"**

This criticism of Sperry's conception of the mental appears in two places at least. Bindra (1970) used these words as he argued that the unique organizational properties of mental brain-processes have not been specified to a degree that distinguishes them from properties of equally complex nonmental brain-processes; what Sperry's theory needs is a characterization of mental phenomena in "substantive neural terms" (p. 582). In introducing Sperry's (1976b) chapter, the editors alerted the reader to the same flaw, calling it the "conceptual difficulty in distinguishing neural events with emergent consciousness from neural events without emergent consciousness" (p. 161).

Sperry (1976b) himself wrote on this question:

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. (p. 168)

In response to Bindra and later on, Sperry (1970a, 1976b) acknowledged the large job neuroscience has to do of specifying the nature of the organization of neural events that amounts to the mental character of some of the processes they comprise. This is not simply a "conceptual difficulty," but the very large theoretical difficulty of producing a substantive hypothesis of far greater concreteness than the one Sperry has offered to this point.

Bindra's (1970) judgment that Sperry's proposal was as uninformative in this regard as it could be is contradicted by the judgment of two other equally sophisticated scientists. Dewan (1976) found Sperry's theory to be anything but empty, calling it "a novel and enlightening viewpoint . . . which may well be the first sizable step toward a real understanding of [the mind-body] relationship" (p. 181). And Weimer (1977) stated that only one hypothesis on the nature of consciousness exists in the psychological literature that deserves to be called "theoretical." As compared to Sperry's (1952, 1965, 1968, 1969, 1976b) contribution, the other attempts are "merely paraphrastic" (p. 292). Counting advocates is, of course, not the way to decide such questions, but these judgments contrary to Bindra's suggest that Sperry may have been saying somewhat more than Bindra gathered. Therefore, Sperry's proposals about the mental properties merit further attention, with the understanding (which is Sperry's own) that he has not yet provided a concrete specification of these properties.

Sperry (1980) characterized his conception of the mental as a kind of "functionalism" and the mental properties as "functional" properties. The notion of functional properties has to do, evidently, with how the molar brain-processes that are set going in certain circuits "fit" into larger units of activity in the brain. Two relevant aspects of "fit" can be mentioned. Which mental occurrence takes place at any time depends on the flow-pattern of excitation of which the relevant cerebral circuit is a part, how the latter was previously activated and is now perturbed by sensory input or its "context" of other molar brain-processes. The second large aspect of "fit" shows Sperry again sensitive to what others have arrived at from a nonphysiological perspective. For example, O'Shaughnessy (1974) wrote of the "holism" or relativity of mental phenomena, stating that these "undeniably real and unquestionably individual events" do not possess an absolutely autonomous identity; their being the specific mental phenomenon each is depends on the particular "mental setting" in which each occurs. Similarly, Sperry gave signs of trying to go beyond the concept of a multiply determined molar process. The character of the process is a matter as well of its functional role in a larger system of processes. For example, what it helps produce also contributes to its distinct identity. In other words, the kind of mental phenomenon it is depends on its rela-

tional properties as well as its intrinsic properties (where the latter are the organizational properties of its constituent events). Perhaps mental phenomena are introspectively characterized in terms of their role, as well as in terms of the qualitative characteristics the respective molar brain-process may possess (cf. Armstrong, 1968).

Sperry (1977a) expressed this kind of "functionalism" most explicitly in statements such as this: "Subjective meaning is conceived to derive . . . from the functional or operational impact or the way a given process 'works' in the context of brain dynamics" (p. 239). Throughout, he emphasized that mental properties belong to organizations of neural events that act causally in specific ways as a unit. The cerebral design of the relevant brain-circuits was said to be a design for specific effects. The idea of some mental properties as functional properties became perhaps most vivid where Sperry (1976b) applied it in the following case:

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 the left hemispheric components combine and function as a unit in the causal sequence of cerebral control. In the divided brain, each hemispheric component gets its own separate causal effect as a distinct entity. (p. 174)

#### Fifth Objection:

#### "Why Could Not Brains Have Evolved Exactly As They Did Without Any Conscious Experience?"

Puccetti (1978) raised this critical question because he concluded that Sperry was, after all, "just a more sophisticated psychoneural identity theorist" (p. 64). Indeed, Sperry shared with identity theorists the expectation that science will develop a proper physical description of the mental phenomena. If Sperry is correct, science will eventually identify in an objective (nonintrospective) way the configurational and functional properties of the brain-processes that are mental phenomena. Apparently, Puccetti proceeded from this to reason as follows: *Those who, like Sperry, believe that a person's mental phenomena are in fact a subset of the person's physical processes could have no possible explanation for the subset's being mental, that is, an explanation for its making a difference that they are mental. That some physical processes are mental seems just an extra added feature that does no work, given their basic nature as purely physical processes. In the view of the identity theorists (including Sperry), all of the person's activities could be explained in terms of purely physical descriptions, which do not mention anything mental. Therefore: "Why could not the brains of higher animals have evolved exactly as they did, with all the molecular and presum-*

ed configurational properties their brain circuits have, without *any* of their neural machinery being contingently identical with conscious experience" (Puccetti, 1978, p. 64)? Monist interactionism cannot answer this question and is, therefore, a poor mind-body solution.

Puccetti's objection was directed at the wrong target. The objection seems tailor-made for addressing parallelist and epiphenomenalist views. From such views, it follows that everything could have been just the same in the absence of the mental. According to such views, the mental need not be included in any explanation of brain-process or behavior. For example, Addis (1982) acknowledged for Bergmann's (e.g., 1956) psychophysiological parallelism the implication that everything else could have been quite the same in the absence of the mental: "Could the universe have been such that those brain states could occur without those [concomitant mental states] or any mental states at all? Yes, but it isn't that way" (p. 410). But why isn't it that way? What answer can a parallelist or epiphenomenalist give to the question of why brains evolved in such a way that mental phenomena accompany some of their processes? The mental phenomena could not have made any difference to the evolution of brains, and this evolution could have occurred exactly as it did without mental concomitants (cf. Natsoulas, 1984b).

Among the proposed solutions to the mind-body problem, Sperry's has perhaps the least difficulty with Puccetti's question. Sperry (1980) broke with "the idea that the objective physical brain process is causally complete in itself without reference to conscious or mental forces" (p. 196). This statement could be misread. It means that the truly complete physical description of the brain must include reference to all mental phenomena, which literally *are* brain-occurrences. Therefore, the brains of higher animals could not have evolved exactly as they have without certain of their processes being mental phenomena, because this would mean that the brains had not evolved exactly as they have. Without the mental phenomena that in part constitute brains as loci of process, they would be different brains. You just could not have the brains that we have now, intact, connected, in good working condition, without also having mental phenomena.

Another way to understand Puccetti's question is as concerned with *the subjective (inner) perspective* a person's mental phenomena make possible. Puccetti, along with many others, seems to have distinguished between (a) experiencing a mental phenomenon and being aware of experiencing it through experiencing it and (b) observing or describing from a third-person perspective the "corresponding" brain-process (said by Sperry *to be* the mental phenomenon). Sperry (1976b) had stated, "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 to describe and understand in objective terms the phenomena

of subjective experience" (p. 175). Puccetti's objection may ask whether the expectation of a completely physical understanding of the brain does not imply that the brain could be exactly the same whether or not subjective experience existed, in the sense of our having direct (reflective) awareness of experiencing mental phenomena.

Again, Sperry's answer would be negative. For a mental phenomenon not only to occur but also to be subjectively experienced, certain further processes must occur, in addition to the mental phenomenon itself; and these additional occurrences would be included in a complete physical description:

The conscious subjective qualities . . . derive from the selective operational interactions of brain events in a matrix of brain activity . . . . 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 the internal relations of the observed brain. (Sperry, 1976b, p. 174)

Mention of "an observer brain" served to bring out what is required as well for special access to one's own mental phenomena. In Freud's (1895/1966; Natsoulas, 1984a) term, Sperry's conception of direct (reflective) awareness would seem to be an "appendage" theory of consciousness—which requires, for a psychological process to be conscious, that it interact with one or more special further processes whose function it is to make the person directly aware of the psychological process.

However, I cannot assign with full confidence Sperry's view of direct (reflective) awareness to the category of appendage theories. Another, less likely possibility is that his view was of the "self-intimational" kind. An example of the latter is Freud's own conception relative to one large category of processes of the psychological apparatus, which he considered to be intrinsically conscious. That is, their having a subjective (inner) aspect is not due to an appendage that bestows it on them (see Natsoulas, 1984a). The unconscious psychological processes (on whose existence and efficacy Freud, of course, insisted) do not possess a subjective side; they are, one might say, purely objective mental occurrences; and they remain so, Freud held, when they "become conscious" by entering into a special relation with intrinsically conscious psychological processes. In the occurrence of the latter, simply in their occurrence with no additional process, there is included a consciousness of their occurrence (cf. Freud's teacher Brentano, 1911/1973; Natsoulas, 1983a, gives some attention to Brentano's self-intimational conception of "inner perception").

It seems more likely that Sperry's conception of direct (reflective) consciousness was of the appendage kind. I have drawn this conclusion mainly from Sperry's (1976b) brief discussion of "the privacy of subjective experience" (p. 174), where he stated that different "causal relationships" are involved in

achieving objective as opposed to subjective descriptions of the same mental phenomenon. Subjective description of mental phenomena requires "an intimately involved relation . . . . I have used the example of a corpuscallosum-type of intercommunication system . . . to illustrate the kind of interaction that is required" (Sperry, 1976b, p. 174). Hypothetically, another brain would have to interact, by means of such a system, with the first brain in order for both people to experience the identical mental phenomenon. What does this imply for one's access to a mental phenomenon that takes place in one's own brain? Sperry's statement about a second brain would seem to mean that the first brain also must exemplify that "intimately involved relation" (i.e., an interaction of mental phenomena *with further processes*) in order for the first person to have immediate access to his or her mental phenomena.

The alternative to this relation is that the first person's access is due to an intrinsic consciousness. Two points can be made against attributing a self-intimational hypothesis to Sperry: (a) had Sperry held inner access to be self-intimational, he could not have proposed consistently that another person might, hypothetically, experience the first person's subjective qualities (as a result of their brains getting into the proper, corpuscallosum-type interactional relation). If inner access is strictly self-intimational, then there is no possible way to have inner access to another person's experience. The only subjective way to gain information about the other person's experience would be to have the same experience (e.g., an experience of the same shade of red) and to have self-intimational access to one's own experience. (b) If one reads very carefully the above last indented quotation from Sperry (1976b, p. 174), one can make him out to be saying the following: the direct (reflective) consciousness of sensory qualities derives from the selective operational interactions of brain-processes in the matrix of brain-activity. Therefore, an observer's brain would have to interact in the same way with these qualities (better: with the molar processes whose properties they are) in order for the observer to have the same kind of (inner) access to them.

I tentatively conclude that the self-intimational conception of direct (reflective) consciousness is the less likely choice for Sperry. In his view, mental phenomena do not possess a subjective side except in the proper context. Their interaction with certain other processes, perhaps forming larger reverberating wholes, gives them their subjective side, constitutes their having a subjective side. Therefore, if something like this is correct, inner (subjective) access could be included, contrary to Puccetti, in a completely physical understanding of the brain, since all relations among processes at the molar level of organization would be included.

**Sixth Objection:  
"Emergent Subjective Properties Do Not Exist"**

This statement appears in Smart's (1981) commentary that sought to elucidate and evaluate Sperry's (1980) conception of the mind-body relation. Sperry's (1952) own early criticism of psychoneural isomorphism fits in well with Smart's rejection of emergent mental properties. For this reason, Smart did not frame the above statement as a criticism of Sperry's mind-body solution. However, Sperry's more recent efforts attempted the reconciliation of such properties with the physical nature of the substrate in which they occur. In fact, Sperry (1969) espoused the kind of view of these properties that Smart rejected. He stated that the qualitative contents of perceptual experience are "not really out where they seem to be;" they do not belong to the objects perceived, but are "entirely inside the brain itself" (p. 535).

Earlier, Sperry (1952) had written, "It becomes difficult to see how anything is gained by having the neural process copy the contents of consciousness" (p. 294); therefore, we should not look for processes in the brain that have the same properties (e.g., unity, continuity) as our perceptual contents seem to have. For Smart, this has been an important argument against the objection to physical monism that perceptual experiences could not be brain-processes given the difference in their properties. According to Smart (1981) the critics have gotten the properties of experience wrong. For example: "The having of a yellow triangular sense datum is a brain process that is neither yellow nor triangular" (p. 112). Indeed, if experiences were, for example, yellow or triangular, then they could not be brain-processes, since we know that brain-processes are never yellow or triangular. According to Smart, an environmental object that is visually perceived by having the above experience is normally yellow and triangular. Being properties of the environment, these properties cannot be used against Smart's physical monism. Therefore, there is no problem of the sort Sperry has been trying to solve, since yellowness and triangularity are not (emergent) properties of brain-process.

However, Smart (1981) has the admitted problem of making plausible the idea that experiential properties are not really properties of experience; he realized he was "up against strong intuitions" (p. 112). And not only intuitions, I should say, since many of the properties attributed by him to the environment are not acknowledged by physical science. Nevertheless, these are, according to Smart (1981) a kind of physical property: "The yellowness of the banana is a certain (highly disjunctive and idiosyncratic) physical constitution that explains a certain pattern of visual discriminations on the part of the normal human percipient in normal conditions" (pp. 111-112). One is led to raise questions concerning the yellowness of an hallucinated banana or of a flash of light one seems to see upon direct electrical stimulation of

one's brain. If there are no yellow things around, the property of yellowness belongs, according to Smart, to *nothing* in such situations. In both cases, what is happening in one's brain (i.e., one's visual experience) is much like what happens when a yellow object or light is affecting one's visual receptors.

Sperry surely would reply that Smart has simply ruled certain words can only be used to describe the properties of objects. In practice, these words serve to characterize objects in the environment *and* to identify the properties of the perceptual experiences that the objects normally produce. Are there not qualities of visual experience such as those we call "yellow"? Is there serious doubt, really, that a yellowness is somehow present to us when we hallucinate a flash of yellow light? Would we experience this yellowness if it were merely a causal property of yellow objects and electrified electrodes, thus existing externally to our perception?

If one's brain is electrically stimulated and one has, consciously, a visual experience that is much like veridically seeing a yellow light, then this experience has seemed to one to be of a certain kind. If we identify the kind by reference to normal environmental causes of the experience, we do so on the basis of experiential properties that distinguish this kind from other kinds. We also become aware of such properties in forming the belief, for example, that we are now seeing a yellow object. We cannot tell, normally, that we are seeing a yellow object without having direct (reflective) awareness of the visual experience we are having as a visual experience of a certain kind. If we simply were having, unreflectively, a visual experience of a yellow object, it would be for us as though we were not. It would be for us as are, apparently, the nonconscious visual perceptions of patients with "blind-sight" in their scotomas (Natsoulas, 1982). Though these perceptions may affect their behavior, they cannot put the perceptions to deliberate use.

Smart (1981) stressed, "We are not acquainted with the physiological nature of the brain process" (p. 112). However, there is a clear sense in which we are so (directly) acquainted with, for example, our perceptual experience. For we are able to recognize its occurrence and recurrence in us, what kind it is, similarities between it and other brain-processes (e.g., others of our perceptual experiences), and so on. Smart himself mentioned our ability to detect the waxing and waning of some experiences (see Natsoulas, 1974). The point is, Smart would insist, we are not acquainted with the brain-processes' physiological nature. But a physical monist could not hold that a perceptual experience has also a nonphysiological nature. What Smart meant was that our inner access does not reveal our brain-processes to us as physiological processes; otherwise, many people would not have thought that their perceptual experiences and other mental occurrences are transient modifications of an immaterial substance. Even those who believe that their experiences are brain-processes (e.g., Sperry, Hebb, Uttal, and Smart) do not (at present)



find confirmation of their belief through introspection. This lack of confirmation is due, however, to their (our) presumptions about what it would be like to become aware in this internal way of a physiological process. At present, physiological knowledge about experience is not helpful in preparing us for what to expect when we become aware of having an experience.

**Seventh Objection:**  
**"No Satisfactory Explanation of How Qualities of Sensation  
 Relate to their Operational Effects"**

Does this criticism, which Sperry (1952) directed at the time upon his own position apply as well to his "modified concept" (Sperry, 1969) of the mind-body relation? The earlier view was later appraised by Sperry as successfully capturing the "functionalist" dimension of the more complete view. The central point had been that mental phenomena are "brain patterns designed, directly or indirectly, for the adjustment of muscular contraction" (Sperry, 1952, p. 310). There were, as later, references to "higher order functional and operational effects" on the flow of brain-activity leading to behavior. Although Sperry (1952) emphasized the central organization of brain-activity for motor effects, his conception of the mental was not a motor theory: "This continued emphasis on the motor approach to mental activity should definitely not be taken to imply that subjective experience resides within any motor reaction or within the motor system" (p. 309; cf. B.F. Skinner's largely proprioceptive account of conscious content as discussed in Natsoulas, 1983c, 1985). Rather, the mental phenomena were localized at the level in the nervous system where, one might say, behaviors were "chosen" to be performed, that is, "where the coordinated action of the entire motor system may be governed as an integrated whole through the combined influences of most of the sensory excitations and mnemonic traces" (p. 309).

The identity or category of a mental phenomenon depended on its "functional value as measured with reference to motor adjustment" (p. 309); "the geometric, spatiotemporal, and other properties" of the brain-process "may vary considerably" and still it would be the same mental phenomenon. We can see, therefore, why the immediate sensory qualities left a serious unsolved problem. The qualities would seem to be intrinsic properties rather than relational ones (i.e., preparatory states for responding). They do not seem to vary with the response that one makes upon experiencing them. For example, the experienced color does not change as one alternately calls it "red" and presses a button. Moreover, one often produces responses *with reference to* how one experiences the environment or one's body; the response varies depending on how one takes one's experience qualitatively to be. One exercises a choice among responses in the light of the qualities of one's experience, rather than

having a response evoked, which determines the quality of its experiential cause.

The following differences between Sperry's modified view and his early one may explain why he did not continue to apologize for his treatment of the sensory qualities. (a) In the later conception, the functional properties of a mental phenomenon were less closely tied to the motor output. The functional properties now pertained to how a mental phenomenon fit into brain-dynamics, how it contributed to the flow of brain-excitation. (b) The configurational properties of the mental molar brain-occurrences were more firmly attached to the cerebral circuitry. There were, now, mental *intrinsic* properties of molar brain-occurrences (though these were internally relational, i.e., pattern-properties), as well as mental *relational* properties exemplified by a mental process's causal relation to other cerebral processes at the same level of brain-organization. My interpretation here is consistent with Sperry's (1970a) descriptive phrase for the mental properties, namely, "holistic properties with causal effects" (p. 589). This would seem to say that the properties of a mental occurrence that distinguish it as mental do not consist entirely of functional properties. The relation to behavior was supplemented in the later conception by an emphasis on experience itself as an operational product: the neural mechanisms whose activation is a mental phenomenon are "specifically structured on an operational, functional basis to create particular sensations, percepts, and feelings, and to provide a rapid representation of external reality" (Sperry, 1970a, p. 589).

Sperry certainly gave the impression that he thought the weakness of his earlier mind-body proposal had been eliminated. However, he would readily admit the problem remains of specifying the relevant configurational properties of qualitative mental phenomena, which constitute them as qualitative. Has there been any real improvement in this regard? I believe that the original weakness may be somewhat less severe because the later writings have been suggesting in a general way the level at which the intrinsic properties are to be found. The idea that the activation of a certain brain-circuit is, for example, the experience of red because of the nature of the patterning therein of neural impulses may usefully suggest that our typical level of neurophysiological investigation is not the right level, if we are to succeed in detecting the mental properties themselves: "A full explanation of the brain process at the conscious level will not be possible solely in terms of the biochemical and physiological data such as we are now perforce engaged in gathering" (Sperry, 1969, p. 535).

However, the identification of certain brain-processes, as Sperry described them, with experiences (e.g., the visual-qualitative experience of seeing a yellow banana) is not convincing for many people in the absence of specific, objective description of the relevant properties. On the basis of their direct (re-

flective) awareness, they find no basis to think that Sperry is on the right track. In fact, the experiential qualities constitute a reason for many to reject any physical monist view. People of this persuasion would criticize Sperry's new conception similarly to how he (Sperry) criticized his earlier conception. They would ask how their experiences of various kinds could be the kind of brain-occurrence with the kind of properties that Sperry claimed. For example, their visual experiences do not seem an organization of neuronal activity (however complex and determined by specialized anatomical circuitry) any more than Sperry's (1952) visual experiences seemed mere preparations to respond.

Here, Smart (1981) is helpful, because he encouraged us to think how little we know subjectively about the nature of our experiences. I want to add that we also know very little from an objective perspective about Sperry's mental properties. I do not mean this simply as a criticism of Sperry's effort. I mean to express, rather, my own conviction that the functioning of the brain is not as mundane as think the critics who compare it with their highly meaningful and luxuriant mental phenomena. It is often such a comparison between something rich and vibrant and something else of an uninteresting basic simplicity that decides the question of whether experiences could be brain processes. I believe that such views simply reflect the historical point at which we find ourselves in our understanding of the brain. The best we have been able to do in capturing in objective language the relevant higher-order properties of brain-process is the sort of scientific poetry that, following Sperry, Dewan (1976) produced:

I am proposing that our "inner world" which we "perceive" within "ourselves" is the emergent self-controlling virtual governor resulting from generalized entrainment of large numbers of superadaptive optimum control systems arranged into a hierarchical mutually cooperative structure—of sublime and majestic engineering dimensions! (p. 193)

The erroneous nonphysical characterization of mental occurrences is not due only to introspective ignorance, but due also to our inability imaginatively to grasp the unique kind of brain-functioning that possesses among its properties the qualities we experience.

### References

- Addis, L. (1982). Behaviorism and the philosophy of the act. *Noûs*, 16, 399-420.
- Armstrong, D.M. (1968). *A materialist theory of the mind*. London, England: Routledge and Kegan Paul.
- Bergmann, G. (1956). The contribution of John B. Watson. *Psychological Review*, 63, 265-276.
- Bindra, D. (1970). The problem of subjective experience: Puzzlement on reading R.W. Sperry's "A modified concept of consciousness." *Psychological Review*, 77, 581-584.

- Brentano, F. (1973). *Psychology from an empirical standpoint*. New York: Humanities Press. (Second German edition published in 1911)
- Dewan, E.M. (1976). Consciousness as an emergent causal agent in the context of control system theory. In G.G. Globus, G. Maxwell, and I. Savodnik (Eds.), *Consciousness and the brain* (pp. 181-198). New York: Plenum.
- Eccles, J.C. (1973). *The understanding of the brain*. New York: McGraw-Hill.
- Eccles, J.C. (1974). Cerebral activity and consciousness. In F.J. Ayala and T. Dobzhansky (Eds.), *Studies in the philosophy of biology* (pp. 87-107). Berkeley: University of California Press.
- Eccles, J.C. (1976a). Brain and free will. In G.G. Globus, G. Maxwell, and I. Savodnik (Eds.), *Consciousness and the brain* (pp. 101-121). New York: Plenum.
- Eccles, J.C. (1976b). How dogmatic can materialism be? In G.G. Globus, G. Maxwell, and I. Savodnik (Eds.), *Consciousness and the brain* (pp. 155-160). New York: Plenum.
- Feigl, H. (1981). *Inquiries and provocations: Selected writings 1929-1974*. Dordrecht, Holland: Reidel.
- Freud, S. (1966). Project for a scientific psychology. *Standard edition* (Vol. 1, pp. 295-397). London, England: Hogarth. (Composed in 1895)
- Hebb, D.O. (1980). *Essay on mind*. Hillsdale, New Jersey: Erlbaum.
- Hebb, D.O. (1981). Consider mind as a biological problem. *Neuroscience*, 6, 2419-2422.
- Natsoulas, T. (1970). Concerning introspective "knowledge." *Psychological Bulletin*, 73, 89-111.
- Natsoulas, T. (1973). Own emotion awareness. *Interamerican Journal of Psychology*, 7, 151-187.
- Natsoulas, T. (1974). The subjective, experiential element in perception. *Psychological Bulletin*, 81, 611-631.
- Natsoulas, T. (1977). Consciousness: Consideration of an inferential hypothesis. *Journal for the Theory of Social Behaviour*, 7, 29-39.
- Natsoulas, T. (1978). Toward a model for consciousness, in the light of B.F. Skinner's contribution. *Behaviorism*, 6, 139-175.
- Natsoulas, T. (1981). Basic problems of consciousness. *Journal of Personality and Social Psychology*, 41, 132-178.
- Natsoulas, T. (1982). Conscious perception and the paradox of "blind-sight." In G. Underwood (Ed.), *Aspects of consciousness* (Vol. 3, pp. 79-108). London, England: Academic Press.
- Natsoulas, T. (1983a). A selective review of conceptions of consciousness with special reference to behavioristic contributions. *Cognition and Brain Theory*, 6, 417-447.
- Natsoulas, T. (1983b). Concepts of consciousness. *The Journal of Mind and Behavior*, 4, 13-59.
- Natsoulas, T. (1983c). Perhaps the most difficult problem faced by behaviorism. *Behaviorism*, 11, 1-26.
- Natsoulas, T. (1983d). What are the objects of perceptual consciousness? *American Journal of Psychology*, 96, 435-467.
- Natsoulas, T. (1984a). Freud and consciousness: I. Intrinsic consciousness. *Psychoanalysis and Contemporary Thought*, 7, 195-232.
- Natsoulas, T. (1984b). Gustav Bergmann's psychophysiological parallelism. *Behaviorism*, 12(1), 41-69.
- Natsoulas, T. (1985). The treatment of conscious content: Disorder at the heart of radical behaviorism. *Methodology and Science*, 18, 81-103.
- O'Shaughnessy, B. (1974). The id and the thinking process. In R. Wollheim (Ed.), *Freud* (pp. 222-241). Garden City, New York: Anchor/Doubleday.
- Place, U.T. (1956). Is consciousness a brain process? *British Journal of Psychology*, 17, 44-50.
- Popper, K.R., and Eccles, J.C. (1977). *The self and its brain*. Berlin: Springer-Verlag.
- Puccetti, R. (1978). Unravelling the world knot: Scientists and philosophers on the mind-brain controversy: Review of *Consciousness and the brain* edited by G.G. Globus, G. Maxwell, and I. Savodnik. *British Journal for the Philosophy of Science*, 29, 61-68.
- Savage, C.W. (1976). An old ghost in a new body. In G.G. Globus, G. Maxwell, and I. Savodnik (Eds.), *Consciousness and the brain* (pp. 125-153). New York: Plenum.
- Searle, J.R. (1980). Author's response: Intrinsic intentionality. *Behavioral and Brain Sciences*, 3, 450-457.
- Searle, J.R. (1983). *Intentionality*. Cambridge, England: Cambridge University Press.
- Skinner, B.F. (1974). *About behaviorism*. New York: Knopf.
- Smart, J.J.C. (1959). Sensations and brain processes. *Philosophical Review*, 68, 141-156.

- Smart, J.J.C. (1981). Physicalism and emergence. *Neuroscience*, 6, 109-113.
- Sperry, R.W. (1952). Neurology and the mind-brain problem. *American Scientist*, 40, 291-312.
- Sperry, R.W. (1964). Problems outstanding in the evolution of brain function. In *James Arthur lecture*. New York: American Museum of Natural History.
- Sperry, R.W. (1965). Mind, brain, and humanist values. In J.R. Platt (Ed.), *New views on the nature of man* (pp. 71-92). Chicago: University of Chicago Press.
- Sperry, R.W. (1966). Brain bisection and mechanisms of consciousness. In J.C. Eccles (Ed.), *Brain and conscious experience* (pp. 298-313). New York: Springer-Verlag.
- Sperry, R.W. (1968). Hemisphere deconnection and unity in consciousness awareness. *American Psychologist*, 23, 723-733.
- Sperry, R.W. (1969). A modified concept of consciousness. *Psychological Review*, 76, 532-536.
- Sperry, R.W. (1970a). An objective approach to subjective experience: Further explanation of a hypothesis. *Psychological Review*, 77, 585-590.
- Sperry, R.W. (1970b). Perception in the absence of neocortical commissures. *Research Publications of the Association for Research in Nervous and Mental Disease*, 48, 123-138.
- Sperry, R.W. (1976a). Changing concepts of consciousness and free will. *Perspectives in Biology and Medicine*, 20, 9-19.
- Sperry, R.W. (1976b). Mental phenomena as causal determinants in brain function. In G.G. Globus, G. Maxwell, and I. Savodnik (Eds.), *Consciousness and the brain* (pp. 163-177). New York: Plenum.
- Sperry, R.W. (1977a). Bridging sciences and values: A unifying view of mind and brain. *American Psychologist*, 32, 237-245.
- Sperry, R.W. (1977b). Forebrain commissurotomy and conscious awareness. *Journal of Medicine and Philosophy*, 2, 101-126.
- Sperry, R.W. (1978). Mental monism: Consciousness as a causal emergent of brain processes. *Behavioral and Brain Sciences*, 3, 367-369.
- Sperry, R.W. (1980). Mind-brain interaction: Mentalism, yes; dualism, no. *Neuroscience*, 5, 195-206.
- Sperry, R.W. (1982). Some effects of disconnecting the cerebral hemispheres. *Science*, 217, 1223-1226.
- Sperry, R.W. (1985). *Science and moral priority*. New York: Praeger.
- Uttal, W.R. (1978). *The psychobiology of mind*. Hillsdale, New Jersey: Erlbaum.
- Weimer, W.B. (1977). A conceptual framework for cognitive psychology: Motor theories of mind. In R. Shaw and J. Bransford (Eds.), *Perceiving, acting, and knowing* (pp. 267-311). Hillsdale, New Jersey: Erlbaum.