

## Consciousness and Commissurotomy: I. Spheres and Streams of Consciousness

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This begins a series of articles whose purpose it is to review and to analyze all that is known or held about the consciousness of commissurotomed people. The study of these people is an unusual area of contemporary scientific research because questions loom large therein concerning their consciousness. Psychologists of consciousness may hope to improve their understanding of the general topic through detailed and careful attention to the forms that consciousness takes in commissurotomed people— who possess, some researchers argue, two simultaneously flowing streams of consciousness! In the first installment of the series, most of the discussion centers on the difference between *spheres* and *streams* of consciousness in the explanation of behavior produced after the cerebral hemispheres have been disconnected from each other. Also receiving particular attention are certain agnostic and skeptical positions that question how disunified consciousness actually is in the commissurotomed or that deny consciousness to the mute hemisphere.

### Does Surgery Engender Two Streams of Consciousness?

The consciousness of commissurotomed people is the main question of this article. Those psychologists who, in increasing numbers, are addressing the problems of consciousness (Natsoulas, 1978, 1981, 1983) should attend closely to this area of empirical research, which is one of few where questions loom large about the consciousness of the people studied. In this regard, Newcombe (1985) expressed the general opinion among researchers concerned with commissurotomy when she stated, "The data *per se* require an explanation that cannot avoid the question of consciousness and intention" (p. 168). By improving our understanding of the consciousness of commissurotomed people, we may hope to improve our understanding of consciousness in general. The question here is *whether we can explain their behavior without having to postulate a stream of consciousness in every disconnected cerebral hemisphere*, or two streams of consciousness transpiring, therefore, within each such person. As Puccetti (e.g., 1973, 1975, 1976, 1977) would ask, does brain surgery engender (or make

manifest) two streams of consciousness? I use the concept of a stream of consciousness in the full sense, with which all contemporary psychologists are well acquainted. It was William James himself who spelled the concept out in great detail a long time ago and as part of his *magnum opus*, which psychologists still study and revere (James, 1890/1981). Consequently, all psychologists will recognize the above question takes the topic of consciousness and commissurotomy well beyond the presence in both cerebral hemispheres of "information processing abilities" (Gillett, 1986). Everyone will grant computers possess such abilities. Eccles (1970) once held the commissurotomed person's mute right hemisphere is a kind of computer. As such, it has information processing abilities, of course; and it is devoid of all conscious experience. Eccles was right about computers, and probably wrong about the right hemisphere. For those who would blithely impute consciousness to computers, Puccetti (1983) had harsh yet appropriate words. It was not at all clear to him, he stated, "that with cognitivism we have not passed from the sterile abyss of behaviorism to an equally sterile attitude of rank superstition" (p. 737). No computer has a stream of consciousness (James, 1890/1981; Natsoulas, 1985-1986; cf. the implications of Searle's, 1980, and Sayre's, 1986b, assessment of "the mental life" of the computer). A stream of consciousness consists of no less than a succession of awarenesses. Each awareness in the stream is a cognitive apprehension of something or, at least, it seems so to be when the something does not exist (Natsoulas, 1982). In any case, each awareness has a meaningful content. And certain effects of awarenesses depend on their having that content (cf. Dretske, 1985; Heil, 1986; Sayre, 1986a). Sperry (1976b) expressed this view when he stated, "The conscious subjective properties . . . have causal potency in regulating the course of brain events" (p. 175; cf. Sperry, 1977, p. 119). Neither meaning (content) nor subjectivity characterizes the contrasting information processing that goes on in computers. That a computer has different causal properties than the brain is only the least that one can rightly say (cf. Doty, 1975).

### Agnostic and Skeptical Positions

Recently, Gillett (1986) joined certain past authors (see Zangwill, 1974) in arguing that to postulate "two separate spheres of consciousness" (as did Sperry, 1965, p. 299) is unreasonable and unnecessary for explaining the behavioral findings with commissurotomed people. Somewhat similarly, Rey (1983) stated,

Perhaps [the cerebral commissures] serve to integrate consciousness in the normal case, but when they are cut, consciousness becomes centered only in the left hemisphere; or perhaps only in the right! Or in both. Or, for all we presently know, in neither. I know of no evidence that supports one of these hypotheses to the exclusion of the others. (p. 734; cf. Puccetti's, 1983, reply)

Such agnostic and skeptical positions differ markedly from the position of some researchers who have tested commissurotomed people. These researchers would agree with Zaidel's (1985) statement that "two separate and simultaneous streams of consciousness in the same individual [are] easily demonstrated in the disconnected brain" (p. 314). This statement by a psychologist who has interrogated the right hemisphere for extended periods of time appeared without qualification, explanation, or embarrassment. Elsewhere, Zaidel (1983) summarized his extensive studies by saying that, had a Martian performed as the right hemisphere does, the Martian would have overwhelmed Zaidel with its humanness, familiar scope of cognition and values, and sense of the past and future. However, not all researchers in the field share Zaidel's understanding of right hemispheric functioning. For example, LeDoux (1985) argued, "Physical partitioning of the human brain through split-brain surgery can, but does not necessarily, lead to a splitting and doubling of consciousness" (p. 207). A close look at LeDoux's argument reveals not a denial of consciousness in some disconnected human right hemispheres but a denial of the *humanness* of the consciousness that goes on there. That is, the consciousness of the right hemisphere is human only when its linguistic abilities are properly developed. Although LeDoux and Gazzaniga (1981) also emphasized the verbal, they qualified their emphasis in an important way: "While nonverbal processing, such as processing of the sensory world or of one's emotional state, can and obviously does reach awareness, its primacy in awareness quickly leads to verbal analysis" (p. 110). Human awareness and verbal analysis are two things; the first is not reducible to the second. Therefore, verbal analysis is unnecessary for consciousness of a human kind, and a disconnected right hemisphere may be conscious in this way though, on its own, it lacks linguistic abilities. Gazzaniga and LeDoux's position on consciousness deserves examination. In the present series of articles, agnostic and skeptical positions regarding the existence of dual consciousness after commissurotomy shall figure prominently, though not all the positions at once. Such positions are, in general, very valuable for present purposes; they serve to forestall a quick and easy answer to the main question that I shall be considering. Among the skeptical positions that I shall address in this first installment is Gillett's (1986) recently published case against consciousness in the mute disconnected hemisphere. Before that, discussion turns to Marks's (1981) claim that the operation of severing all the commissures that connect the cerebral hemispheres does not disunify the patient's consciousness except on those occasions, subsequently, when he or she faces special stimulatory conditions. More immediately, I discuss the "functionalist" view of Sperry (1977/1985), according to which the right and left disconnected hemispheres may produce, relative to each other, both unified and disunified conscious experiences.

### Spheres of Consciousness and Streams of Consciousness

Let me begin by discussing in a preliminary way the difference between two concepts that have been used in the literature to describe and to explain the psychological functioning of commissurotomized people. Psychologists have characterized these people as each possessing (a) two streams of consciousness or (b) two spheres of consciousness (e.g., Sperry, 1977/1985; see Moor, 1982). My purpose in considering the two concepts is to prepare for an examination, in subsequent sections, of a use of "sphere of consciousness" that bears on the issue of how many streams of consciousness a commissurotomized person has. Before I proceed, I should explain that I do not seek here to improve the concept of a sphere of consciousness, and I do not advocate that psychologists adopt this concept. I believe that, in the long run, psychologists will find the less expedient concept of a stream of consciousness more scientifically fruitful. The difference between spheres and streams is not merely a linguistic matter; the two concepts correspond to two competing perspectives on the consciousness of commissurotomized people, and also on psychological explanation more generally. These two perspectives are suitably designated "realist" and "functionalist." Consider, first, the "realism" of the concept of a stream of consciousness. The concept purports to have a real referent that transpires within a person or animal. Contrary to the dualism of James's *Principles* (1890/1981), my view is that an individual's stream of consciousness is an ongoing process in the person's brain (cf. Werth, 1986). Let me call attention, therefore, to the following statement reproduced from a well-known article by Sperry (1969) on the mind-brain problem. This statement could very well be a brain-process description of the stream of consciousness, or parallel segments of it:

The present view suggests the presence of ongoing central processes specifically organized for conscious awareness around the different sensory modalities. The central mechanisms have their own intrinsic organization and special dynamics that in large part are determined centrally and autonomously. The sensory input becomes incorporated into the central process, altering the dynamics of the system and thereby its conscious properties. The initial train of sensory inflow is largely absorbed and transformed within the higher level central mechanism, and only indirectly through its perturbation of the holistic properties of the central process does the sensory input influence awareness or the volitional motor response. (p. 535)

The ongoing brain process that is the stream of consciousness proceeds whether or not this process is determining or influencing behavior at the moment. We each know the referent of the concept, or some of its durational constituents, very directly in our own case. Although, for a while, my stream of consciousness may not include any reflective constituents (James, 1890/1981; Natsoulas, 1985-1986), the inclusion of such components in my stream is how I know that a stream of consciousness proceeds within me. This means that

I do not infer the existence of my stream of consciousness from how I am behaving. I do not postulate it as a way to explain why I am behaving as I am. Therefore, we do not hesitate, normally, to ascribe the same kind of stream to other people even at times when we have no desire to explain any particular piece of their behavior. Our very common ascription of a stream to people who are, as we say, only thinking is compatible with interpreting the stream, together with Sperry (1952), as a "pre-premotor" brain process. Whether or not the psychologist needs to explain the person's behavior with reference to the stream, the person's stream flows on. The latter statement may seem unnecessary to make, yet it emphasizes the realism of the stream; the concept of the stream of consciousness is not just a conceptual instrument for bringing order to the scientific construal of behavior. The concept is such that skeletal motor paralysis would not be decisive with regard to whether the concept is applicable to the paralyzed person. In contrast, the concept of a sphere of consciousness is closely tied to the behavior that the concept is used to explain. Whether a person at a certain time possesses a single sphere of consciousness or two such spheres is a matter of the behavior that the person is manifesting and the number of spheres needed to explain this behavior. Accordingly, the internally fully integrated behavior of an individual indicates a single sphere of consciousness—if it indicates any at all. That is, it may not be parsimonious to invoke consciousness at all, if the behavior can be otherwise explained. It would seem highly consistent with the spheres approach not to consider the person as having even a single sphere of consciousness, at any particular moment, unless the character of the behavior to be explained somehow demands it. In terms of brain function, we may say that the brain's functioning in a disunified manner relative to behavior may constitute grounds for proposing the existence of a second sphere of consciousness. And then, when the brain stops functioning in a disunified manner (as present behavior shows), the second sphere goes out of existence (if that is the correct expression) perhaps quite suddenly, as quickly as it was invoked. Thus, the picture that the spheres approach furnishes us is of a person possibly proceeding through the day with frequent shifts in the number of spheres of consciousness that he or she possesses, from one to two to none and so on, depending on what he or she is doing and what, minimally, the psychologist needs to explain it. I believe that the much less instrumental concept of a stream of consciousness is also less ambiguous of application. Evidently, two spheres can vary in their degree of "separateness" (see next section). If their "separateness" declines sufficiently over time, one may want to think instead of a single, somewhat disunified sphere. In contrast, two streams of consciousness cannot merge into a single stream. Being anatomically distinct and nonoverlapping processes, either both streams flow on, or only one of them does, or both streams stop. However similar two streams may

be, they would remain separate and distinct; sameness is not identity. Bogen (1981) mentioned the hypothetical healing of completely severed cerebral commissures. The healing would result in a single stream (though not according to Bogen, who held that intact people, too, have two streams) where previously, due to the commissurotomy, there were two streams. However, this hypothetical healing would not constitute a merging of the two streams; rather, a single stream of consciousness would replace the two streams, a stream that did not exist while the hemispheres were disconnected. The new stream (after healing) would transpire in an anatomical structure that included parts of the cerebral commissures and parts of the cerebral hemispheres. Later in the present article, the notion of a fusion of processes across the commissures shall enter the discussion. This notion from the literature pertains to how a single process is produced across structures that we know are such as to support two distinct processes. As I shall argue, fusion is no mere matter of causal interaction between the two processes; nor is fusion a matter of "communication" between the two processes, as some psychologists like to say. As will also be seen, the picture that I have drawn of distinct streams is not translatable into the language of spheres. I stated that, however similar two streams of consciousness may be, they remain separate and distinct. The same does not apply to the functionalist proposal of spheres of consciousness. The more reason that a psychologist has to think of the commissurotomed person's two spheres as similar, the less reason that the psychologist has to consider them as two.

### Never Totally Separate Spheres of Consciousness

Marks (1981; see below) stated that conscious unity has a different physical basis in commissurotomed people than conscious unity has in people with commissures intact. Consequently, commissurotomed people have a disunified consciousness in certain situations, where intact people have a unified consciousness. Indeed, thinking along with Marks in terms of spheres rather than streams, one might as well consider the commissurotomed each to possess a single sphere that varies in unity depending on the situation. Attributing two separate spheres to a commissurotomed person holds difficulties because their consciousness may never be (perhaps not even in sleep) completely "divided." As Bogen (1981) emphasized, "Having two hemispheres in a separate head is *not* the same as having two spheres in the same head" (p. 100). Total separation, two quite distinct spheres of consciousness, would require (a) that the two spheres not be affected in common by, for example, environmental or bodily stimulation or by activity in subcortical structures (causal independence), (b) that the same perceptual and other awarenesses not take place at the same time in both spheres (uniqueness) and (c) that

neither sphere contains awareness of what there is awareness of in the other sphere (mutual ignorance). If one does think of commissurotomed people as possessing all along two spheres of consciousness, it is clear that in none of these people are their two spheres totally separated (cf. Moor, 1982, pp. 94-95; Sperry, 1977/1985, pp. 21-22). As the present article proceeds, examples will make evident their lack of two distinct spheres in the above sense. Therefore, Moor (1982) quite rightly concluded, "There is a certain arbitrariness about how much disconnection is demanded and how much connection is tolerated in establishing separate spheres of consciousness in split-brain patients" (p. 95). That the commissurotomed person's two spheres may be very much "unseparated" comes over vividly in Puccetti's (1983) report of an observation that Jerre Levy orally described. The completely commissurotomed L.B. startled Levy when his left hemisphere identified ten consecutive objects he felt with his left hand and could not see. Prior to these trials, the left hemisphere had performed at chance levels in choosing which one of several names belonged to the object felt with the left hand. Such failed performances are due to the absence in the disconnected left hemisphere of adequately informative tactual awarenesses of objects felt with the left hand, together with inadequate cross-cuing and subcortical "communication" from the informed right to the uninformed left cerebral hemisphere (Myers and Sperry, 1985). Levy asked L.B. how he managed the feat of ten correct choices. L.B. explained that

he "noticed" that his eyes were wandering about the room and visually fixating on particular places as he struggled to guess the correct name. He then *inferred* that when he "found" his eyes fixated upon a round object like the doorknob, the object held in his left hand out of sight was also round. When his eyes fixed on a square floor tile, he guessed that the palpated object was square as well, and his eyes scanning the outline of the door resulted in a successful guess of the oblong-shaped object in the hand. To check that this was indeed what was going on, Levy blindfolded L.B.; his performance immediately fell to its customary chance level. (Puccetti, 1983, p. 737)

Puccetti interpreted the mute hemisphere's cross-cuing behavior as a conscious performance, which seems quite reasonable (contrast Gillett, 1986, discussed below). If it was a conscious performance, then the right hemisphere attempted to and succeeded in determining the left hemisphere's visual awareness in such a way as to influence the left hemisphere's answers to Levy's questions. Thus, there occurred common visual stimulation of the two hemispheres and some of the same visual awarenesses in both hemispheres, and the mute hemisphere had some thoughts concerning the speaking hemisphere's seeing and inferring. Although L.B. failed to satisfy all three of the criteria for totally separate spheres, there are good reasons to think each of his hemispheres includes a stream of consciousness. These reasons did not diminish when Myers and Sperry (1985) demonstrated that L.B. and another completely commissurotomed person had the capacity for interhemispheric transfer of in-

formation presumably through subcortical structures to the point where they could orally identify stimuli projected only to the right hemisphere. While this "communication" may take subcortical pathways, the left hemisphere's performance resembles what takes place with cross-cuing. The left hemisphere becomes aware of the transferred information and puts it to use in conjunction with certain cognitive strategies. The information travels, though not directly, from one stream of consciousness to the other, rather than serving to "fuse" processes in the two hemispheres into a single stream. I shall recur to this point in a subsequent section on "fusing." I stated above that Myers and Sperry's demonstration with L.B. does not detract from his having two streams of consciousness. Perhaps the case is strengthened by showing that an even less divided sphere is compatible with two streams (see below).

### Is There a Single Experience of Seeing the Spot?

It is tempting to summarize the considerations to this point with the statement: commissurotomed people possess two rather than one sphere of consciousness to the degree that their two streams, one transpiring in each hemisphere, differ in their causes and contents and are ignorant of each other. Insofar as the two streams flow in unison, have the same determinants, contain the same awarenesses at the same time, and are somehow aware of each other, they constitute a single sphere of consciousness. That is, the temptation is to define spheres in terms of streams. However, there is some indication that Sperry's (1952, 1977, 1977/1985) "functionalist" understanding of consciousness (see next section) gives rise, rather, to a tendency to define streams in terms of spheres. Part of the time, Sperry's concept of consciousness (as a totality) seems to have been the concept of a sphere rather than the concept of a stream. Therefore, Sperry (1977/1985) could say some aspects of consciousness are *not divided* in completely commissurotomed people: "Even in the bisected brain, the question of whether there exists a right-left division of conscious experience is not subject to an unqualified 'yes' or 'no' answer" (p. 21). Notice the reference to *conscious experience itself*. As Sperry saw it, a bilateral duplication in the two hemispheres of the processes relevant to consciousness means consciousness is not divided. As an example of what he had in mind, he mentioned the bilateral representation of stimulation from both sides of the face. Also, if a commissurotomed person explores an out-of-sight object with both hands at once, both hemispheres will be affected extremely similarly. Another example of undivided consciousness, among others Sperry provided, was the spread of emotion from one disconnected hemisphere to the other through subcortical structures to which both hemispheres remain fully connected (Sperry, Zaidel, and Zaidel, 1979; cf. Gazzaniga and LeDoux, 1978). In listing the second of these three examples of



undivided consciousness, Sperry used the phrase "a bilateral unified percept of an object in both hemispheres." This phrase succeeds in encapsulating the issue. Use of this phrase naturally evokes the question whether, in such cases, the consciousness of the commissurotomed person is divided or unified (or both?). Are there two streams of the above experience of feeling the object? Or was Sperry tempted to draw the conclusion that Marks (1981) expressed as follows?

The ambient visual field of the split-brain patient is unified even in the experimental setup [Trevarthan and Sperry, 1973]. Thus, for example, if a moving spot is flashed in the periphery of the left visual field, the split-brain patient can report the fact and indicate, left-handed, a similar awareness. Presumably this is accounted for by subcortical structures [Trevarthan and Sperry: "extrageniculate visual system"]. On . . . any reasonable . . . criterion, there is a single experience of seeing the spot. (p. 24)

In fact, Trevarthan and Sperry (1973) entitled their experimental report "Perceptual Unity of the Ambient Field in Human Commissurotomy Patients," and concluded, "Ambient vision remains undivided after hemispheric deconnection, in spite of the complete separation of focal visual perceptions at the vertical meridian caused in the same subject by the operation" (p. 569). *Is there a single experience of seeing the spot in the periphery and, at the same time, two experiences of seeing an object when two objects are presented less peripherally, one of them in each half-field?* As will be seen, when Marks (1981; see above quote) argued there is a single experience of the peripherally presented spot, he claimed something else than there being "a representation of the visual field in the undivided parts of the brain that are in functional communication with both hemispheres at once" (Trevarthan, 1974a, p. 247). The latter statement, together with Trevarthan's (1974b) consistent presentation of the experimental results (Trevarthan and Sperry, 1973) in terms of the experience of the commissurotomed person, rather than in terms of the two hemispheres, suggests that unified ambient visual perception proceeds in subcortical structures, whereas more focally presented objects are perceived by one or the other hemisphere, depending on the visual field in which the objects are presented. Accordingly, Trevarthan (1979) spoke of "an undivided brain-stem 'ambient' vision in commissurotomy patients" (p. 201). The alternative is, of course, two streams of consciousness, one in each hemisphere, that both include experience of certain peripheral stimulation to either field (Puccetti, 1981a). Were it not for Sperry's "functionalism," the latter would be the natural interpretation of his position, especially after he stated, concerning the bilateral representation of stimulation from both sides of the face, "We presume, however, by extrapolation, that these unified 'whole-face' experiences in each hemisphere are cut off from their counterparts in the opposite hemisphere" (Sperry, 1976b, p. 172).

### The Hypothesis of Conscious Unicity through Functional Unity

Searching for a consistent answer to the question that serves as the title of the preceding section, one may find the following distinction helpful. Puccetti (1981b, 1983) distinguished between (a) the possible “unicity” or singleness of consciousness and (b) “unity in the sense of consciousness constituting a unified whole.” Then he added, “It is clear that conscious unity is compatible with duality as well as unicity” (Puccetti, 1981b, p. 95). In Puccetti’s highly controversial view (cf. Bogen, 1969, 1985; Harrington, 1985b; Oakley and Eames, 1985; Wigan, 1844/1985), any person with two adequately functioning hemispheres (whether disconnected or fully attached) does not possess merely a single consciousness. Duality rather than unicity of consciousness characterizes him or her. I do not discuss Puccetti’s view here, although the view is useful for the distinction it provides. Thus, each of the person’s two consciousnesses—in the sense, apparently, of streams—may be themselves internally unified and also functionally unified relative to each other. Functional unity means the two streams work to a common effect. Yet, they are no less, according to Puccetti, two streams. Applying the unity-unicity distinction to Sperry’s view of spheres and streams, one can give the following tentative interpretation. Perhaps Sperry never meant to suggest two disconnected hemispheres ever have between them a single (undivided, unseparated) conscious experience. After commissurotomy, conscious unicity is gone for good. Rather, Sperry meant the commissurotomized person’s two consciousnesses are often unified in the sense of their functioning together to produce a common, integrated result (cf. Trevarthan, 1979). Unfortunately, Sperry’s position appears to be less straightforward than this understanding of it. The complexity of his position follows from his conception of consciousness, which is “functionalist” in a sense that requires some explanation. (Throughout this discussion, I place quotation marks around the word to restrict its reference to Sperry’s brand of functionalism.) *In brief, normal conscious unicity in the person with hemispheres connected is a consequence of functional unity.* Or, as Sperry (1977) explained,

I see consciousness and the conscious self as being normally single and unified, mediated by brain processes that typically involve and span both hemispheres through the commissures. This interpretation implies: first, that the fiber systems of the brain mediate the stuff of conscious awareness as well as the switching mechanisms, synaptic interfaces, or other interaction sites of the gray matter; and second, that the fiber cross connections between the hemispheres are not different in this respect from fiber systems within each hemisphere. Third, this interpretation is based on a theory of consciousness that goes back to the early 1950s (Sperry, 1952) in which the subjective unity in conscious experience, along with other subjective effects is ascribed not so much to corresponding spatiotemporal unity in neural activity or to other isomorphic or topological correspondence but rather to the operational or functional effects in brain dynamics. What counts in determining subjective meaning on these terms is the way a given brain process works in the context

of cerebral organization. Subjective unity is accordingly conceived in terms of organizational and functional relations which in turn leads to the idea of a functional (thus causal) impact. (p. 116)

Note the reference to subjective unity in conscious experience, which would seem to be an internal property of the experience rather than a property of how the experience relates to something else. An instance of experience, such as hearing a tone, is unitary, internally unified, because the processes constituting this instance of experience operate together in brain dynamics to a common effect. And it is from this functional unity that unicity of consciousness arises across the commissures. For example, people with intact, normally functioning commissures experience right and left visual half-fields as continuous with each other and have only a single such experience at a time. Although they focus firmly on a fixation point, they experience the half-fields once, not twice, and as undivided, despite the fact that components of the process transpire bilaterally and in good part duplicatively (as well as in subcortical cell groups according to LeDoux and Gazzaniga, 1981, p. 110). Sperry (1976b) explained the single internally unified experience as due to the relevant parts of the hemispheres' functioning together as a unit in "the causal sequence of cerebral control" (p. 174). In contrast, when "commissural communication" fails to work, the brain process is divided or separated and the two parts of it, one part in each hemisphere, have separate effects. Here, Sperry was referring to what transpires under tachistoscopic conditions when a stimulus figure is flashed to each disconnected hemisphere. Under these conditions, a duality of consciousness is manifested; as it is when commissurotomed people efficiently perform different manual sorting tasks with each of their two hemispheres simultaneously, that is, tasks that involve opposed decisions between hemispheres and that are difficult to execute by people with commissures entirely or partially intact (Ellenberg and Sperry, 1979, 1980). According to Sperry's "functionalist" conception of consciousness, the functional disunity of the two disconnected hemispheres makes for duality of consciousness. The obvious question to raise is what happens to the duality of consciousness when two disconnected hemispheres work to a common, integrated effect, as Trevarthan (1979) especially emphasized that they normally do.

### Perhaps a Consequence of the "Functionalist" Approach

Unicity of consciousness through functional unity of brain process—this was Sperry's answer to the problem that Eccles, too, faced. Although Eccles's dualist proposal was a different one from Sperry's, Eccles (1970) well stated the problem in the following terms:

One is confronted by the extraordinary problem of trying to reconcile the unitary nature of my conscious self with the neurological events of the utmost diversity and complexity that are assumed to underlie it, and that involve the "weaving" by impulses of spatio-temporal patterns in the "enchanted loom" of Sherrington with its thousands of millions of units or nerve cells. . . . As Sherrington (1940) points out, there is no "centralization upon one pontifical nerve cell." The antithesis must remain that our brain is a democracy of ten thousand million nerve cells, yet it provides us with a unified experience. (p. 80)

Not only does the total pattern have many constituents, but these patterns of neural activity are not, according to Sperry (1952), any kind of copy of the object one perceives. The four-dimensional geometric character of the brain process may greatly vary and yet give rise to the same experience, since this experience amounts to the brain process having a certain effect: "The same conscious effect . . . can be produced by different neural events on different occasions in different neural contexts provided the critical operational result at the holistic functional level is the same" (Sperry, 1969, p. 587). Accordingly, Sperry's "functionalist" account of consciousness is more compatible with an understanding of consciousness as a sphere than as a stream, because he emphasized the effect of the brain process more than its intrinsic character. Also, his account is not readily reconciled with this statement: "This division by surgery of the normally unified realm of conscious awareness [results in] two distinct domains of conscious experience that exist in parallel, and in some cases have content that is mutually contradictory" (Sperry, 1976b, p. 170; cf. Sperry, 1977, pp. 113-114). The "functionalist" view does not lead to two distinct domains of conscious experience that exist in parallel and have, at times, mutually contradictory contents and, at other times, mutually non-contradictory contents. The idea of two domains assigns content to each domain whether or not the two deconnected hemispheres are functioning together as a unit; even when the two domains possess the same content (see Sperry's, 1977/1985, examples of factors that unify the commissurotomed person's conscious experience), a unicity of consciousness is not thereby the case. The "functionalist" perspective on consciousness leads more readily to Mark's (1981) conclusion, "Split-brain patients, unlike us, have on occasion a disunified consciousness" (p. 39). Marks was saying these people exemplify a doubling of consciousness under appropriate experimental conditions and not during everyday life (cf. Moor's, 1982, p. 102, objection). The latter is an overstatement; there are situations in daily life like the testing conditions. For example, the person feels with the left hand for a particular small object among other small objects upon awakening in the dark. Another example is seeing an object to the left (right) of the vertical meridian at the left (right) limit of horizontal eye rotation, as can occur when sitting in an armchair with head resting and still (cf. Myers and Sperry, 1985). Both situations produce lateralization of sensory input, one hemisphere receiving information

the other hemisphere does not receive. Also, Gazzaniga (1985) suggested a hemisphere may cause the initiation of action of the whole person:

Consider the everyday life of a split-brain patient. The dominant left hemisphere is dealing with the world, fielding its questions, planning action, accounting for the body's moods, and so on. Suddenly, the right half-brain decides it wants the patient to take a walk. What does the left brain do? What does it think? More generally, what does the left brain make of the activities initiated by the right half-brain? (p. 70)

That this occurs in everyday life was an inference from experimental observations, and Marks (1981) would object to the inference on the grounds there is no need for it to explain integrated behavior (see below). The behavior in this case is integrated not only because it is the whole person's behavior, but also because the person will explain his or her purpose in engaging in the behavior. However, the relevant issue is not the frequency of disunified spheres of consciousness; it is the character of the consciousness of commissurotomed people when their hemispheres are working together, not at cross-purposes, without conflict. From Sperry's "functionalism" and the normally integrated behavior of commissurotomed people, it seems to follow that intact commissures are unnecessary for undivided conscious experience, and commissurotomed people's sphere of consciousness is usually as unified as that of people with adequately functioning cerebral commissures (cf. Nagel's, 1971, p. 403, fifth interpretation).

### **Perhaps Another Consequence of the "Functionalist" Approach**

One wonders what more exactly it is for the commissurotomed person's consciousness to be unified? Does such a person ever have a double stream of consciousness? Perhaps he or she can have a double stream only transiently and partially. Instead, should one speak of a single sphere of consciousness that sometimes is partially disunified? After all, even during laboratory testing, these people's hemispheres appear to function together as a unit in large part. As Nagel (1971) pointed out, "The patient is functioning largely as if he were a single individual: in his posture, in following instructions about where to focus his eyes, in the whole range of trivial behavioral control involved in situating himself in relation to the experimenter and the experimental situation" (p. 408). This is also true in everyday life: not only does the commissurotomed person's behavior appear consistently integrated; he or she does not resemble a hemispherectomized person, as though only one hemisphere were operative at a time (Bogen, 1969; Smith, 1966; Zangwill, 1967). All along the way, both hemispheres are making a collaborative contribution to the person's stream of behavior. Except for the consistently different responses that each hemisphere produces with special testing, the hemispheres are functioning as a unit in the determination of behavior with rare excep-

tions (Trevarthan, 1979). On this basis, commissurotomed people may be said to have a unified sphere of consciousness that gives occasional mixed signs of disunity, ambiguous signs that the hemispheres are not (entirely) functioning as a unit. From Sperry's "functionalist" account, it would seem also to follow that *commissurotomed people have only a single stream of consciousness*. At every successive moment, even during laboratory testing, there is reason to assume a single experience of one kind or another, that is, if one judges from the functional effect. I admit that much in Sperry's writings is better understood as referring to two effects (often the same) rather than a single effect the hemispheres produce together. Marks (1981) presented his own position, that commissurotomed people have only an occasionally disunified single consciousness (see below), in contrast to Sperry's view that "split-brain patients always have a disunified consciousness" (p. 17). Similarly, Benner and Evans (1984) stated, "Sperry's studies of commissurotomy patients lead him to argue that split-brain persons have two conscious streams of experience and therefore two minds" (Sperry, 1977, p. 424). Let me add: What could be more clear in this regard than Sperry's (1976a) quick review of the effects of dividing the brain surgically? This said, I must remind the reader that subjective unity of conscious experience depends on the component brain processes functioning as

a unity or entity, regardless of the multilevel and multicomponent makeup of the neural events involved. The overall, holistic functional effect could thus determine the conscious experience. If the functional impact of the neural activity has a *unitary effect in the upper-level conscious dynamics*, the subjective experience is unified. (Sperry, 1977/1985, pp. 22-23)

The same was stated in the article (Sperry, 1977) to which Benner and Evans referred. The precise constituents of the cause are not determinative and can vary widely. The brain process is "grainy," while the conscious experience is smoothly continuous (Sperry, 1980, p. 198). The total brain process corresponding to a conscious experience is unified by operating as an entity in cerebral dynamics. Its operating as an entity is experienced (from the inside) as a unity. Now apply this to disconnected hemispheres: what counts is their working together, so far as consciousness is concerned. Their singleness of function, whatever patterns the intrinsic activity might take (is this too strong?), is introspectively a unified conscious experience, a single conscious experience. At a certain level of functioning, of producing effects, functional unity yields conscious unicity. Sperry (1977/1985) wrote of "a unitary effect at the upper-level conscious dynamics." What is this level? At this level, can two hemispheres disconnected from each other produce a single unified effect? What did Sperry have in mind when he wrote of dynamics at this level? One would naturally think that Sperry had a stream of consciousness in mind. In seeking some clarity on these questions, it is useful to address a more unambiguous view than Sperry's, a view relevantly both like and unlike Sperry's.

### A Different Functionalist Approach

Although Marks (1981) advanced a functionalist position with some similarities to Sperry's, Marks clearly was not applying the concept of a stream of consciousness. According to Marks, laboratory studies have shown simultaneous conscious experiences occur in a commissurotomed person without direct (reflective) awareness of this fact (see next section). However, the studies have not shown these conscious experiences are components of streams, which flow through the person's life. Of course, Marks acknowledged that neural processes are taking place now that were related by direct causal routes before the commissurotomy and are no longer so related. But Marks disagreed this fact gives grounds for holding the consciousness of a commissurotomed person is disunified:

Why should neural processes unrelated by direct causal routes not be the physical basis for a single mental state? If one accepts—as I do—the general account of mind advocated by philosophers as diverse as Fodor [1975] and Grice [1975], there is some reason for thinking they sometimes are. On this view, minds are the things which have mental states; and mental states are the states required by an adequate psychological theory of the organism. This account does not require corresponding types of neurological states for each type of psychological state [cf. Sperry, 1969, p. 587]. Nor does it require any direct causal links between the neural events which are the physical basis for a single psychological state. It would be sufficient if causally unrelated neural events jointly, though separately, produced effects which were, from the standpoint of the psychologist, the basis of a single mental state. (p. 23)

Although the physiological connections are not decisive, Marks found it useful to express his thoughts in terms of unified and disunified consciousness. Consistent with the above methodological statement, whether or not a person's consciousness is unified or disunified (or whether the person possesses one or two spheres of consciousness) depends on behavior manifested from moment to moment. Marks (1981) argued the assumption of a disunified consciousness should be strictly limited to "those spots where it does genuine work" (p. 42). The psychologist must ask whether accounting for a certain behavior that transpires under certain conditions requires a single sphere or two spheres. And the very next behavior may be accounted for by the other number of spheres. For example, tachistoscopic presentation of different materials in the half-fields will work, with proper visual fixation, to disunify consciousness in identifiable ways (Marks, 1981, p. 50). Marks meant causally unrelated neural events, occurring in the hemispheres, will be differently affected for the moment by unlike stimulation and therefore produce different behavioral effects. And then, when the person looks away from the tachistoscope, his or her consciousness will be unified once more, since the corresponding neural processes now work, in the absence of differential stimulation of them, to the same effect. Marks (1981) was untroubled by Nagel's (1971)

objection to Marks's kind of view. Nagel had written such a view implies "minds pop in and out of existence" without any fundamental change in the commissurotomed person; more reasonably, consciousness is disunified before and after as well as during the experimental trials. Marks responded that the operation of unifying mechanisms in the brain may well depend on external factors. Those experimental conditions that prevent independent and simultaneous duplication of certain visual processes in the disconnected hemispheres, also prevent the unification of consciousness that depends on such duplication. One would rightly think of an experimental trial as an "intervention" that works to interrupt a unified performance. Before the intervention and after those special, and unusual, conditions are withdrawn, duplication across hemispheres and integrated behavioral function are the rule. As Benner and Evans (1984) concurred, "Split-brain patients can thus be viewed as people whose minds temporarily function in a disunified manner" (p. 427). Marks (1981, p. 48) explained his account does not require commissurotomed people to behave in a nonintegrated fashion only in laboratory tests. Insofar as they elsewhere manifest such behavior, Marks would explain the behavior in terms of factors other than a disunified consciousness. Presumably, this is because we have no evidence this nonintegrated behavior is due to simultaneous experiences transpiring without direct (reflective) awareness of their joint occurrence. I must, therefore, consider this further aspect of Marks's view.

### A Further Aspect of Marks's Position

Marks (1981) did not define unity and disunity of consciousness in terms of behavioral integration and nonintegration; explanation of the latter will include reference to mental states and their properties, including the unity or disunity of consciousness; the above experimental intervention disunifies consciousness to a degree that a deficiency of behavioral integration manifests itself. As part of his explanation of the nonintegrated experimental behavior of commissurotomed people, Marks proposed the occurrence of simultaneous conscious experiences. However, the person can orally indicate the occurrence of only one of the conscious experiences (and can indicate the occurrence of the other experience with the left hand). Marks defined unity and disunity in terms of direct (reflective) awareness. He stated, "Split-brain patients sometimes have a disunified consciousness: that is, under certain experimental conditions, they have simultaneous conscious experiences whose joint occurrence is not introspectively disclosed" (p. 17). This aspect of Mark's position leaves room for theoretically important cases he did not consider. A mere causal relation between conscious unity (disunity) and behavioral integration (nonintegration) allows for the possibility of behavioral



integration in the absence of unified consciousness. Whereas some cases of behavioral integration may require a unified consciousness, others may be caused in a different way, even taking place under disunified consciousness. This is what Puccetti (1981a) had in mind when he stated, "Fred Astaire and Ginger Rogers may have danced as one, but they were two nevertheless" (p. 118). For Puccetti, "genuine integration" would require a single consciousness. But it is not obvious that Fred and Ginger, dancing together, fell short of real integration, and that this can only happen with unicity of consciousness. Consider a related example, the case of two excellent pianists who, due to accidents, have the use of only their right and left arm respectively. With practice together, they could jointly perform well a great many compositions, each playing the respective hand's part. Of course, their consciousnesses are mutually disunified by Marks's criterion; neither can have direct (reflective) awareness of the other's conscious experiences. (Puccetti, 1985, found it necessary to argue that two people cannot introspect each other's experiences, in order to further argue that two minds per person would mean an inability of each to have direct, reflective awareness of the other's experiences. In her reply, Harrington, 1985a, did not fully grasp Puccetti's point.) Perhaps the pianists' consciousnesses are not mutually disunified by Sperry's "functional" criterion, since their brain processes are working together to produce a common, integrated effect in the upper-level cerebral dynamics (see below). In any case, the example of the two unfortunate pianists shows that genuinely integrated behavior (one could not tell without looking whether one or two people were performing) does not require unified consciousness in the introspective sense Marks defined. And this is also true when the integrated behavior is performed by a commissurotomized person. This person normally performs in an integrated manner though, in my view, his or her consciousness is always disunified in Marks's sense. That is, a commissurotomized person has two simultaneous conscious experiences, at any point where neither stream is stopped. Even when there is experimental reason to believe a commissurotomized person is simultaneously having two different conscious experiences, his or her behavior may be integrated. Levy (1983) pointed out that double responses (one by each hemisphere) are extremely rare in a certain competitive perception experiment she has repeatedly conducted. On almost every trial, she found the commissurotomized person will ignore stimulation presented in one or the other half-field. The subject responds to one of the two, but very seldom to both. Yet, under these conditions, there is an excellent, familiar reason to suppose two different visual experiences on each trial. It can be shown with the same stimuli and different instructions that the nonresponding hemisphere is visually affected, is having visual experiences throughout a series of trials. These are produced by the same stimuli that the subject ignores in Levy's experiment. Surely, no one will argue that the change in

instructions is responsible for the occurrence of visual experiences.

### **The Preferred Interpretation**

I have just expressed what I believe is the preferred interpretation of the consciousness of commissurotomed people. Even when the commissurotomed person's behavior is a good example of an integrated behavior, more than a single conscious experience at a time typically occurs in him or her. This interpretation is the preferred one for the following kind of reason. This reason does not stand alone; it is an example of what makes the present interpretation compelling. The visual experiences of a person with left (right) hemispherectomy transpire at least in part in the visual areas of the right (left) hemisphere. This brain process which takes place in the hemispherectomized person also takes place, twice at a time, in the commissurotomed person. He or she retains both visual areas wherein transpire visual experiences at least in part. The connections between disconnected hemispheres and the rest of the brain are not equivalent in function to the cerebral commissural connections (see below). The subcortical pathways between disconnected hemispheres cannot fuse the brain processes in the parallel visual areas and so produce a single stream of visual experiences. If they could fuse the two processes, the experimental findings with commissurotomed people would be very different than they are. Marks would agree with this argument to an extent. He did explain some of the nonintegrated behavior of the commissurotomed person along these lines. He introduced two different simultaneous conscious experiences for the purpose of explaining the dual, conflicting perceptual reports such people give when their two hemispheres are stimulated differently. I do not consider Marks's grounds to be good ones for refusing to apply the same kind of explanation to such people's integrated behaviors. As I have suggested, behavioral integration does not require a unity of consciousness in all cases. Marks would object to the preferred interpretation on grounds of explanatory parsimony; one should only assume the minimum needed for immediate explanation. Marks would question whether it is necessary to postulate the occurrence of two simultaneous experiences during the integrated performances. Whereas Sperry (1969, 1970) believed there is a stream of consciousness that flows on in the intact person whether or not behavioral grounds exist from which to infer it at every point, Marks would not introduce any mental states not required for immediate explanatory purposes. Presumably, Marks is not concerned with development of plausible explanations in the light of all that one knows. According to Marks's philosophical perspective on correct scientific reasoning, there may eventually develop good reasons for introducing a stream of consciousness or even two; however, this must be forced upon us by the need to explain particular

behaviors. Until the scientific data so force us, we should make use of as little as possible in formulating scientific explanations. I believe this preferred methodological approach is a safe one for psychologists, but has not much more in its favor. The approach rejects speculation, hews closely to the data, and allows for a gradual process of revision in how the data are explained as new data become available. The safety of this approach is of a special kind, since no scientific method is a sure thing, that is, carries a guarantee to reveal truth, except perhaps if the method is purely descriptive. Marks's methodological principle does not ensure a gradual accumulation of true beliefs. This would be the case for a descriptive approach that hewed to the data still more closely, and sought to describe nothing beyond the data. For example, Marks argued against two streams per commissurotomized person. However, such people may in fact possess two streams each; we may discover this, in which case Marks's approach has led him to a false conclusion. The psychologist's account properly executed in accordance with Marks's principle of explanatory parsimony is a *correct* one rather than a necessarily true one. The account qualifies as a correct account from the vantage point of a shared conviction among scientists as regards how psychological research should proceed. I do not suggest such a shared conviction in fact exists, only that for a procedure to be correct, the shared conviction must exist. If it does exist, correct scientific behavior may well require that the stream of consciousness be ignored, although James considered it the most concrete thing anyone can know, and certainly it seems to underlie our actions. In place of the stream, the parsimonious psychologist's account substitutes only those mental states that one must use to explain particular behavior. Although this procedure is slow and inefficient, and does not take advantage of all one knows, it is correct procedure since it goes forward in accordance with the rules. The present and future scientific community will understand and forgive errors of interpretation in view of what data were available and defined as such at the time of the interpretation.

### Localizing Streams of Consciousness

As stated, Sperry (1969, 1970) did postulate a stream of consciousness in the intact brain, and proposed a kind of abstract theory of the brain process to explain the stream. Although Sperry's perspective on brain and consciousness had a "functionalist" dimension, he did not conceive of the mental as merely something psychologists use to explain behavior (contrast Marks, 1981); the mental and consciousness are actual parts of the nervous system's functioning. This brings us back to the question I raised before discussing Marks's position: What did Sperry mean by a unitary effect in the upper-level conscious dynamics? Sperry thus expressed his view when he described

what it takes (in the brain) for a conscious experience to be unified. If he was, as seems likely, exercising the concept of a stream of consciousness, a problem arises for his account of commissurotomed consciousness: How can neural activity in disconnected hemispheres combine into a single stream? The "functionalist" aspect of Sperry's account seems to call for a single sphere of consciousness, at times, in commissurotomed people. And a single sphere defined in terms of functional unity (common effect) may mean a single stream, given Sperry's "functionalist" account of all conscious unity and unicity. However, disconnected hemispheres cannot produce a single, joint effect in the upper-level conscious dynamics, on the most obvious interpretation of the latter phrase. The relevant processes cannot interact so as to get tied together into a single unified process. Sperry (1976b) stated,

I would credit the neocommissures with a unifying role in conscious activity under normal conditions that in effect serves to tie the conscious function of the hemispheres together across the midline into a single unified process. The callosal activity thus becomes part of the conscious event . . . . This interpretation does not exclude the possibility that the conscious processes in left and right hemispheres may function separately in the undivided brain under exceptional conditions, and particularly where pathology tends to depress commissural function. (p. 171)

There is some "communication" between hemispheres through subcortical pathways. However, these pathways carry limited information, although more information than researchers had thought (Myers and Sperry, 1985). Such informational transmissions between hemispheres cannot cause their processes to combine into a single process. As Myers and Sperry (1985) argued on the basis of previous studies and their recent laboratory observations of two commissurotomed people, the receiving hemisphere uses the subcortically transmitted information *as a cue relevant to a certain cognitive strategy adopted in performing the experimental task*. That is, the information is an object of awareness in the receiving hemisphere, as is information from the external world and body outside the nervous system. Unification of processes in the hemispheres into a single stream of consciousness is, presumably, a function the commissures have evolved to perform. And all the commissures have been cut completely in the people under discussion here. Therefore, two distinct upper-level conscious dynamics must transpire in the commissurotomed person, even when these are entirely compatible and result in a fully integrated pattern of behavior. Had this not been Sperry's view, where could he have localized the single stream the commissurotomed person supposedly possesses when the hemispheres are working to a common effect? Sperry's "functionalism" cannot remove the localization requirement, since the mental is not, in his view, merely explanatory—it is real. Sperry would certainly not claim the stream is behavioral. Early on, even as he propounded a "functionalist" view of consciousness, he wrote of conscious experience as "premotor

or better pre-premotor:" and he added, "If obliged to localize the conscious experience, we could only suggest vaguely those brain centers midway functionally between the sensory input and the motor output, 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" (Sperry, 1952, p. 309). At this point, Sperry mentioned the possibility that the brain stem contains the brain centers of consciousness. However, when he later modified his mind-body solution (Sperry, 1969, 1970), he identified consciousness with properties of brain processes at a molar level of cerebral activity. Accordingly, consciousness is an "emergent property of cerebral activity, . . . an integral component of the brain process that functions as an essential constituent of the action and exerts a directive holistic form of control over the flow pattern of cerebral excitation" (Sperry, 1969, p. 532).

### The Distinctness of Streams

Production of some integrated behavior does not require unicity in the upper-level conscious dynamics, only functional unity, that is, the hemispheres' functioning as a unit in the production of behavior. However, after commissurotomy, there evidently are limits to how much functional unity can occur between hemispheres. For one thing, processes in the hemispheres cannot function together to produce a unicity of consciousness. As we have seen, a common sphere of consciousness is a different matter. Streams provide the terms by which to define spheres, not vice versa. Thus, depending on the contents and objects of awareness in the streams, the hemispheres may share to a greater or lesser extent a single sphere of consciousness, and be undivided in this sense. Whereas one may talk of a single sphere or two and of degrees of there being one or two, the concept of a stream of consciousness does not allow a continuum between a single stream and two streams. At any point in time, there are no degrees of their being two streams in the commissurotomed person, which does not deny that a stream may contain "time-gaps," as James (1890/1981) discussed. "Time-gap" refers to a stream's stopping and starting, that is, to a duration of its being "turned off." When a stream does flow, one awareness succeeds another; the present awareness turns into the next one and so on. Then for a while, perhaps no awareness occurs that is a successor of those that have constituted this stream. And, again, the process continues after the time-gap, with each awareness (after the first) succeeding the one immediately before it. Sperry (1977) mentioned the stream of a disconnected hemisphere may stop when the experimenter has been giving tasks only to the other hemisphere: "Occasionally the commissurotomed subject may become so absorbed in a right-hemisphere task that speech and

left-hemisphere functions are temporarily depressed to the extent that one questions whether consciousness may not be shifted entirely to the working hemisphere" (p. 105). Sperry added that this seems to occur more frequently under the reversed conditions. Sperry thus implied the commissurotomed person has two streams, one proceeding in each hemisphere albeit with time-gaps. And during a stoppage of one stream, all awareness will not cease if a person has a second stream that is not stopped. If indeed one stream may flow on while the other is stopped, we may speak of the degree to which there are two streams in such a person—though not at any point in time, where there is activity either in one, two, or no streams. The degree of double consciousness would be the proportion of time both streams are flowing. The idea that a stream may stop and then start again requires comment pertaining to the idea, also mentioned, that the awarenesses are related to each other as successors. How does the first awareness after a time-gap belong to a stream that stopped? The first awareness after a time-gap is a successor relative to a stream no less than an awareness that immediately follows a previous awareness. All are in one stream because they are stages of a single ongoing process that may stop and start again, an extended process that transpires in particular anatomical structures. The identity of a stream is the identity of a brain process that goes on. Therefore, we can see how it is two streams do not lose their separateness when they affect each other, or when one stream contains certain awarenesses that refer to the behavior the other hemisphere produces or even to some part of the other hemisphere's stream. Nor do they lose their separateness when they are much alike and affected by the same factors. Sperry (1977, 1982) stated that the speaking hemisphere, when asked, says it knows nothing of the inner experience or processing involved in the performances of the mute hemisphere. However, even if the speaking hemisphere could tell us something of that inner experience, the two streams would not necessarily lose their separateness. The speaking hemisphere could know by a process of inference from behavior or from the contents of its own stream. But would the two streams lose their separateness if it could be shown one of them included direct (reflective) awareness of components of the other? Puccetti (1985) in effect stated, if this were to happen, it would mean the two streams had merged. The next section considers this question.

### **Do Distinct Streams Require Only Indirect Mutual Awareness?**

I shall give an answer very shortly, but first let me state the evident facts of the matter in the commissurotomed person. The two streams affect each other differently than the way one segment of a stream affects the subsequent segment of the same stream. Each stream acquires knowledge of the other

stream only through subcortical pathways and the other stream's determination of behavior of which the first stream can be perceptually aware. Therefore, it is not strictly true "the most plausible account of unity of consciousness depends on communication between cerebral hemispheres" (Moor, 1982, p. 102). "Communication" is far less than what is required, and may well be the wrong kind of relation for the purpose of creating a single stream of consciousness. Myers and Sperry (1985), among others, have shown such "communication" does exist in commissurotomed people between their two streams. Analogously, two people who together instantiate the consciousness<sub>1</sub> relation (see Natsoulas, 1983) do not thereby have a merging between them of their streams of consciousness (cf. James, 1890/1981, p. 211). Now a stream that had direct (reflective) awareness of components of the other stream would be nonperceptually and noninferentially aware of components of the other stream. One might think this could happen only within a single stream; either (a) an awareness includes awareness of itself or (b) a successor awareness is an awareness of the awareness that it succeeds, that turns into it. Another kind of direct (reflective) awareness might be, so to speak, at a slightly greater distance. An awareness could evoke an awareness of it that occurred nearly simultaneously with it. This possibility assumes a stream can have some breadth, more than a single awareness at a time. However, this kind of direct (reflective) awareness would be less intimate than the successor type because the latter includes, according to James (1890/1981), some of the same qualitative content as the succeeded awareness, which is its object. The less intimate kind of direct (reflective) awareness could theoretically obtain between streams of consciousness. For this to happen, the "communication" between streams would have to be more direct than apparently occurs between disconnected hemispheres. As indicated, the "communication" that does occur requires awareness of something other than an occurrence in the other stream, and inference to the contents of the other stream. In contrast, "communication" at the cortical level, through intact commissures, might constitute direct (reflective) awareness between streams on the assumption there are two of them in the intact individual (Puccetti, 1973, 1981b). In such a case, there would not have to be something else of which a stream included awareness and on the basis of which inferences were made. If this evocatory kind of causal relation occurred in the way of direct (reflective) awareness across streams, I do not see that the two streams would be thereby joined. I cannot agree with Puccetti's (1985) unqualified statement about introspective access necessarily ruling out a duality of conscious streams:

If I have two cerebral hemispheres and each is the organic basis for a mind, then I, one and the same person, have two distinct minds. But as we saw . . . , minds cannot introspect each other. It makes no difference if you internalize the two minds to my body. If there is another mind in my head besides the one now thinking what to say next in

this commentary, I cannot have introspective access to its conscious contents with this same mind (based, no doubt, in the left cerebral hemisphere). If I could, they would not be two minds, but one. (p. 646)

The case Puccetti made against introspective access between streams rested on the example of sensation, or an experience of pain. The kind of direct (reflective) awareness I have suggested could go on between streams (by means of the commissures) is not the kind of direct (reflective) awareness we have of our sensations. The latter kind is self-intimational, in the sense that the direct (reflective) awareness is part of experiencing the pain (cf. Natsoulas, 1985, final section). The experience of pain and that most intimate first-person access to it that makes it a personal experience are a single process. Obviously, two streams cannot involve a single process and be separate streams. The only kind of direct (reflective) awareness that could theoretically transpire between streams is the kind that is completely distinct from what it is awareness of. I have in mind direct (reflective) awareness that a certain process of thought is proceeding in our mind. In such a case, we are aware only of the fact that one or another thought occurred without awareness of any qualitative content that may belong to the thought. Our direct (reflective) awareness takes place from the outside, as it were, the respective thoughts evoking further thoughts to the effect that they occurred.

### **Interhemispheric Fusion Process**

In discussing the intact person's sphere of consciousness, Sperry (1977/1985) suggested the fiber cross-connections between cerebral hemispheres at the cortical level perform the same function as do connecting fibers within a hemisphere; namely, they "mediate conscious awareness" (cf. Sperry, 1976b, p. 171). Sperry was surely not suggesting a visual experience transpiring within a hemisphere becomes united with a visual experience transpiring in the other hemisphere simply as a consequence of the activation of connecting fibers between the corresponding brain structures. That is, if commissural fibers do fuse the counterpart cerebral activities into a single stream, they do so by means other than mere "communication." After all, subcortical fibers also accomplish "communication" between hemispheres, though they presumably do not create fusion of processes. These "communications" must do more than transmit information and even more than duplicate processes across the hemispheres. Gazzaniga and LeDoux (1978) pointed out that the cortical connections may have a duplicative function: "The commissural system serves as a mechanism by which the neural activity . . . of highly specified cortical populations in one half-brain is duplicated in the interrelated populations in the opposite hemisphere" (p. 17). Perhaps duplication of processes across hemispheres is part of the interhemispheric fusion process. Accordingly, upon



duplication, the two corresponding processes can be joined as only what has been made the same or very similar can. LeDoux and Gazzaniga (1981) stated, "The unity [i.e., unicity] of conscious awareness of the sensory world is maintained by the interhemispheric integration (fusion) of the [duplicate] bi-hemispheric representations into unitary percepts" (p. 109). In contrast, Bogen (1981) expressed skepticism about integration through the commissures: "Their potential for inhibition may complicate hemispheric interaction more than it synchronizes" (p. 101). Puccetti (1985), who had joined Bogen (1969) in contending people with intact commissures have two streams of consciousness (i.e., no fusion), assumed the existence of an inhibitory mechanism operating across hemispheres. This mechanism purportedly prevents a hemisphere from having any direct (reflective) awareness of the stream progressing in the other hemisphere. As a result, according to Puccetti, one never is introspectively aware of having two visual experiences of the same scene simultaneously, which in fact one constantly does have in his view. *Ex hypothesi*, one has two streams of consciousness, one in each hemisphere, and these have very similar visual contents by virtue of very similar patterns of visual stimulation. Both Bogen and Puccetti would see the following description as a picture of coordination and collaboration between hemispheres, rather than a picture of unicity of consciousness: "The two hemispheres normally perceive, think, emote, learn, and remember as a unit. They even speak as a unit, in that the right hemisphere during speech is not idling or diverted, but is actively focused to aid and maintain the cerebral processing involved in speech, to add tone and expression, and to inhibit unrelated activity" (Sperry, 1977/1985, p. 21). However, Sperry did not mean to imply that either hemisphere has direct (reflective) awareness of processes taking place in the other hemisphere, any more than Puccetti (1985) so claimed. Sperry believed the two hemispheres manage to become highly integrated (through the commissures) to the extent of yielding a unicity of consciousness. The integrated or fused process includes three parts, a part in each hemisphere plus the commissural activity that binds the other two parts together into a single process. In that sense, the stream passes through the corpus callosum. Sperry (1977, p. 171) gave indication of the more than "communication" needed for unicity of consciousness when he stated callosal activity must itself be part of the single conscious event across the hemispheres. Consistent with Sperry (1976b), Anderson and Gonsalves (1981) suggested the commissures fuse experiences that are potentially dual. And they do so in the same way that, within a hemisphere, "the visual, auditory, and tactile modalities overlap in experience and are held in one unity of consciousness. You can see a book and then reach out and touch it; the experiences overlap and correlate with one another in making up a common perceptual space" (p. 100). This unification across sensory modalities is accomplished, according to Anderson and

Gonsalves, by means of the same kind of fibers as comprise the corpus callosum. Be that as it may, Anderson and Gonsalves's hypothesis, too, is suggestive of the more than "communication" between hemispheres (or between parts of a hemisphere) that needs to occur to create a single stream. The visual, auditory, and tactual experiences are somehow integrated into a single stream; perhaps they occur simultaneously within that stream, as a single multimodal experience. Again, the commissurotomed people, lacking any such fusion mechanism between hemispheres, must be granted distinct streams of consciousness in their two hemispheres.

### **Recent Denial of Consciousness to Mute Deconnected Hemisphere**

However, Gillett (1986) did not think commissurotomed people possess individually two streams of consciousness, although he acknowledged, "There is no question that each hemisphere 'performs' tasks which show a degree of informational complexity. The behavior produced would normally be considered the conscious performance of an intelligent person" (p. 225). Marks (1981) assessed the evidence in the same way: "If a person with commissures intact exhibited similar behavior, there would be no doubt that conscious ability was involved" (p. 7). Yet some behavior of the commissurotomed person that we would normally consider an intelligent person's conscious performances requires, according to Gillett, a different kind of explanation. Take the behavior of P.S. (Gazzaniga, LeDoux, Volpe, and Smylie, 1979) for example. His right hemisphere apparently managed to utter "Gun . . . hold up" when an appropriate picture was flashed to the left of his fixation point and therefore only to his right hemisphere. Against the critics' wish to treat of this case as not indicating a second stream, Puccetti (1983) argued we ourselves never make such visual reports unless aware of having seen something that deserves the description we provide. Nevertheless, according to Gillett, this behavior when produced by the commissurotomed person's right hemisphere must be otherwise explained. We lack in this case a certain category of evidence (see next section) that would allow us to do otherwise. The lack of this evidence supposedly forces us to take recourse in an entirely different kind of explanation. This lack does not merely increase our uncertainty and our need to be more tentative in our interpretations. Rather, the absence of the necessary kind of evidence renders unreasonable, or much less reasonable, the kind of explanation for the behavior that we would normally give. Thus, Gillett found reason (see below) to believe the behavior of the right hemisphere comes about independently of any stream of consciousness. The behavior only appears a conscious performance; as a result, presumably, of our having repeatedly observed the same behavior when it was a conscious performance. Much more than for us, Gillett stated, the

behavior is problematic for the person whose behavior it is, in the sense that his or her organism manifests it. Where researchers in the field would refer to the person's speaking hemisphere, Gillett repeatedly wrote of the commissurotomed person. Yet he did not mean the speaking hemisphere; he meant the human being whose commissures had been cut. Wilkes (1978) also expressed the commissurotomy research findings in terms of the person, but Gillett would reject her following interpretation: "He knows and does not know that *p*; . . . he acts purposefully and does not know that he is acting; . . . he disagrees with and disputes his own judgments; . . . he is both aware and unaware of an unpleasant smell; . . . he hears and does not hear an order—which he obeys" (p. 188). These statements of Wilkes (1978) imply the presence of consciousness within the commissurotomed person of which the person knows nothing. Therefore, the person cannot issue reports from which the researchers could draw that certain particular mental states take place in a second stream of consciousness. The behaviors of the right hemisphere cannot support such inferences. Accordingly, Gillett held the person is merely "making mistakes" when his or her right hemisphere produces behavior (for which the person is nonetheless responsible). The problematic character of this hemisphere's behavior, from the person's perspective, appears rather clearly in a subject that Sperry, Zaidel, and Zaidel (1979) studied. The experimenter presented to the subject, actually to the right hemisphere only, four photographs of the subject herself and asked her to point to the one she liked best. Then she was asked whether she knew the people in the photographs:

Yeah . . . do I? . . . No . . . I don't know really. [After pausing, she continued reflectively.] What do you think, Dr. Sperry; what's the matter with me? . . . I mean, am I thinking or what? . . . k . . . keep pointing to that one, and I don't know why. Whose face is it? Probably me and that's why I like it; nobody else does. Yeah [in a more definite tone] that's a picture of me. (p. 159)

To the person, quite rightly according to Gillett, the behavior of the mute hemisphere appears to be a "mistake" (see below; cf. Zangwill's 1974, p. 275, comment on a subject who quickly and smoothly rationalized the mute hemisphere's choice). In the above case, the subject finds the pointing behavior of the mute hemisphere especially problematic because the special scleral contact lens she is wearing prevents any direct perceptual identification of the pictures by the speaking hemisphere. The oral identification that gradually dawned on the speaking hemisphere was indirect and depended on the mute hemisphere's reaction to the speaking hemisphere's guess. This reaction communicated itself to the speaking hemisphere through the mute hemisphere's behavior, which could be perceived, or through the mute hemisphere's emotional reaction to the correctness of the speaking hemisphere's guess, a reaction conveyed to the speaking hemisphere through subcortical pathways.

LeDoux and Gazzaniga (1981) held a very different view than to consider the mute hemisphere's behavior a series of "mistakes," even from the perspective of the commissurotomized person. They proposed the left hemisphere readily interprets the behavior "not as anomalous, but as natural" (p. 110). This observation led Gazzaniga and LeDoux (e.g., 1978) to a special conception of consciousness that I shall discuss in a subsequent article.

### The Linguistic Requirement

From Gillett's perspective, in what sense is the behavior of the mute hemisphere a series of "mistakes?" The behavior at issue is not under the direct influence or determination of a stream of consciousness (cf. Nagel's, 1971, p. 402, first interpretation), whereas the above verbal behavior of Sperry, Zaidel, and Zaidel's subject is, in contrast, an expression of a stream of consciousness. Streams are distributed only one to a person, whether or not the person is commissurotomized. In the case of this subject, and other commissurotomized people, the one stream proceeds outside the hemisphere that produces the left hand's pointing behavior. However, the stream does proceed in the brain itself; the stream of consciousness is a process of the brain. This must be Gillett's (1986) underlying position, since he held human cognition is "not carried out in some immaterial, inner, cognitive substance or mental life" (p. 227). As LeDoux (1985) stated, observations upon commissurotomy left "little room for any conclusion other than that mental experiences are directly tied to neural tissue. The mind could, it seemed, be neatly compartmentalized by a physical act" (p. 199; however, see Popper and Eccles, 1977). Gillett's proposed reason to believe the mute hemisphere's behavior comes about independently of a stream of consciousness consisted in the assumption that the behavior is explainable entirely in nonmentalistic terms of brain function and the claim that "certain detailed propositional attitudes and consequently certain conscious thoughts cannot be justifiably ascribed" (Gillett, 1986, p. 227) to the mute hemisphere. Explanation in terms of brain function, he assumed, is relatively straightforward; that is, undemanding of mental concepts. In contrast, Sperry (e.g., 1980) has repeatedly argued nonmental explanation of the kind of behavior that, also, the mute hemisphere displays cannot succeed. "Mental explanation" is any explanation that includes concepts referring to mental events, states, or processes; where these may be, as in Sperry's monist interactionism (see Natsoulas, 1981, 1984), brain occurrences or, as in Eccles's dualist interactionism (see Popper and Eccles, 1977), occurrences in the nonphysical conscious willing self. Much less straightforward, in Gillett's view, is explaining the behavior of the mute hemisphere in terms of a stream of consciousness. In the absence of a hemisphere's ability to use language and evidence that such use would provide, the ascription

of conscious thought and the like cannot go forward. For the ascription of conscious thoughts to a hemisphere, nonlinguistic performances, however complex, cannot suffice. The person would have to speak, or make a comparable use of language with regard to his or her performance, in order for the performance to be explained in terms of a stream of consciousness. Therefore, on what basis did Zaidel (1985) make the following statement? "The recognition that the disconnected right hemisphere is conscious has highlighted the implausibility of the insistence that consciousness presupposes language" (p. 314; cf. Bogen, 1985, p. 27). Zaidel made this statement as a result of having applied an alternative strategy, which Gillett neither discussed nor mentioned. It is a fact that psychologists can formulate explanations of the mute hemisphere's behaviors in terms of its possessing a stream of consciousness, explanations based on what we know of such behavior in intact people. We can then use the further behavior of this hemisphere to confirm or disconfirm hypotheses about its consciousness, just as we do, without second thoughts, with respect to the speaking hemisphere. This is the kind of investigatory process in which Sperry, Zaidel, and Zaidel (1979) engaged. Eccles (Popper and Eccles, 1977) had characterized the mute hemisphere's consciousness as limited and inferior to the consciousness of the speaking hemisphere (cf. Eccles, 1981). Sperry (1977/1985) described the empirical response of his research group as follows: "We accordingly devised some tasks specifically designed to test for self-consciousness and levels of social awareness in the disconnected minor hemisphere" (p. 20). Gillett did not explain how the procedure of Sperry, Zaidel, and Zaidel (1979) is unreasonable, nor did he mention their study. Instead, he required a more "austere" procedure. One is led to wonder whether an illiterate person who lost his or her capacity for speech, due to brain damage, would also lack a stream of consciousness behind his or her nonverbal behavior. Why would Gillett's austere procedure be less desirable in the case of such a mute person than in the case of a mute hemisphere? Gillett would apply the same arguments to both cases, judging from the vague suggestion of the following sentence: "There is no blithe continuation of personal life with largely intact psychological function here [in the case of a person with left hemispherectomy] despite the impression created by Parfit and others" (p. 228). Did Gillett mean the mute hemisphere left alone in the body does not possess a stream of consciousness? How, then, do people with left hemispherectomy deceive those who come to believe as Marks (1981) stated? "No one thinks that people with either right or left hemispherectomies lack minds completely characterizable as human" (p. 47; Bogen, 1981). Sperry (1977) made a useful comment that bears on this issue when he pointed out that upon recovery temporary aphasics can relate their conscious experiences that transpired during the mute period. LeDoux (1985) adopted a view of the right hemisphere that implies at least some people with left hemispherectomy

might no longer be human: "All things considered, the cognitive status of a language-deficient isolated right hemisphere is . . . more like that of a chimpanzee than a human being" (p. 203). All depends, in this view, on whether the right hemisphere has acquired language. If it has not, then "man's minor hemisphere has the potential to provide the best model available of what human brain function may have been like prior to the development of language millions of years ago" (LeDoux, 1984, p. 84). Presumably, the many conscious performances and the "personhood" that, as Bogen (1969) noted, survive left hemispherectomy would be ascribed to the right hemisphere's acquisition of linguistic capability.

### Against "Mistake" Interpretation of Mute Hemisphere's Behavior

Before argument against Gillett's interpretation of the mute hemisphere's behavior, an instance of such a "mistake" in an intact person may be helpful:

On the previous week he had . . . entered the lift on the ground floor, intending to travel to level five, had pressed the button for the fourth floor "out of habit" (his own room is on the fourth floor). This week, whilst waiting for the lift he had remembered his previous error and reminded himself that he must press button 5 and not 4 this time. On entering the lift, however, and much to his irritation, he watched as his finger stabbed the fourth-floor button once more. (Oakley and Eames, 1985, p. 225).

Although "the person" is conscious of the mute hemisphere's behavior, the behavior is not among "the person's" conscious performances. Although "the person" perceives the mute hemisphere's behaviors when they occur, "the person" does not know them in the internal way that "the person" knows behavior produced by the speaking hemisphere. In the case of behavior produced by the speaking hemisphere, "the person" is often aware of the behavior's very early stages and aware of causes of it in the stream of consciousness. This is not true for behaviors produced by the mute hemisphere. The mute hemisphere's behaviors are unexpected, as in the above example, or "the person" expects them as "the person" expects other people's behaviors. Gillett (1986) wrote of the commissurotomed people as "struggling with certain confusions to which they find themselves subject" (p. 227). He meant that "the person" takes the behaviors of the mute hemisphere as unintended. To call them "mistakes" is somewhat misleading because they are often not mistakes by objective standards, being instead correct responses for the task the experimenter gave the hemisphere. The simultaneous performances of the two hemispheres can both be accurate though they differ from each other. For example, if the hemispheres are instructed to retrieve two different particular objects and each hemisphere follows instructions, neither choice is erroneous. If the two hands settle on a common object when the hemispheres are differently instructed, this counts as a mistake and a sign of confusion probably

pertaining to the instructions. Also there occurs "disgusted shaking of the head or irked facial expressions triggered from the minor hemisphere after it has heard its speaking partner making what is known to be an incorrect answer" (Sperry, 1977, p. 107). This behavior by the mute hemisphere turns the tables by being an objection to the intentional behavior of "the person." What Gillett probably had in mind was not the idea of a mistake but of unintended behavior. Since the behavior of the mute hemisphere purportedly has no stream of awareness behind it, it cannot be a piece of intentional or voluntary behavior. Whenever the mute hemisphere produces a behavior, this is never a successful performance because it is never a performance. Even if "the person" recognized the behavior as correct, the behavior would be a "mistake" in this sense. For example, suppose the response had to be carried out by the left hand and both disconnected hemispheres received the needed information. Since the left hand is under the mute hemisphere's control, its evidently correct behavior should still be seen by "the person" as external to him or her (cf. Oakley and Eames, 1985, p. 228). If both hemispheres perform correctly in the simultaneous version of this task, Gillett would explain the two performances differently. The performance of the speaking hemisphere would be explained in terms of a stream of consciousness, while that of the mute hemisphere would be explained in terms of "brain function." However, Gillett made no attempt to support his position by offering an explanation in terms of brain function of one or two hard (or easy) instances of the mute hemisphere's behavior. The question remains whether such an explanation can be accomplished (cf. Sperry, 1977, p. 119). Gillett's confidence that this can be done was not shared by Sperry (1977/1985), who wrote,

We have not been able to see any real justification in our test findings for denying consciousness to the disconnected mute hemisphere. Everything we have observed in many kinds of task performance over many years of testing reinforces the conclusion that the mute hemisphere has an inner experience of much the same order as that of the speaking hemisphere, though differing in quality and "cognitive" faculties, as will be outlined later. Clearly, the right hemisphere perceives, thinks, learns, and remembers, all at the very human level. It also reasons nonverbally, makes studied cognitive decisions, and carries out novel volitional actions. Further, it can be shown to generate typical human emotional responses when confronted with affect-laden stimuli and situations. (pp. 15-16)

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