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Consciousness and Commissurotomy: II. Some Pertinencies for Intact Functioning

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Study of the consciousness of commissurotomized people may enlighten us with regard to consciousness more generally. Researchers in this area have addressed, for example, the general problem of the unity of conscious experience. They have proposed various means by which such unity is accomplished, based on their observations of commissurotomized people. Some of these means are (a) a verbal-conceptual consciousness system that unifies by making the individual (or cerebral hemisphere) consciously aware and spinning out interpretations, (b) the transmission of information from each cerebral hemisphere to the other via subcortical pathways, (c) the duplication or equalization of processes between cerebral hemispheres by means of the forebrain commissures, and (d) the production of a single stream of consciousness per intact human being in a tripartite structure that includes a part of each cerebral hemisphere and the forebrain commissures.

The present article is the second installment in a planned series of articles. The first installment has appeared bearing the subtitle "Spheres and Streams of Consciousness" (Natsoulas, 1987b). The direct purpose of this series is to address what psychologists know or knowledgeably hold concerning the consciousness of certain very rare individuals. They are the people who have submitted themselves to the surgery of complete forebrain commissurotomy. Neurosurgeons have discovered that this drastic procedure is a life-sustaining remedy that brings these people's extreme, otherwise intractable epilepsy under control. (On the resulting "split-brain syndrome," see Bogen, 1985; Sperry, Gazzaniga, and Bogen, 1969.)

Why should such effort as the present series be directed to trying to understand the commissurotomized person's consciousness? Since this question may concern some readers, I shall answer it here in the following two ways.

1. One answer consists of this whole series of articles itself insofar as it succeeds in contributing to a certain transformation in the members of our scientific discipline. I hope that they will become transformed in time from psychologists of behavior and psychologists of mind and behavior to psychologists of consciousness, mind, and behavior. One might think that

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the historic return of mind to psychology in very recent decades has also been a return to consciousness. Although this is true to a clearly visible degree (see Natsoulas, 1978a), the problems of consciousness (Natsoulas, 1981) remain, for many psychologists, either too difficult to admit or not compatible with contemporary methodology, which remains highly behavioristic.

A primary motivation for all my work on consciousness has been and continues to be to do as much as I am able to do to contribute to the process of bringing the scientific field of psychology out of the inner darkness of the twentieth century (Natsoulas, 1988). Among other projects and problems on which I am currently working, in this connection, are these:

(a) the problem of how people have immediate awareness of (some of) their own mental occurrences (Natsoulas, 1970, 1973, 1977a, 1978c, 1982a, 1983b, 1985a, 1986b, in press-b);
(b) a more adequate characterization of the content and structure of perceptual consciousness (Natsoulas, 1974, 1977b, 1978b, 1980a, 1980b, 1982b, 1983f, 1984c, 1984f);
(c) the development of a conceptual psychological approach to the whole subject matter of consciousness (Natsoulas, 1978a, 1981, 1983a, 1983c, 1986a, 1986-1987);
(d) the improvement of radical behaviorism with respect to its treatment of consciousness (Natsoulas, 1978c, 1983b, 1985c, 1986c, 1988);
(e) the problem of the unity of consciousness, including the problem of "the subject," that is, the special relation of the organism or person to his or her mental occurrences (Natsoulas, 1979, 1983e, 1983-1984, 1984d, 1984e, 1985–1986);
(f) exposition, explication, and development of the unfamiliar though rich conception of consciousness that was formulated by Sigmund Freud, a great advocate of the widespread improvement of consciousness (Natsoulas, 1984a, 1985b, in press-a);
(g) an improved understanding of the character and nature of the stream of consciousness as pioneered by William James and beyond (Natsoulas, 1985–1986, 1986–1987); and
(h) an adequate characterization of the content and structure of "retrowareness" (i.e., the occurrent nonperceptual veridical awareness of anything about a past state of affairs or event; Natsoulas, 1986a).

Addressing the consciousness of the commissurotomized person, as I am doing in the present series of articles, will serve to broaden my efforts on behalf of consciousness into the highly important subfield of psychological neuroscience. (See also Natsoulas, 1982a, 1987a, for other discussions of consciousness pertaining to this subfield.)

2. The next section provides a further answer to the question of why "Consciousness and Commissurotomy." The section consists of a discussion that

bears on the pertinency of commissurotomy for increasing our comprehension of intact functioning at the conscious level. In addition, this section performs the function of introducing the two special topics that I address in the remainder of this second installment.

The Pertinency of Commissurotomy

The psychological investigation of commissurotomized subjects is one of the few areas of contemporary empirical research in which questions pertaining to the subjects' consciousness loom large. Indeed, a prominent British neuropsychologist has stated that the phenomena and research findings are such in this area that explanations in terms of consciousness and intention cannot be avoided (Newcombe, 1985, p. 168). In trying to explain commissurotomized people's behavior in experimental situations, even those scientists who would avoid any reference to consciousness find themselves becoming concerned with what each cerebral hemisphere has awareness of and which cerebral hemisphere is responsible for which actions. There is explicit or implicit acknowledgement that to fail to be so concerned is to avoid central phenomena of human personhood. After all, surgery on these patients has converted the human "dual brain" (Benson and Zaidel, 1985) into something bearing significant resemblance to two distinct brains.

And already, consciousness research on commissurotomized people has received credit for inspiring a new solution to the mind-body problem. I am referring, of course, to Sperry's (1952, 1964, 1965, 1966, 1969, 1970a, 1970b, 1976a, 1976b, 1977a, 1977b, 1978, 1980, 1982, 1985, 1987) synthesis of the two dominant mutually antithetical solutions of dualist interactionism and reductive materialism (which Hebb, 1981, called the only doctrines worth considering for scientific purposes). It seems appropriate to call Sperry's mind-body solution "monist interactionism" (cf. Searle, 1980, pp. 455–456), and I have recently discussed it from this angle: monist as opposed to dualist, interactionist as opposed to reductionist (Natsoulas, 1984b, 1987a). In the address that Sperry (1982) presented on the occasion of his accepting the Nobel Prize in Physiology and Medicine, he stated, "One of the most important indirect results of the split-brain work is a revised concept of the nature of consciousness and its fundamental relation to brain processing" (p. 1226). Another commissurotomy researcher with a different conception of consciousness (see later) has stated, "There is some rather compelling evidence that favors the view that neural mechanisms underlie, and in some (theoretically) determinable way, account for mental experience. Much of this evidence comes from split-brain studies conducted over the past thirty years" (LeDoux, 1985, p. 199). This same researcher has attributed psychology's return to consciousness in part to "experimental observations on brain function that seemed to demand explanation in mentalistic terms" (LeDoux, 1986, p. 349). Prominent among these observa-

tions have been animal and human studies of the effects of commissurotomy (e.g., Myers and Sperry, 1953; Gazzaniga, Bogen, and Sperry, 1962).

Now some psychological neuroscientists do want to avoid explanations that consider consciousness. Among them, Cook (1986) recently stated as follows concerning the corpus callosum, which is the largest bundle of nerve fibers that connect the two cerebral hemispheres at the cortical and other levels:

> Because of its large size, midline location and rapid evolutionary development, its importance, as compared to other association fibers, may be enhanced, but we are not in a position to speculate about the soulfulness or spiritual properties of this or any other nerve tract. At best, we might be able to show that the corpus callosum plays a role in normal thought processes, but we must leave questions of consciousness and the soul to be answered by philosophers and metaphysicians. (p. 78)

As I shall explain, this statement reminds me of Skinner's (1987) recent, half-hearted behavior of relinquishing feelings—to the science of physiology! Of course, this is a very common theme in the story of twentieth-century psychology, namely, the psychologist whose hands are tied by his or her philosophical commitments giving up psychological phenomena to someone else (to a different kind of psychologist or scientist, or to a nonscientist) to investigate who has greater freedom or ability to do so. It is curious that such relinquishment proceeds with an aura of competence, which may have its source in a display of methodological purity. Methodological purity seems to license remarkable scientific actions. For example, a clinical neurologist, wanting to be rid of the concept of consciousness, hoping that it "fades into well-deserved obscurity," denies any interest in his patient's brain:

> As a clinical neurologist, I have been trained not to deal with the concept of consciousness. I can deal with responsiveness for that I can test with a stimulus, grading the response or noting the nonresponse. What is going on in the patient's brain between the stimulus and the response is his own province. Presumably, what is going on is consciousness or awareness of the stimulus or response—but it is still the private domain of the individual. Therefore, I will deal with responsiveness. (Joynt, 1981, p. 109)

Skinner (1987) stated,

> In the case of feeling, both the conditions felt and what is done in feeling them must be left to the physiologist. What remains for the behaviour analyst are the genetic and personal histories responsible for the bodily conditions the physiologist will find. (p. 502; strangely, it was only months before that Skinner, 1986, p. 716, had stated, "Psychophysiology does not tell us 'what really happens when people think and have feelings' ")

Note how feelings are first assigned to the physiologist, and then in the very next sentence, the behavior analyst is described as, in fact, studying feelings as effects of his or her favorite causes, certain genetic and personal histories.

In Cook's (1986) case, too, what is first held by him to be methodologically

off limits soon finds its way back as something that the scientific discipline works to explain. Cook's (1986) relinquishment of consciousness to the philosopher did not prevent Cook from quite naturally concluding, soon after, in the same book, on the basis of research and theory in the neurosciences, that "the fact remains that brains are 'integrated' via the forebrain commissures and present to the conscious self a unified view of the world" (p. 158). This statement expresses what would be Cook's answer to a certain question of consciousness. It is the kind of answer that psychological neuroscientists will be in a better position to establish eventually than philosophers who know little about the brain's functioning.

A Verbal Interpretation of the Unity of Conscious Experience

Let me comment on the central concept that is involved in my general point concerning the pertinency of commissurotomy. This comment will lead to the introduction of the first of two pertinencies for intact functioning that I shall discuss in the two subsequent main sections of the present article.

My general point is that the effort to understand the characteristics of the consciousness of commissurotomized people could repay us with more general insights into the very nature of consciousness. However, bare references of the latter kind, to "the very nature of consciousness" and the like, are somewhat ambiguous. This is because the ordinary word *consciousness* has a number of clearly different senses (see Natsoulas, 1978a, 1983a, 1983c, 1986–1987). Therefore, we must be especially vigilant with regard to what an author has reference to when he or she is making use of the term in scientific discourse.

The problem of mutual comprehension does not end there. I illustrate this further point by using a view of consciousness that has been promulgated in recent years jointly by two leading researchers on the consciousness of commissurotomized people. My choice of illustration is also motivated by how these researchers have made empirical work on consciousness and commissurotomy pertinent to their conception of consciousness in general.

With the different ordinary senses of consciousness firmly in mind, one may still find the following sentences puzzling.

> Where we ought to look for the neural substrate of consciousness is quite a different question. We are not likely to find a center of consciousness [cf. Barlow, 1980; Luria, 1978]. The neural mechanisms underlying conscious experience, if they are ever uncovered, will surely be revealed as complex systems of interconnected neurons. (LeDoux and Gazzaniga, 1981, p. 110)

These sentences assert that consciousness is actually something else than the unified (or disunified) visual perceptual experience with which Puccetti (1981b) had been occupied in the article on which the authors are commenting.

Puccetti obviously thought that he was discussing the problem of how conscious experience is unified between the cerebral commissures. (His view was that it is not so unified.)

The conceptual dimension of scientific research is not always stable because scientists often are uncertain as to the location of those joints of nature where they must conceptually carve. Consequently, they keep trying out new concepts that may better fit the phenomena of interest to them. The revising of ordinary and previous technical concepts is a crucial scientific activity. However, it takes effort to stay abreast of the revisions, and not slip back to the previous mode of conceptualizing the respective subject matter.

LeDoux and Gazzaniga (1981) went on to imply that they were using the word *consciousness* to refer to the verbal account a person or a cerebral hemisphere fashions for a current or just past piece of behavior (cf. Hebb, 1980, 1981; James, 1890/1981, p. 291; Rachlin, 1984, 1985). Elsewhere, I have had occasion to develop criticisms of related views of consciousness (Natsoulas, 1977a, 1983c, 1985a, 1988). I believe that Gazzaniga and LeDoux's concept of consciousness most closely resembles Fingarette's (1969, 1974, 1985; see Natsoulas, 1981, pp. 167–171) concept of explicit consciousness; except that they applied their concept with reference to particular behaviors, rather than to the extended "engagements" that Fingarette emphasized as the objects of explicit consciousness. I should include as well Skinner's (1945a, 1945b, 1953, 1957, 1969, 1976) conception of consciousness, because Skinner interpreted consciousness as a matter of verbal operant responding to private stimuli and incipient or covert behaviors.

The view that Gazzaniga and LeDoux have been advocating becomes very clear in the following statement by LeDoux (1985):

> The main thesis is this: natural language plays a crucial role in human consciousness. It allows for the common coding of divergent experiences and for the construction of a continuous, unified sence of self and reality. Natural language and consciousness, however, are evolutionarily recent facets of brain function, and they coexist with other systems which are more a part of our biological heritage as vertebrates. These relatively primitive systems, which are also capable of registering experiences and regulating purposeful behaviors, operate largely outside of conscious awareness. The conscious self thus only comes to know and understand these hidden mental dimensions when they are expressed in behavior. Once expressed, however, the behavioral output of these systems becomes subject to conscious interpretation and incorporation into the subjective experience of self. (p. 198)

In this important part, Gazzaniga's and LeDoux's own scientific behavior fits the interpretation of being guided by their highly informed understanding of the characteristics of the commissurotomized person's consciousness. It can readily be shown that these scientists' concept and conception of consciousness derive from the empirical research on commissurotomized people. Gazzaniga and LeDoux have been particularly impressed by how the deconnected speaking hemisphere makes sense, on the spot, of behavior that the hemisphere

did not itself produce. Moreover, Gazzaniga and LeDoux have used the behavior of commissurotomized people as evidence for their view of the nature of consciousness in intact human beings.

After this introductory section on the pertinency of commissurotomy, I shall address the above important part of Gazzaniga and LeDoux's scientific behavior, providing both explication and criticism of it. For this behavior is relevant both to the comprehension of the commissurotomized person's consciousness and to the pertinency of this comprehension to our developing perspective on consciousness in general.

A Subcortical Contribution to the Unity of Conscious Experience

An expectation or hope of pertinency was the closing thought, as well, of a recent empirical report concerning "transfer of cognitive information" by means of the subcortical pathways from the deconnected right cerebral cortex to the left one of the same person, and vice versa. The experimenter concluded, "Along with the behavioral and other physiological mechanisms, the subcortical bridge may in time be revealed to be a major factor in the ability to maintain a unity of conscious experience for split-brain subjects and perhaps for normal humans as well" (Cronin-Golomb, 1986b, p. 519).

The underlying reasoning for this statement would seem to be as follows. (a) Because people with complete forebrain commissurotomy lack the normal connections between their two cerebral hemispheres at the cortical level, study of their consciousness (in comparison to the consciousness of corresponding intact people) will reveal to us the contribution of the commissures to "the unity of conscious experience." The forebrain commissures are the brain structures with respect to which, to say the least, the two groups differ in a very major way. Other things being equal, any differences detected between the two groups in "unity of conscious experience" will be due to the (non)intactness of the cerebral commissures. (b) In contrast, the subcortical pathways are intact in both groups. What these pathways accomplish in the commissurotomized person with respect to "unity of conscious experience" will be relatively easy to show, because the person's forebrain commissures have all been cut. (c) Perhaps the subcortical pathways accomplish the same kind and degree of "unity of conscious experience" in both groups. (The forebrain commissures accomplish additional "unity.") That is, perhaps the function of the subcortical pathways can be isolated by means of the commissurotomized person. Cronin-Golomb also mentioned déja vu and tip-of-the-tongue experiences (in normal people) as due, possibly, to the intercerebral transfer of information not by means of the forebrain commissures, but she did not develop the point.

Cronin-Golomb (1986b) performed two experiments (see also Cronin-Golomb, 1986a) on L.B., N.G., and A.A., who are completely com-

missurotomized members of the Vogel-Bogen series of surgical patients (Bogen and Vogel, 1975). Her results show that the connotations of a pictured object that only one cerebral cortex sees transfer efficiently to the other cerebral cortex entirely by means of subcortical pathways. With these experiments in mind, let me pursue further Cronin-Golomb's concluding thought in the interests of giving support to the thesis of the pertinency of commissurotomy.

Cronin-Golomb implied that both the intact person and the commissurotomized person are accurately characterized as possessing "unity of conscious experience." Both were said to have an "ability to maintain" this unity, an ability in which the subcortical transfer of information may be a major factor. For normal human beings, one might think either (a) that the cerebral commissures simply make for more unity of conscious experience of the same kind as the subcortical pathways make for the commissurotomized people or (b) that the extra unity that the commissures add include a unity of conscious experience that is of a distinct kind. These alternatives need to be considered.

The unity of conscious experience that Cronin-Golomb had in mind in the case of commissurotomized people seems to amount only to a similarity between the mental contents of the two cerebral hemispheres. As a consequence of the information transmitted by the subcortical pathways, there is greater resemblance in the mental processes across the hemispheres than would be the case in the absence of this factor. Cronin-Golomb (1986b, Exp. II) emphasized, and performed an experiment to show, that the subcortical pathways do not make possible a sharing between hemispheres of visual perceptual experience—not even in the sense that one hemisphere undergoes limited visual imagery that is produced by the visual perceptual experience of the first hemisphere. Whenever either hemicortex chooses correctly a picture of an object that is identical to the picture that the experimenter presented only to the other hemisphere, the correctness is due to the transfer of associations, for which the identical picture is the best match.

By virtue of the transfer of associations or connotations, the receiving hemisphere's activities come to resemble mentally the activities of the transmitting hemisphere. That is, the subcortical pathways function to render the two hemisphere's thoughts similar to each other (across hemispheres). For example, A.A. pointed out a picture of a duck with his right hand when the experimenter presented pictures of three animals to his left hemisphere and a picture of a fish to his right hemisphere. The subsequent exchange between A.A. and the experimenter was reproduced by Cronin-Golomb (1986, p. 508):

S: Both animals that go in the water.
E: What was on this side [left hemifield]?
S: . . . .
E: You just know it's an animal that goes in the water?

S: Yes. What's a duck that goes in water? Mallot?
E: Mallard?
S: Yes, on this side [right hemifield]. And *that's* [left hemifield] maybe a wooden duck.
E: A decoy?
S: Yeah . . .it could've been.

Cronin-Golomb commented that this final guess lacked conviction. Evidently, thoughts about water had been evoked subcortically in the left hemisphere but not thoughts about fish.

Other thoughts that were evoked in the left hemisphere by the subcortical route were (a), when a picture of the devil was seen by only the right hemisphere, thoughts about a desert, which helped the left hemisphere choose the "correct" picture of a snake and (b), when a picture of a gun was seen by only the right hemisphere, thoughts about something harmful, which led to choosing the picture of a black eye. The following further examples show the same thing. The left hemisphere's comments occurred in the absence of identifying the picture presented to the right hemisphere.

> Left visual hemi-field presentation to subject NG of a bald eagle, a music stand, a devil, a gun, and an angel elicited the following respective comments: "good, perfect"; "reminds me of when I was a teenager . . . record player . . . jukebox . . . jazz"; "scared"; "accident, ambulance"; "weddings . . . high blood pressure . . . funerals." (Cronin-Golomb, 1986b, p. 509)

There may be a kind of unity that is not possible in the absence of the cerebral commissures, a kind of unity of conscious experience that the subcortical pathways on their own cannot bring about between the two cerebral hemispheres. Two people cannot have between them this kind of unity, which is a literal sharing of experiences, whereas two cerebral hemispheres can, according to some scientists, when they belong to an intact human being.

Accordingly, Sperry (1976) construed this unity of conscious experience as "an intimately involved relation," when he stated,

> The only way an observer brain would be able to interact with and *thereby experience the subjective qualities of another brain* would be through *an intimate communication* into the interior of the observed brain that would enable it to react to the internal operational effect and internal relations of the observed brain. An observer relation is not enough; the second brain must be in *an intimately involved relation* with the internal operations of the first brain. Reasoning from our split-brain findings in animals and human patients, I have used the example of *a corpus-callosum-type of intercommunication system* in this connection (Sperry, 1969) to illustrate the kind of interaction that is required. (p. 174; italics added)

Sperry may or may not have gotten right how the two connected cerebral hemispheres relate to each other in the creation of a unity of conscious experience; however, he did call attention to the extraordinary relation between cerebral hemispheres that the forebrain commissures alone make possible.

Consistently with Cronin-Golomb's implied view of the unity of conscious

experience in the commissurotomized person, a number of the researchers in this special field would claim that, in the intact person, the unity of conscious experience has a qualitatively different dimension. Cronin-Golomb did not have occasion to discuss the issue, but she did write several times of one cerebral hemisphere's "accessing," through the forebrain commissures, information or material that the other hemisphere contains. Thus, it seems that the normal person's brain does more of the same kind of thing that the commissurotomized person's brain can do, that is, more along the lines of duplicating connotative associations intercerebrally (cf. the example of fish-water-duck). For example, the normal brain "transfers" or duplicates visual experiences that only one cerebral cortex starts off with due to special experimental arrangements. However, I should call attention, as well, to the following mode of expression: "These observations . . . imply an inability of either hemisphere *to access visual material* presented to its disconnected partner, *for the purpose of performing integrative visuospatial processing*" (Cronin-Golomb, 1986b, p. 516; italics added). Perhaps this processing amounts to more than mere duplication in her view.

A Commissural-Integrative View of the Unity of Conscious Experience

The other researchers that I mentioned hold that the normal person's unity of conscious experience is not simply a matter of intercerebral information transfer and duplication of processes between the hemispheres (as some authors seem to hold; see last section of present article). In expressing their view (e.g., Sperry, 1976; see quotation from him near the end of the previous subsection), I shall use a concept that they do not often use, namely the concept of a stream of consciousness (James, 1890/1981, Ch. 9; James, 1892/1963; Natsoulas, 1985–1986, 1986–1987; Werth, 1986; Wild, 1969). Some additional quite relevant use of the concept can be found in the previous installment of this series of articles (Natsoulas, 1987b).

Whatever unity the commissurotomized person's consciousness possesses exists in a context of "double consciousness." I pair a dictionary definition of the latter term with a highly similar scientific characterization of people with complete forebrain commissurotomy:

> A condition which has been described as a double personality sharing in some measure two separate and independent trains of thought and two independent mental capabilities in the same individual. (*Oxford English dictionary*, Vol. 2, p. 848)
>
> Split-brain studies in animals and humans have demonstrated that sectioning of the forebrain commissures produces two independent mental entities, each with thoughts, feelings, and plans for actions that exist outside the realm of awareness of the other. (LeDoux and Gazzaniga, 1981, p. 109)

The "realm of awareness" of each deconnected cerebral hemisphere must be its realm of direct (reflective) awareness (Natsoulas, 1983b, 1986a, pp. 480–485).

Thus, each deconnected cerebral hemisphere has immediate, noninferential cognizance of at least some of its own mental occurrences and none of the other hemisphere's mental occurrences (cf. Marks, 1981, p. 17). In contrast, such a hemisphere evidently can have nondirect awarenesses (in the form of thoughts) about components of the other hemisphere's stream of consciousness (see the section entitled "Never Totally Separate Streams of Consciousness" in Natsoulas, 1987b).

According to the researchers whose view I am in the process of presenting, the unity of conscious experience in the commissurotomized person is a matter of the person's having content in common between the streams of consciousness that flow one in each of his or her cerebral cortexes. The common content is due to common causes or to one stream's being affected by the other stream through behavior or through subcortical pathways that run from one hemisphere to the other (Bogen, in press; Sperry, 1977/1985). Whereas the unity of conscious experience in commissurotomized people is not a matter of the person's possessing a single stream of consciousness (see Natsoulas, 1987b), the latter is the case for intact people, these researchers would say (e.g., Sperry, 1977).

Theirs might be called the "commissural-integrative" view. The following three statements, among others, make it clear that Sperry was among the authors who espoused this kind of view. The three statements are less ambiguous than Sperry's statement that I quoted near the end of the previous subsection. That statement can be read in terms of two distinct streams of consciousness, which possess, however, special access to each other. The following clearly have reference to a single stream per intact person:

> How should we conceive the unifying role of the corpus callosum and the nature of the information it carries between the two domains of consciousness? Do the conscious qualities extend from grey matter into the corpus callosum? (Sperry, 1969, p. 532)
>
> I would credit the neocommissures with a unifying role in conscious activity under normal conditions that in effect serves to tie the conscious function of the hemispheres together across the midline into a single unified process. The callosal activity thus becomes part of the conscious event. The fiber systems uniting right and left hemispheres are viewed as not being essentially different in their relation to consciousness from those uniting front and back or other areas within the same hemisphere. I know of no evidence as yet that says we must exclude white-matter neural events from consciousness, or, in other words, that conscious effects are confined to grey-matter dynamics. (Sperry, 1976, p. 171)
>
> I see consciousness and the conscious self as normally being single and unified, mediated by processes that typically involve and span both hemispheres through the commissures. (Sperry, 1977, p. 116)

The single stream of consciousness of the normal person is identical to a single ongoing brain process that, so to speak, straddles the two cerebral hemispheres and includes activity, all along the way, in the cerebral commissures as well as in certain locations of the two cerebral hemispheres. Thus, this single process that expands in the dimension of time, possibly without

interruption from the start to the end of one's life, does not consist of a succession of brain processes that transpire in different parts of the brain. That is, the stream of consciousness is not a discontinuous train of processes with one of them producing the next one and so on, as though each component of the stream required for its realization a different locus in the brain. Rather, the successive stages of the single process consists of continuous transformations of the process as it advances in time (cf. Sperry, 1969, p. 535). The brain process that is the stream of consciousness might be a purely excitatory reverberatory circuit that keeps becoming modified depending on influences that impinge upon it and its own internal dynamics. (See Cook, 1986, p. 141, who added however, "Such a view of callosal function remains an interesting possible development of the excitatory hypothesis, but the predominantly inhibitory effect of callosal activity appears incongruous within such a hypothesis;" cf. Bogen, 1981, in press; however, see Berlucchi, 1983.)

Puccetti (1987) characterized the above integrative view (across the commissures) as holding "that it is only upon callosal activation that conscious experience emerges" (p. 154). Of course, Puccetti was not attributing to Sperry and others "the seat of the soul" conception of the functioning of the corpus callosum, which is a view that has evidently, according to Selnes (1974), been at some time proposed. Those holding the integrative view acknowledge that the corpus callosum is not necessary for the possession of a stream of consciousness; the corpus callosum is not a necessary part of the structures wherein activity constitutes the stream. The cerebral commissures make it possible for a single stream to be formed in a combination of neural structures that can give rise to two streams of consciousness if the commissures are cut. We know that the latter is true from studies of the hemispherectomized (Bogen, 1969; Smith, 1966) as well as from studies of commissurotomized people.

A Verbal Consciousness System

In this section, I present a certain conception of human consciousness that was inspired by research on the consciousness of commissurotomized people. I present this conception in a preliminary way that befits the fact that the conception is now in process of being enriched and developed. Although I am somewhat critical, I do not try to eliminate the conception from further consideration. My approach is not the traditional one in psychology with respect to that with which one happens not to agree. I do not assume that I can foresee all the ways in which the conception of human consciousness that I discuss might develop to answer criticisms and overcome present implausibilities.

According to Gazzaniga and LeDoux (1978), "the conscious verbal self" performs the function of human consciousness. This is a system in the brain that is usually located in the left cerebral hemisphere. Gazzaniga and LeDoux

also refer to it as "the verbal conscious system," "the verbal system," and "the interpreter module."

I believe that "the consciousness system" is also a useful term for it provided that this does not lead to confusion with Sigmund Freud's perception-consciousness system—which is a very different system, although there occur in it conscious psychical processes of a verbal kind (see Natsoulas, 1984a, 1985b, in press-a). As will be seen, a reasonable interpretation of Gazzaniga and LeDoux's consciousness system is that it is not any kind of perceptual system. Although this is a point where their conception of the system is developing, there is a great distance to go before the system can be identified with Freud's perception-consciousness system. In order not to raise expectations, let me say that the present article does not include any further comparisons of the two hypothetical systems. Given the continued strong interest in unconscious psychical processes, I realize how useful it would be to bring Freud's thinking about consciousness into contact with a conception of human consciousness that is informed by contemporary research in psychological neuroscience.

Although the normally functioning intact human brain possesses only one conscious verbal self according to Gazzaniga and LeDoux, they proposed that forebrain commissurotomy may double some people's human consciousness (LeDoux, 1985). Whether commissurotomy has this effect will depend on whether the individual's cerebral hemispheres have developed in such a way as to each include a substantial part of the brain's linguistic mechanism.

The expectation is not, however, that a nonverbal deconnected cerebral hemisphere would lack all consciousness. Such a hemisphere may well include a nonverbal consciousness system. This system is analogous in function to the verbal consciousness system. However, it provides less than human (though "humanlike") consciousness (LeDoux, 1985, 1986).

As noted earlier, contemporary use of the word *consciousness* is not unambiguous; therefore, we need to find out what Gazzaniga and LeDoux meant when they proposed that the conscious verbal self enables the person to be conscious in the specifically human way. Gazzaniga and LeDoux (1978) introduced their basic answer to this question relative to their experimental observations of the subject P.S. He was one of five, not quite completely commissurotomized people that Gazzaniga and LeDoux (1978) studied. Although P.S.'s (and the others') anterior commissure remained intact, his experimental performances that are relevant to the present discussion were just as though he had received full forebrain commissurotomy.

In a certain visual matching task, the left and right cerebral hemispheres produced different choices of a picture, by means of the right and left hands respectively. This was as it should be since the hemispheres were presented with a different picture as sample to match for meaning. By means of looking, there occurred in each hemisphere awareness of the other hemisphere's

behavior though not of the sample picture presented to it. After each trial, the experimenter orally asked P.S what he had seen on the trial. The following is how Gazzaniga and LeDoux (1978) summarized a major finding:

> In trial after trial, we saw this kind of response. The left hemisphere could easily and accurately identify why it had picked [its] answer, and then subsequently, and without batting an eye, it would incorporate the right hemisphere's response into the framework. While we knew exactly why the right hemisphere had made its choice, the left hemisphere could merely guess. Yet, the left did not offer its suggestion in a guessing vein but rather as a statement of fact as to why [that] card had been picked. (pp. 148–149)

According to these authors' conception, human consciousness is a matter of the functioning of a special system of the brain in the monitoring of the person's behavior and making causal sense of the behavior. For the purpose of giving an interpretation of the behavior, the verbal conscious system applies additional information and assumptions that fit the case. Thus, human consciousness consists of the verbal conscious system's enabling the person or cerebral hemisphere to play psychologist with respect to behavior.

It is interesting to note that, among all the activities of the commissurotomized people, that which captured Gazzaniga's and LeDoux's imagination and resulted in their conception of consciousness were the cases in which these people are forced to make sense of behavior after the fact. Such people display, as well, many behaviors that the right or the left hemisphere deliberately initiates. Intact people also display many behaviors that they deliberately initiate. A consciousness system that enabled a hemisphere or person to play psychologist with respect to the latter kind of behavior would provide "introspective" awareness. That is, the system would produce direct (reflective) awareness of the basis on which the particular behavior was chosen to be performed.

Judging from how Gazzaniga and LeDoux (1978) described P.S.'s performance, the conscious verbal self was considered as also producing awareness of environmental states of affairs. Gazzaniga and LeDoux considered the system's observations of behavior to be with respect to the behavior's environmental setting. The conscious verbal self of P.S.'s left hemisphere produced awareness (and interpretation) of the left hand's pointing to a certain picture. Therefore, we seem to have been led to think that a capability of the conscious verbal self is the visual perceptual awareness of hand and picture, among many other things.

Attribution of this capability to the behavior-observing conscious verbal self greatly diverges from the accepted view that the person is perceptually aware of environment, body, and behavior by means of other systems of the brain than the verbal one. Is the verbal consciousness system really capable of yielding, for example, visual perceptual awareness? Or does the verbal consciousness system depend on other systems to provide perceptual awarenesses

with respect to which, in many cases, the verbal system does something that renders them conscious?

The second answer is suggested by the following part of an attempt to lay out some of the brain circuits that are involved in the generation of feelings (see end of present section for more on latter):

> Light reflected from some object in the environment excites the retina, which in turn generates impulses transmitted along the optic nerve to subcortical relay stations. At the thalamic level, the input is primarily projected to neocortical receiving areas. . . . At the cortical level, the input then undergoes several levels of modality specific processing and then is transmitted over cortico-cortical pathways to modality independent areas . . . for linguistic and conscious coding. (LeDoux, 1986, pp. 352–353)

However, this statement and others are ambiguous with regard to whether perceptual awareness of the object in the environment has already transpired before the "highly processed inputs from the cortical association areas" have entered the consciousness system. Also, there is the not quite identical open question of what it is that the latter system makes the person or hemisphere aware of, in the first place, when it processes input from the cortical association areas belonging to perceptual systems. Let me proceed as though this ambiguity did not exist and return later in the present section to the alternative that the verbal consciousness system produces perceptual awareness (and feelings).

Gazzaniga and LeDoux (1978) stated, "It is as if the verbal self looks out and sees what the person is doing, and from that knowledge interprets a reality" (p. 150). It is *as if* the verbal self looks out and sees the behavior in context. Seeing is something other than the activities of the consciousness system. This is suggested by the following two quotations.

> It is the verbal system, not the left hemisphere per se, which is compelled to interpret behaviors that are produced by the isolated hemisphere in test situations and by the neural systems of either hemisphere in daily life. (LeDoux and Gazzaniga, 1981, p. 110; cf. LeDoux, 1985, p. 202)
>
> Consciousness in my scheme of brain events becomes the output of the left brain's interpreter and those products are reported and refined by the human language system. The interpreter calls for an untold number of separate and relatively independent modules for its information. (Gazzaniga, 1985, p. 135)

Sticking with the visual case, I take it that the visual perceptual system is the system that produces visual perceptual awareness. In the commissurotomized person, we have the operation of two largely independent visual systems, each producing visual perceptual awarenesses of which the other cerebral hemisphere has no direct (reflective) awareness. Even under conditions of intact functioning, the person may have visual perceptual awareness without consciousness in the sense that I recommend to Gazzaniga and LeDoux. Gibson (1979), for one, adopted such a view of perceiving. He defined

perceiving as involving awareness of something in the environment or something in the observer or both at once, and he insisted that such awareness does not imply consciousness. Having adopted the view that visual perceptual awareness precedes the operations of the consciousness system, Gazzaniga and LeDoux may wish to claim that the system works to give the person consciousness of his or her visual perceptual awareness, that is, to produce *conscious* visual perception.

What exactly does Gazzaniga and LeDoux's human consciousness amount to? It must include judgments (interpretations) of the behaviors that the person perceives himself or herself as emitting. Notice the natural way to refer to the behavior interpreted; namely, it is *perceived* behavior that is interpreted. This implies that the interpreter module not only produces judgments about the behavior. In order to do so, it must produce direct (reflective) awareness of the visual system's output. Otherwise, how could the person know what it is and which behavior he or she is having visual perceptual awareness of?

This interpretation of the relation between the consciousness system and perceptual systems would seem to be compatible with the following fundamental, "rather radical" hypothesis except for its exclusive reference to the monitoring of behavior and "impulses for action," as though these were the only possible objects of the awareness that the consciousness system produces.

> Could it be that in the developing organism a constellation of mental systems ["emotional, motivational, perceptual, and so on": Gazzaniga and LeDoux, 1978, p. 150] exists, each with its own values and response probabilities? Then, as maturation continues, the behavior that these separate systems emit are monitored by the one system we come to use more and more, namely, the verbal, natural language system. Gradually, a concept of self-control develops such that the verbal self comes to know some (though surely not all) of the impulses for action that arise from the other selves, and it tries either to inhibit these impulses or free them, as the case may be. Indeed, it could be argued that the process of psychological maturation in our culture is largely the process through which the verbal system learns to regulate, in accord with social standards, the behavioral impulses of the many selves that dwell inside of us. (LeDoux, Wilson, and Gazzaniga, 1979, p. 550)

The visual system, say, produces visual perceptual awarenesses. According to the Gazzaniga and LeDoux view, the activity of this system may result directly in behavior. Such "direct" behavior is not conscious action since how the behavior is produced does not involve the consciousness system. However, the consciousness system may produce judgments concerning the nonconscious behavior that the visual or any other system produces. Obviously, these judgments do not change the nonconscious behavior's status as nonconscious; if the behavior is not conscious action, it does not become conscious action when the consciousness system characterizes it. Behavior can only be conscious action if it is produced by a consciousness system. In such cases, the respective consciousness system does not need to grasp the behavior's meaning by making inferences.

I do not intend to rule out, with the latter statement, Freudian unconscious determinants of conscious action. I mean only to suggest that the person is cognizant without inference of his or her (conscious) reasons for doing as he or she does. The unconscious determinants of conscious action do not enter as reasons for performing the action.

If the conscious verbal self were capable, with respect to other systems, only of monitoring their impulses for action and the behavior that they produced, then all perceptual awarenesses would not be conscious. This conclusion depends on the theses (a) that perceptual systems are never themselves reflective (self-conscious), only the consciousness system can give direct access to the awareness-products of the perceptual systems; and (b) perceptual awareness is a product of the perceptual systems, not of the verbal system. Of these two theses, abandoning the first would be more descriptive of Gazzaniga and LeDoux's present position than abandoning the second, which they may be in process of doing (see final part of present section).

Assuming that neither of the above theses is abandoned, one can argue as follows. Monitoring behavior is monitoring it in a context that one may grasp, in many cases, only by perceptual means. It must be the case that the conscious verbal self has inner access to (at least) the experiential products of perceptual systems. When the conscious verbal self gives to the person judgments about behavior in whose production this system did not participate, the conscious verbal self must do so on the basis of the experiential output of one or another perceptual system by which the person perceives the behavior.

In the case of monitoring impulses for action produced by a different system, the verbal conscious system must produce awareness of certain central events that precede the occurrence of behavior by the other system. This is entirely consistent with the verbal conscious system's function (that I am urging) of direct (reflective) awareness with respect to the perceptual awarenesses that the perceptual systems produce. By the way, I have not suggested in this way that the verbal conscious system gives or can give immediate awareness of *all* perceptual system products (even of the perceptual-awareness kind).

According to the modification that seems necessary to render Gazzaniga and LeDoux's conception of consciousness more plausible, P.S.'s behavior can be understood, in significant part, as due to the left cerebral hemisphere's lack of access to the awareness-outputs of the various psychological systems that exist in the right hemisphere. P.S.'s left hemisphere did have access to the right hemisphere's behaviors, though perhaps not to its impulses for actions. But P.S.'s left hemisphere did not have direct (reflective) awareness of the visual perceptual experiences of the sample presented by the experimenter exclusively to the right hemisphere. Nor did the left hemisphere have direct (reflective) awareness (as did the right hemisphere, no doubt) to any processes of reasoning that transpired in the right hemisphere (e.g., with regard to which

picture to choose as a match for the presented sample).

In contrast, P.S.'s left cerebral hemisphere did have direct (reflective) awareness of visually experiencing the behaviors that the right hemisphere chose to produce. Notice how I express the latter point. Surely, what I just stated is the proper explication of Gazzaniga's (1983) abbreviated statement that "behaviors generated by the right hemisphere . . . are incorporated into the conscious stream of the left hemisphere" (p. 535).

Although I do not believe that I am distorting the implications of Gazzaniga and LeDoux's explicit view, what I have been suggesting about their mechanism of consciousness may not be what they themselves would say. Their emphasis on the consciousness system's "continuous monitoring" of behavior may well lead to not noticing my point that the consciousness system must do such monitoring always by means of direct (reflective) awareness, since the perceptual systems are distinct from the consciousness system.

An objection to my analysis may be that I have gotten wrong the form in which information arrives from the perceptual systems and, so to speak, enters the consciousness system. At this point, this information is not in the form of Gibson's perceptual awareness, one might argue. The consciousness system does not receive such information by the means of making the person or hemisphere directly (reflectively) aware of the particular perceptual experience that he or she is now having.

However, the judgments and interpretations and reports that the consciousness system produces are all instances of conscious action. This means that they are done on the basis of consulting the stream of consciousness. Let me explain. Suppose that I utter a judgment about *x*, which may be anything at all that I am perceiving, a judgment that is based on my perceiving *x*. That is, I would not have reason to make this particular judgment about *x* except for the fact that I am now perceiving it. For example, *x* might be someone's doing a little dance, and unless I was having perceptual awareness of *x*, I would have no reason at all to make the judgment that I am making. It follows that I must have awareness not only of the person's doing the dance, but I must also be aware of seeing it.

What I just argued is consistent with the following statement by Gazzaniga (1985). He was discussing the interpretation of behaviors that are produced directly by systems other than the consciousness system.

> The proposition is that the normal human is compelled to interpret real behaviors [of the human himself or herself] and to construct a theory as to why they have occurred. Interpreting our behaviors would be a trivial matter if all behaviors we engaged in were the product of verbal conscious action. In that case, the source of the behavior is known before the action occurs. If all actions consisted of only these kinds of events, there would be nothing to explain. (p. 74)

"Nothing to explain" is an exaggeration, of course. However, Gazzaniga's point

was that certain central causes of the action would be known because the action is conscious. Among these known causes are those perceptual awarenesses on which the action is based.

Gazzaniga and LeDoux (1978) included direct (reflective) awareness in their description of the consciousness function performed by the verbal system. They just added it on to the function of monitoring behavior, as though the latter could occur without direct (reflective) awareness. They wrote that the verbal system continuously monitors "our overt behavioral activities as well as our perceptions, thoughts, and moods" (p. 146). However, a recent statement by LeDoux (1985) seems to treat of the consciousness system as having direct observational access to behavior and only indirect access to mental occurrences. In a paragraph that I quoted in full in an earlier section of this article, LeDoux (1985) wrote that the conscious verbal self "only comes to know and understand these hidden mental dimensions [belonging to the remaining systems of the brain] when they are expressed in behavior" (p. 198; see also Gazzaniga's, 1985, Figure 5.4). Accordingly, it is these systems' behavioral output that becomes incorporated into "the subjective experience of self."

LeDoux (1985) gave the following reason for why we can only be conscious of our behavior and not other outputs of nonlinguistic systems in the brain. These systems were said to encode information "in a way that is not decipherable by the verbal system" (p. 208). This reason could have lead LeDoux in a different direction.

Starting from the fact that we have direct (reflective) awareness of components of our stream of consciousness, the theorist might wonder what enables us to have such access. (Perhaps LeDoux would not find this a congenial starting point, since what I consider an obvious fact here, the fact that we have inner access to, for example, many of our thoughts, perceptual experiences, feelings, and so on, is for LeDoux a hypothesis or postulation. He wrote, "We are barely sure, scientifically speaking, that humans are consciously aware": LeDoux, 1986, p. 335.) Some of the inner access could be accounted for in terms of a verbal response to a component of the stream. That is, one might have linguistic thoughts about occurrences in the stream that, through a process of conditioning, evoke those thoughts about them.

Other kinds of access to a component of the stream could not be given a purely verbal account. For example, awareness of a mood state must involve more than identifying or describing the mood (or having thoughts to the same effect). Thus, the consciousness system must do more than enable the person to speak and think about his or her mood. (Recall James's, 1890/1981, distinction between knowledge about and knowledge by acquaintance.) There must be more than a verbal kind of awareness; there must be, as it were, a qualitative awareness—wherein the person has awareness feelingly of how the nervous system is feelingly affected by its bodily or en-

vironmental context and by the processes internal to the system itself.

However, this different direction, as I called it, starting from the idea that the verbal system cannot as such decipher the nonbehavioral outputs of the other brain systems, runs against the view that Gazzaniga and LeDoux have been developing. This becomes dramatically clear when LeDoux (1986) states that feelings are instances of the brain's activity of linguistic coding! Or, at least, they are outcomes, products, or results of such coding. Accordingly, feelings are among the outputs of the verbal conscious system when there is input into the system from the limbic areas of the brain.

Very quickly, however, LeDoux (1986) in effect retracted his conjecture on the role of linguistic coding. Such coding is carried out by a system that operates *with or without* language, it seems. Thus, the statements that have been made about the conscious verbal self that emphasize the verbal dimension *also apply* in those cases where the individual does not have language, with certain qualifications that were encapsulated in the statement, "One who is without the capacity to speak or understand speech . . . may nevertheless possess humanlike self-awareness" (LeDoux, 1986, p. 351).

After this is said, the implication may still be present that in those individuals in whom the conscious verbal self is indeed functioning verbally, it is linguistic coding by this system that produces feelings and, presumably, our various perceptual experiences. Contrary to what I have been arguing, the verbal conscious system gives to the intact linguistic human being his or her perceptual awareness of the world.

Thus, LeDoux has avoided the criticism that nonlinguistic adult and infant human beings and animals must also have feelings and other kinds of experiences. His reply is that they do but that their feelings and other experiences are different from those of linguistic individuals. However, his "conceptual leap," as he called it, to *linguistic activity's producing feelings and other experiences* is in need of discussion, to make the idea understandable and plausible at the least. What is needed is not simply to indicate that how we talk or verbally think about something will produce corresponding feelings in us. What is needed is to show that it makes sense to hold *that the exercise of concepts is not only evocative of feelings but creative of them.* LeDoux needs to show some sort of noncausal, essential affinity between linguistic or conceptual activity and feelings.

A Nonconceptual Mechanism of Fusion

It is correct to say, I believe, that the Gazzaniga and LeDoux hypothesis concerning consciousness, which I discussed in the preceding section, explains the unity of conscious experience in terms of (a) a certain cortical system's exercise of concepts, which may be verbal or nonverbal, and (b) the individual's or cerebral hemisphere's use of conventional language. That is, the

hypothetical consciousness system is supposed to process spontaneously in a verbal or conceptual way all or some of the inputs into the system; and, also, this consciousness system is supposed to enable its owner to engage in conscious action, which may or may not be verbal. Because Gazzaniga and LeDoux have not yet developed to the required point just how their verbal-conceptual consciousness system accomplishes what they have attributed to it, my statements concerning the system, at this time, do not distinguish between the system's spontaneous or automatic processing or reactions and the deliberate activities that the system makes possible for the individual or cerebral hemisphere to which it belongs. In the category of deliberate activities are, for example, the individual's or speaking hemisphere's verbal reports to other people concerning the stream of conscious awareness, behavior, and environment. In the following, all of the consciousness system's relevant operations are treated simply as conceptual or verbal processing, without regard to whether such processing is or is not part of something that the system's owner is doing on purpose.

By the very process of verbal or conceptual thought, it would seem, the individual or respective cerebral hemisphere becomes immediately aware of inputs to the consciousness system. At this early point, the process of verbal or conceptual thought has not yet proceeded, relative to the input that is the object of immediate awareness, to the level of inference or interpretation. Inference or interpretation may already be going on and may affect the processing that is the immediate awareness, but the latter is not the direct product of the process of inference or interpretation. In the Gazzaniga and LeDoux view, being consciously aware of something is a matter of characterizing or identifying it, either in words or otherwise. The consciousness system works relative to inputs to it to convert them, as it were, into premises for possible lines of thought. This conversion or transformation of inputs is what makes the owner of the system aware of the inputs and sets the stage for interpretative processing which is based on that of which the owner is aware. The converted input, which may begin lines of thought, is itself the individual's or cerebral hemisphere's consciousness of the input.

In this way, the consciousness system creates, for one thing, a unified sense of self, according to LeDoux (1985). He wrote, "Natural language . . . allows for the common coding of divergent experiences and for the construction of a continuous, unified sense of self and reality" (p. 198). My interpretation of this view is that a unified sense of self is the product of a line of interpretation that the consciousness system spins out from the premises constituted by more immediate, noninferential, though no less conceptual or verbal awareness (including "retrowareness"; see below).

The reader can find further consideration of this interpretative, unifying function in my two published discussions of "conscious personality" (Natsoulas, 1984d, 1984e). Also relevant are my discussions of the fifth ordinary concept

of consciousness (Natsoulas, 1983c, pp. 41–47; 1986–1987, pp. 306–311). I defined the concept of conscious personality as having reference to the total subjective organization of personal consciousness at any time. In another article, I discussed cases, some abnormal, in which this organization is much less than unified (Natsoulas, 1979). My hypothesis with regard to personal consciousness was that its subjective unity (i.e., the unified sense of self) is an achievement that the consciousness system makes possible to varying degrees at different times and in different individuals. Actually, I made no mention of a consciousness system as such; however, it turns out that Gazzaniga and LeDoux held that their system performs the very functions that give to its owner a personal consciousness that is uniquely unified and organized from a subjective perspective.

Insofar as it succeeds, the consciousness system subjectively organizes the flow of conscious awareness that the system is itself producing or to which, at least, it is contributing the dimension of direct (reflective) awareness. The system provides a conceptual perspective on the flow and unifies parts of the flow that, from that perspective, may be widely disparate in time. Therefore, the flow must include "retrowarenesses" among its components (Natsoulas, 1986a).

Retrowarenesses are occurrent nonperceptual awarenesses of something about a past state of affairs or event. Not all retrowarenesses are relevant to the subjective organization of personal consciousness. They may have to do exclusively with matters that lie beyond the stream. Those retrowarenesses that are relevant have as their intentional objects mental occurrences that belong to the same stream of conscious awareness as they themselves belong. These retrowarenesses make possible the creation of a subjective organization of components of the stream belonging to a single individual, to oneself, and as related in various ways to each other and to factors outside the stream (cf. "conscious personal unity" as discussed in Natsoulas, 1984–1985, with reference to William James).

The remarks in this section explicate the Gazzaniga and LeDoux consciousness hypothesis rather than simply reporting it. These authors gave little attention to the verbal-conceptual consciousness system's relation to its own products, and more attention to how the system subjectively organizes behavioral outputs from other psychological systems of the same brain. Nevertheless, much more can be said about the proposed unifying function of the consciousness system. And there are other good reasons for me to take up again, in a future installment of this series of articles, the Gazzaniga and LeDoux hypothesis about consciousness.

In the final section of this installment, I want to discuss, again in a necessarily preliminary way, an account of the unity of conscious experience that is alternative to the postulated verbal-conceptual consciousness system. This alternative is the already mentioned commissural-integrative account. Whether

this kind of account is an alternative or a supplement will depend on the direction that will be taken by further development of thought about consciousness and the brain. It may well turn out that the commissural-integrative account is compatible with the hypothesis of a purely conceptual-verbal consciousness. It may be shown that the two "competing" accounts are actually treating of different problems of consciousness (Natsoulas, 1981). As I have stated elsewhere, apparently competing accounts in psychology often miss each other in the dark as they address different problems. Also, psychologists who want to exercise leadership in the field will overstate the generality of their particular contribution. I postpone to a future article an exploration of the two accounts' mutual compatibility, or potential compatibility given certain modifications.

The commissural-integrative account of the unity of conscious experience introduces a purely physiological, nonverbal, nonconceptual mechanism of fusion. I have already implied how the verbal-conceptual consciousness system differs from the kind of fusion mechanism that I discuss in the present section. Let me make the difference explicit.

Absent all linguistic training or linguistic learning of any kind or absent the capacity to acquire language, the respective consciousness system (assuming that there is one) will nevertheless produce a flow of conscious awareness, or add the dimension of consciousness to the flow. It may be true, as well, that language is not necessary for some degree of conscious personal unity over time. The preceding two sentences represent an interpretation of the Gazzaniga and LeDoux position that, I believe, does their position justice. What I stated does not contradict their hypothesis about consciousness, since the operations of the mechanism that produces nonlinguistic conscious awareness may be conceptual. That is, before the individual or cerebral hemisphere acquires language, this mechanism (i.e., the consciousness system) operates in some essential ways as it does after language has been acquired. Whereas language acquisition expands the system's conceptual repertoire, the system is not devoid of all concepts prior to language acquisition. Somewhat the same can be said as well with regard to an analogous mechanism in some creatures that cannot learn language. In such creatures, their analogous system may operate conceptually with reference to inputs into the system and also perhaps with reference to outputs from the system. LeDoux (1986) stated, "The cognitive underpinnings that make language and consciousness possible do not necessarily correspond with the capacity to express and understand language" (p. 351).

In contrast, the proposed commissural-integrative mechanism of fusion between hemicortexes is purely physiological, nonverbal, and nonconceptual. It is not by making the individual or cerebral hemisphere *aware* of certain inputs that this mechanism performs its function, makes its contribution to the unity of conscious experience. That is, this mechanism does nothing at

all like bringing inputs under a heading; rather, it helps to produce the raw materials, as it were, of mental experience. *Ex hypothesi*, the verbal-conceptual consciousness system makes its owner aware of experiential materials and able to report on what are, already, instances of unified experience, due partly to the functioning of the commissural fusion mechanism. Accordingly, a basic guiding conviction of the commissural-integrative approach is that a problem of consciousness exists of how the nervous system brings unified individual experiences into existence (see Natsoulas, 1981, "the problem of conscious experience"). About experiences, the verbal system may produce judgments and interpretations regarding the sources of the experiences and other matters. The commissural fusion mechanism is seen as preventing the "dispersal" of the individual experiences to distinct streams of consciousness, which we know can happen from the research on commissurotomized people.

I mentioned earlier that Puccetti (1987) characterized the commissural-integrative view a little unfairly when he stated that conscious experience emerges only upon callosal activation. The commissural-integrative view is portrayed more accurately by saying that callosal or commissural activation is part of any conscious experience that is unified between the cerebral hemispheres. Not all conscious experiences involve processes in two cerebral hemispheres. People continue to have conscious experiences who have had a cerebral hemisphere removed because it was terminally diseased. Also, sectioning all the commissures between hemispheres does not put an end to conscious experience, although conscious experiences are, consequently, no longer unified in the sense that they are all components of a single stream of consciousness. Instead, after commissurotomy, there proceed two flows of experience, simultaneously and separately, one in each hemisphere. Sperry (1976), who emphasized the commissural-integrative contribution to the unity of conscious experience, accepted the possibility that activity in the intact commissures might decline to a point where two streams proceed, one in each hemisphere. He stated, "This interpretation does not exclude the possibility that the conscious processes in left and right hemisphere may function separately in the undivided brain under exceptional conditions, and particularly where pathology tends to depress commissural function" (p. 171).

Now, Puccetti's (1973, 1975, 1976, 1977, 1981a, 1981b, 1983, 1985) own view has been that the forebrain commissures do not constitute a fusing mechanism whereby a single stream of consciousness is produced in the intact human being. The commissures function in the way that Cronin-Golomb (1986b) held that the subcortical pathways function between hemicortexes. That is, the commissures simply allow for transfer of information, albeit of a higher grade than the subcortical pathways allow. In a recent book, this is how Gazzaniga (1985, pp. 125–129), too, consistently characterized the functioning of both intact and partially sectioned forebrain commissures. According to Puccetti, within each hemicortex, a stream of consciousness proceeds, and not

only in those people who have been commissurotomized or whose commissures are failing to function normally.

The simple transmission of information is a far cry from a fusing mechanism. As Cook (1986) stated, "The importance of letting the other half of the nervous system know what is going on contralaterally may be self-evident, but clearly the distribution of sensory information must be described as a lower-level function" (p. 76). Nevertheless, Cook saw this lower-level function as responsible for unifying the visual field. But transfer of information by means of the commissures results in duplicating processes across the hemispheres. As a result, both hemispheres would have, presumably, awareness of the entire sensory field. Transfer of information is equalization rather than unification.

Nevertheless, Berlucchi (1983), who expressed the duplicative view as his own, saw the view as quite consistent with Sperry's commissural-integrative account of interhemispheric unity of conscious experience. Berlucchi (1983) stated,

> To return to the physiology of the cortical commissures, I have recently reviewed a massive body of evidence indicating that the functional significance of these connections lies in the unification of sensory information coming from the two halves of the body or the visual field and, in general, the equalization of activity in the corresponding regions of the two hemispheres (Berlucchi, 1981). This is fully in accord with Sperry's (1974) idea that the corpus callosum has a unifying role in conscious experience and cortical activity. (p. 172)

For Berlucchi's account to be in accord with Sperry's commissural-integrative view, he must introduce a fusion mechanism that goes well beyond the mere equalization of activity between cerebral hemispheres.

After all, when Puccetti attributed to normal human brains dual streams of consciousness, he too had occasion to emphasize the equalization of activity between the hemispheres, in order to explain how it is possible for two hemispheres, each with its own mental life, to "cooperate" in the individual's adaptation to the environment, in such a way that there being two is not even evident. Puccetti (1981b) stated, "How much more efficient it is if nature wires in a relay system, so that each half brain sees the same visual target in the same place in extrabodily space at almost the same time" (p. 96). In fact, Berlucchi's (1983) account of "integration" by means of the commissures sounds much like Puccetti's (1981a) analogy of Fred Astaire and Ginger Roger's dancing as one though they were two. Berlucchi (1983) stated, "I believe that corresponding cytoarchitectural areas of the two sides have exactly the same physiological organization and general function in behavior, and the commissural links serve to ensure a yoked synchronous and congruent activity in the two members of each pair of areas" (p. 172).

Being up to the job of integrating activities that on their own would produce two separate streams of consciousness requires more than the transmis-

sion of information and the duplication or equalization of processes. Cronin-Golomb's (1986b) results seem to show that transmission of information is entirely compatible with there being distinct experiences in the two cerebral hemispheres. Insofar as the one stream is affected by the other stream, we do not therefore have a single stream. The question for the fusion view of the cerebral commissures is how they perform the fusion, whereas the subcortical pathways only manage to cause information to be shared between hemicortexes. Thus, what does it take for structures that are not part of the cerebral cortex itself to contribute bodily their activity to the stream of consciousness?

Puccetti (1987) objected that the kind of tripartite activity that authors such as Sperry have in mind, the middle part being integrative commissural activity, could not do in fact what is proposed, namely produce a single stream of consciousness. For example, such tripartite activity could not give rise to a single visual field rather than two of them; that is, it cannot produce what I have called, following Puccetti (1981b), "experiential conscious unicity" (Natsoulas, 1983–1984). The existence and activation of connecting neural fibers between corresponding visual, or other, areas in the brain does not mean that they are necessarily up to doing the job that some authors have attributed to them.

Here is a sophisticated statement that assumes that the commissures are capable of performing the integrative function:

> The axonal connections via the corpus callosum are obvious candidates for the neural substrate underlying such a fusion mechanism. . . . 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. . . . Although these modalities are unified in consciousness, they are located in disparate regions of the brain. Thus the mechanism providing the unity must involve the white fiber cortico-cortico (or subcortical) connections running between these areas. If intermodal unity is accomplished by white-fiber connections, then it is even more likely that intramodal fusion could be accomplished by commissural axonal connections. (Anderson and Gonsalves, 1981, p. 100)

Reading this entirely reasonable statement, one realizes how valuable as antithesis Puccetti's competing account and objections are. Even assuming that Puccetti is wrong on the common presence of dual consciousness in the intact human, his discussions challenge the easy line of thought that (a) naively assumes a single stream per intact human, and then (b) argues what else than the commissures could do the necessary job of unifying consciousness, while (c) leaving obscure how the commissures might accomplish the unification. To say, as Anderson and Gonsalves did, that it is accomplished in the same way that intermodal unity is accomplished within a cerebral hemisphere is not to say how it is done, since the analogy is with an unknown process.

(I shall mention shortly an argument no doubt acceptable to Anderson and Gonsalves that they might use.)

Optimistically though complexly, LeDoux and Gazzaniga (1981) saw the problem to which Puccetti (1981b) drew attention. Responding to his article, they stated,

> The search for the mechanism of fusion is precisely what the field of visual physiology is all about. Perception is the physiological integration (fusion) of sensory inputs into unified percepts. Within each hemisphere, the visual world is multiply represented, and the unified percepts of a single isolated hemisphere thus reflect the integration of processing occurring in many cortical and subcortical cell groups. Similarly, in the intact brain, unified percepts involving both visual fields reflect the fusion of visual processing in the multiple areas representing the visual world within each hemisphere, with the processing occurring in the homologous areas of the other hemisphere. The search for the neural mechanisms that accomplish fusion is well under way. (p. 110)

Let me make three relevant comments on this statement. The first is familiar from my earlier discussion of Gazzaniga and LeDoux's consciousness system.

1. LeDoux and Gazzaniga (1981) distinguished conscious experience from what they were discussing in the above paragraph. Conscious experience is distinct from the parts (representational processing) and integrated wholes (unified percepts) mentioned there. The integrated products of the fusion process must somehow feed a further structure (i.e., a distinct "complex system of interconnected neurons") in which, or out of which, the stream of consciousness flows.

2. Although one may sometimes get a different impression (e.g., LeDoux, 1985), LeDoux and Gazzaniga (1981) accepted that there are two streams of consciousness in the commissurotomized person. They stated, "Split-brain studies in animals and humans have demonstrated that sectioning the forebrain commissures produces two independent mental entities, each with thoughts, feelings, and plans for action that exist outside the realm of awareness" (p. 109). Two streams, one in each hemisphere, would seem to mean that each hemisphere contains its own neural structure that makes for consciousness, its own consciousness system. Since commissurotomy does not bring either neural structure into existence, there must be two such structures, one in each hemisphere, before commissurotomy. Perhaps they form a single system in the intact person, working together to yield a unified effect.

In the commissurotomized person, according to Gazzaniga and LeDoux, the neural structure making for consciousness in the nonspeaking hemisphere is capable in some people of verbal activity, in others it is not. When it is not so capable, the structure can still make possible conceptual thought of a relatively primitive kind and, therefore, a kind of nonverbal, conceptual consciousness. And the two structures, one in each hemisphere, must receive, among other inputs, inputs in the form of unified percepts. Thus, both cerebral hemispheres, on their own, can have conscious perceptual awarenesses; among

other conscious mental occurrences, depending on other inputs into the respective consciousness systems.

In the intact person, do the two consciousness structures produce, as in the commissurotomized person, each its own stream of conscious awareness? Assuming that they do not, Gazzaniga and LeDoux would need a fusion mechanism between the hemispheres that creates a single consciousness system. Again, the mere fact that the two systems are connected, information being transmitted from each to the other, does not mean that they constitute a unified system with a unitary product at any point in time.

An alternative hypothesis would be that the less verbally adept potential consciousness system is inhibited from functioning by the connecting commissures. In that case, one would expect that the consciousness of the commissurotomized person's speaking hemisphere would not differ from the consciousness of a corresponding intact person. More precisely, the only differences that would emerge would be ones accountable in terms of nonverbal inputs that depend on lateralized functioning in the nonspeaking hemisphere. On the basis of observed samenesses and differences, it might be possible to argue that verbal-conceptual consciousness per se does not differ. This is a matter that clearly needs further exploration.

3. The above quoted paragraph from LeDoux and Gazzaniga (1981, p. 110) includes the idea, perhaps, that there are many unified percepts occurring simultaneously in each hemisphere. With commissures intact, these multiple percepts are each informed by representational processing that is proceeding in both cerebral hemispheres. Thus, someone may speak of them as "unified" across the hemispheres as well as within the hemispheres. Obviously, this is a different sense of "unified" than the one that has been at work in the present article. It is better to say that the multiple percepts are "functionally unified" relative to each other; that is, they are informationally consistent with one another, and therefore work to the same effect in the overall brain process (cf. Natsoulas, 1987b).

Puccetti (1987) suggested that a fusion mechanism such as the one that Sperry and others had in mind could only produce two complete visual fields side by side, contradicting our direct (reflective) awareness of our visual experience. Bogen (in press) put forward the following related argument. Many people emphasize the great size, in number of fibers, of the corpus callosum. However, the number of connections between hemicortexes accomplished by this structure is less than a hundreth of the number of connections within each hemicortex. The point is germane to the idea that the commissures are up to the job of serving as a fusion mechanism. Along the same lines, Bogen also mentioned that there are significant constraints, probably, on the commissures' synchronizing role. Dolphins, who have a large corpus callosum, can be half asleep, as it were, the other hemisphere remaining awake.

However, Bogen's calculation hardly seems decisive. The neural units that

are proximately connected across the hemispheres by means of the commissures may be, in effect, continuations of the commissures deeper into each hemisphere where connections quickly multiply from all directions within the hemisphere. Also, there is no need that everything that goes on in each hemisphere be integrated with everything that goes on in the other hemisphere (assuming that the commissures, because of their limited size, cannot accomplish this). The intercerebral cortical connections may suffice for one purpose, namely, to integrate activity in those structures on each side that enable the independent streams of consciousness of the commissurotomized person.

Perhaps the function of the forebrain commissures is specifically the production of a single stream where there would be two without them. This may be the answer to, for example, the functional part of Cook's (1986) question that nearly answers itself: "If there exist two 'cortical modules' specialized for, say, musical chord recognition on the right and phonemic analysis on the left, how does callosal activity allow for meaningful communication between them and why should it bother" (p. 82)?

Assuming that, without commissural function, different important dimensions of auditory awareness proceed in the two cortical modules, one on each side, there is every reason for the cortical commissures "to bother." Only by means of the commissures could there be produced a unified auditory experience possessing all the important dimensions. Moreover, the commissures would produce a single stream of auditory experience rather than two (without the commissures) that would feed into other systems. I am thinking especially here of Gazzaniga and LeDoux's verbal system, which would report a single stream of sound as the cause of the input into the verbal system, rather than a double sound. Note how this extends Anderson and Gonsalves's (1981, p. 100) argument, under the assumption that deconnected cerebral hemispheres cannot have certain kinds of perceptual experiences. When words and music are involved, only a unified process between the hemispheres can give the full auditory experience.

However, Puccetti can reply that whatever only one hemisphere can accomplish in the way of processing can be passively shared by the other hemisphere. Although an experience may be incapable of originating in one or the other cerebral hemisphere, the forebrain commissures may cause the experience to be duplicated in the hemisphere that cannot independently produce it.

Nevertheless, demonstrations of differences between the consciousness of commissurotomized and intact people would seem to be highly relevant to the plausibility of the commissural-integrative view. From the latter perspective, it is reasonable to expect that the substantial machinery of the commissures and the corresponding structures on the other side will make a difference to consciousness. Therefore, one might approach the commissurotomized skeptically, as though they are very different from us with respect

to their consciousness, whether both or either of their cerebral hemispheres are being considered. This suggestion, which I draw from the commissural-integrative view, is not meant to be as extreme a suggestion as LeDoux's (1985) questioning of the humanness of the mute hemisphere's consciousness. Yet there is some resemblance, since I suggest that investigators look for how consciousness is different for the commissurotomized. Cook (1986) has issued a similar call. His call had its source in a certain understanding of what the right hemisphere contributes to the speech activities of the left hemisphere, namely, "the contextual and connotative implications of language." That is, deconnection from the right hemisphere causes the speaking hemisphere to function differently linguistically than the intact brain does, according to Cook.

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