

A Divided Mind: Observations on the Conscious Properties of the Separated Hemispheres

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Each cerebral hemisphere in Patient P. S., a callosum-sectioned patient, appears to possess mental properties deserving of conscious status. The observations seem to answer many questions concerning the issue of whether the mechanisms of consciousness can be split and doubled by split-brain surgery. As P. S. is the first split-brain patient clearly to possess double conscious processes as well as the first with extensive bilateral linguistic skills, the observations suggest that the special nature of human conscious experience is closely tied to linguistic processes.

LeDoux JE, Wilson DH, Gazzaniga MS: A divided mind: observations on the conscious properties of the separated hemispheres. *Ann Neurol* 2:417-421, 1977

Contemporary interest in the neuropsychological mechanisms of human consciousness was stimulated in the 1960s by observations of patients who had undergone cerebral commissurotomy in an effort to control the interhemispheric spread of epileptic seizure activity [7-10]. These split-brain studies demonstrated that each cerebral hemisphere could process information outside the realm of awareness of the other half-brain, and thereby suggested that brain bisection produces a state of double consciousness.

Speculation concerning double conscious mechanisms in split-brain patients has taken two forms. One is the notion that each cerebral hemisphere in man has evolved a separate cognitive style and mode of information processing [1, 5, 11, 15, 16, 24, 25, 30]. The other, which we address here, is the more basic question of whether the mechanisms of human consciousness are actually split following brain bisection [3, 5, 18, 19, 26-29, 33].

As it is relatively easy to assess the nature and limits of cognition and consciousness in the left, speaking hemisphere, the challenge has always been to determine the conscious properties of the mute half-brain. Studies to date [2, 4, 17, 19-23, 32] have not conclusively shown that the separated right half-brain possesses some of the more abstract qualities of mental life. Consequently, the view [26] that the mute hemisphere is an equal partner with the left in terms of conscious processes has been widely criticized on philosophical and empirical grounds [3, 18, 33]. As MacKay [19] has noted, until it can be shown that each

separate half-brain has its own independent system for assigning values to events and for setting goals and response priorities, the split brain cannot be viewed as a split mind.

The question of whether the essence of human consciousness can be represented bilaterally in the split-brain patient has so far remained unanswered. The following observations on a new patient, Patient P. S., may help to resolve the issue. For the first time, it has been possible to ask subjective questions of the separated right hemisphere and to witness self-generated answers from this mute half-brain. This opportunity was made possible by the fact that linguistic representation in the right hemisphere of our patient is greater than has been observed in any other split-brain patient. In addition to an extensive capacity for comprehending written and spoken language, the right hemisphere, though unable to generate speech, can express its mental content by arranging letters to spell words [12].

The observations that follow are not meant to suggest the normal properties of all right hemispheres. The extensive bilateral linguistic representation in this special case allows us to observe what *can* exist, rather than what necessarily exists normally.

Material and Method

P. S., a right-handed boy, experienced a series of severe convulsions at about 2 years of age, with a seizure focus identified in the left temporal region by electroencephalography. Following this early activity he apparently developed

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Accepted for publication May 23, 1977.

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normally until age 10, when generalized seizures recurred spontaneously and became intractable. In January, 1976, he was operated on for complete surgical section of the corpus callosum. A complete medical history has been published elsewhere [31]; this report deals exclusively with psychological evaluation of the conscious properties of the patient's separated hemispheres.

All tasks involved the lateralized presentation of visual stimuli. The subject was seated about 1 m from an opaque screen and instructed to fixate on a dot in the center of the screen. By means of a standard slide projector fitted with an electronic shutter, stimuli were presented to the right or left of fixation for 100 to 150 msec.

The first two tests involved the scaling of words. These tests were aimed at determining whether each hemisphere has its own independent system for assigning subjective values to environmental events.

In the first test, following lateralized presentation of a word, the subject was required to select (by pointing) the number from 1 to 7 that represented how he felt about that word. He was previously instructed that 1 represented "good" and 7 "bad," with points in between indicating gradations of "goodness" or "badness." In all, sixteen words were scaled (Table 1). The words used were selected either because they have been empirically determined to be amenable to "good/bad" scaling [14] or because of their personal significance to the patient. The words of the latter category included "Paul" (his name), "Liz" (his girlfriend's name), "Fonz" (a television character he talks about), and "car" (another frequent word in his vocabulary).

In the second scaling test, the words (Table 2) were all of the personal type. These words, which were chosen on the basis of previous conversations with the subject, were scaled

in a manner similar to the previous test except that a five-point scale was used. On each trial the subject was asked, "How much do you like *blank*?" Subsequently, a word was lateralized and he was required to select by pointing to one of the five points of the scale: "like very much," "like," "undecided," "dislike," or "dislike very much."

The final test involved a series of questions directed to the right hemisphere. These questions were aimed at further evaluating whether this patient's mute half-brain possesses what we regard as some of the essential qualities of human consciousness, including a sense of self, a sense of the future, goals and aspirations, feelings, and personal preferences. In addition, we were interested in having the right hemisphere generate its own responses from an unrestricted population of possibilities. To do this we capitalized on the patient's unique ability among split-brain patients to respond to right hemisphere questions by arranging letters to spell words.

At each trial the examiner asked a subjective question in which the key word or words were replaced by the word *blank*. Subsequently, the missing word or words were lateralized, and the patient was asked to spell his answer. To do this he was provided with two complete alphabets made up of Scrabble letters. The specific questions included the following. "Who *blank*?" The key words lateralized to the right hemisphere on this trial were "are you?" "Would you spell the name of your favorite *blank*?" This question was used on three trials directed to the right hemisphere. The key words on these trials were "girl," "person," and "hobby." The right hemisphere was also asked, "If you had your choice, what *blank* would you pick?" The key word on this trial was "job." Another question asked of the right hemisphere was "What is *blank*?" "Tomorrow" was

Table 1. Word Rating on Good/Bad Scale^a

Word	(Good)	1	2	3	4	5	6	7	(Bad)	Right/ Left Spread
Nice	L	.....							R	5
Car	L,R									0
War				L	.....				R	4
Kiss	L	.....	R							1
Devil			L	.....					R	2
Money	L,R									0
Mother	L	.....							R	5
Sex	L	.....							R	5
Vomit						L,R				0
Paul	L	.....							R	6
Fonz	L	.....							R	6
Liz	L	.....			R					2
Sunday						R	.....		L	-2
Truth				L	.....				R	1
Hate						L	.....		R	2
Love	L	.....							R	3

^aThe right hemisphere ratings (R) were consistently more negative than the left hemisphere ratings (L). This is indicated in the last column, which shows the difference between the left and right ratings. Because the left rating was always subtracted from the right rating, a positive value in the last column is indicative of a more negative rating by the right hemisphere.

Table 2. Word Rating on Preference (Like/Dislike) Scale^a

Word	LVM	L	U	D	DVM	Right/Left Spread
TV	L.....R					1
School		L,R				0
Drafting	R.....L					-1
Home	L,R					0
Church	L,R					0
Mom	L,R					0
Dad	L,R					0
Sex		L,R				0
Vermont			L,R			0
Liz		L,R				0
Nixon				R.....L		-1
Beer			L,R			0
Paul	L,R					0
Police		L,R				0
Fonz	L,R					0
Dope		R.....L				-3

^aThe right (R) and left (L) hemisphere ratings were strikingly consistent on this test. As can be seen in the last column, in only one instance did the hemispheres differ by more than one scale value. For a majority of the words (12 of 16), the hemispheres generated the same rating.

LVM = like very much; L = like; U = undecided; D = dislike; DVM = dislike very much.

lateralized on this trial. Finally, each hemisphere was separately asked, "In one word, how would you describe your blank?" The missing word here was "mood."

Results

The results of the first scaling test are presented in Table 1. It is clear that many of the words elicited quite different evaluations from the two hemispheres. In addition, the right hemisphere rating was consistently higher (closer to the "bad" end of the scale) than the left rating. The results of the second scaling test, which was administered approximately one month after the first, are given in Table 2. The separate ratings by the hemispheres were strikingly consistent.

The right half-brain spelled "Paul" in response to the question "Who are you?" When requested to spell his favorite girl, the right hemisphere arranged the Scrabble letters to spell "Liz." The right hemisphere spelled "car" for his favorite hobby. When the right hemisphere was asked to spell his favorite person, the following was generated: "Henry Wi Fozi." (Henry Winkler is the actor who plays Fonzie.) The right hemisphere generated "Sunday" in response to the question "What is tomorrow?" When asked to describe his mood, the right hemisphere spelled out "good." Later, in response to the same question, the left spelled "silly." Finally, the right hemisphere spelled out "automobile race" as the job he would pick. This contrasts with the frequent assertion of the left hemisphere that he will be a "draftsman." In fact, shortly after the test session, when asked what he would like to do for a living, the left hemisphere said,

"Oh, be a draftsman, I guess." Although hand use was not dictated, the left hand dominated the spelling responses of the right hemisphere, receiving some occasional support from the right hand. Finally, it should be noted that on each of these right hemisphere trials the patient was unable to name the lateralized information, thus confirming that the left hemisphere did not have access to the critical information.

Discussion

Since the conscious properties of the left hemisphere are obvious through a subject's verbal behavior, our main concern has been with the silent inhabitant of the right side of the cranium. In this regard, we have found that the right hemisphere in this patient has a sense of self, for it knows the name it collectively shares with the left. The right hemisphere has feelings, for it can describe its mood. The right hemisphere has a sense of who it likes and what it likes to do. The right hemisphere has a sense of the future, for it knows what day tomorrow is. The right hemisphere has aspirations and goals for the future, for it can describe its occupational choice.

It is important to reemphasize that these responses were self generated by the right hemisphere from a set of infinite possibilities. The only aid provided to the right hemisphere was the two complete alphabets from which he could select letters at will. The fact that the mute half-brain could generate a completely personal answer to ambiguous, subjective questions demonstrates that this patient's right hemisphere has

its own independent response priority-determining mechanism.

These observations suggest that P. S.'s right hemisphere has a distinct consciousness. However, is that conscious awareness really different from that of its skull mate? Consider the responses of the two hemispheres on the word rating tests. The results of the first test demonstrated that each hemisphere can possess its own unique system for assigning subjective values to environmental events (see Table 1). It is of interest here that the right hemisphere ratings were consistently and substantially more negative than those of the left. It is as if the right hemisphere was in a "bad mood" relative to the left. In contrast, the results of the second test, administered at a later date, demonstrated that the half-brains can have largely overlapping opinions and values (see Table 2). Yet the degree of overlap observed—which is not surprising, given the extent to which the hemispheres share the same life experiences—highlights the subjective disparity that can exist between the hemispheres, as observed in the previous test.

These observations seem to answer some of the earlier criticisms [3, 18, 19, 33] of the notion that human conscious processes can be doubled by cerebral commissurotomy. Each hemisphere in P. S. has a sense of self, and each possesses its own system for subjectively evaluating current events, planning for future events, setting response priorities, and generating personal responses.

Certain correlates of the various psychological responses obtained at different test sessions in this study were of interest. On a day that this boy's left and right hemispheres equally valued himself, his friends, and other matters, he was calm, tractable, and appealing. On a day when testing indicated that the right and left sides disagreed on these evaluations, the boy became difficult to manage behaviorally. It is as if each mental system could read the emotional differences harbored by the other. When they were discordant, a feeling of anxiety, which appeared to be read out by hyperactivity and general aggression, was engendered. This clear example of surgically produced psychological dynamism, seen for the first time in P. S., raises the question whether such processes are active in the normal brain, where different mental systems, using different neural codes, coexist within and between the cerebral hemispheres [6, 15].

Finally, it would appear that the presence of a rich linguistic system is a reliable correlate, and perhaps a necessary prerequisite, to some of the richer aspects of mental life. While it is possible that the conscious properties observed in P. S.'s right hemisphere are spuriously associated with linguistic sophistication, the fact remains that in all other split-brain patients,

when linguistic sophistication is lacking in the right hemisphere, so too is the evidence for consciousness.

Supported by US Public Health Service Grant 25643.

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