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Beyond Commissurotomy: Clues to Consciousness

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INTRODUCTION

When the inevitable topic of nature of consciousness is approached in the light of modern brain research, the experienced student has come to brace himself for the mellifluous intonations of someone's personal experience and ideas on the matter, as opposed to data. Yet we all listen dutifully, because ultimately the business of the serious neuroscientist is to figure out the mechanisms of brain and mind.

One of the most thoughtful and experienced neuroscientists in the world on this issue is Roger W. Sperry. His offerings on the subject reflect what can be called the "it" analysis. Consciousness or "it" is this or that, present or not present, and the like. In his words, it is an "emergent property or cerebral activity . . . and is an integral component of the brain process that functions as an essential constituent action and exerts a directive holistic form of control over the flow pattern of cerebral excitation" (Sperry, 1969). Thus Sperry, after years of thought, feels it necessary to instruct a beleaguered yet lackadaisical field of professional brain and behavior scientists that mental properties of the brain are real, and they are on top, and they can exert control over the individual elements that upon interaction give rise to mental phenomena. It is testimony to thinking at the time that this needed saying, and Sperry's papers as usual are extremely important in focusing future work on important questions. Yet in no way should such overviews be

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eyes scanned the 52 letters available, his left hand reached out and selected the "P," set it down, and then proceeded to collect the remaining letters needed to spell "Paul" (Fig. 1). Overflowing with excitement, having just communicated on a personal level with a right hemisphere, we collected ourselves, and then initiated the next trial by saying, "Would you spell the name of your favorite 'blank'?" Then "girl" appeared in the left visual field. Out came the left hand again, and this time it spelled "Liz," the name of his girlfriend at the time. On the next two trials, the question was the same, but the key words were "person" and then "hobby." "Car" was the reply to hobby, and "Henry Wi Fozi" was the response to his favorite person (Henry Winkler is the real-life name of the television character, Fonzie, that P. S., a 15-year-old boy, idolizes). Another question was "What is tomorrow?" He correctly spelled "Sunday." He spelled "automobile race" as the job he would pick. This is interesting, because the left hemisphere frequently asserts that "he"

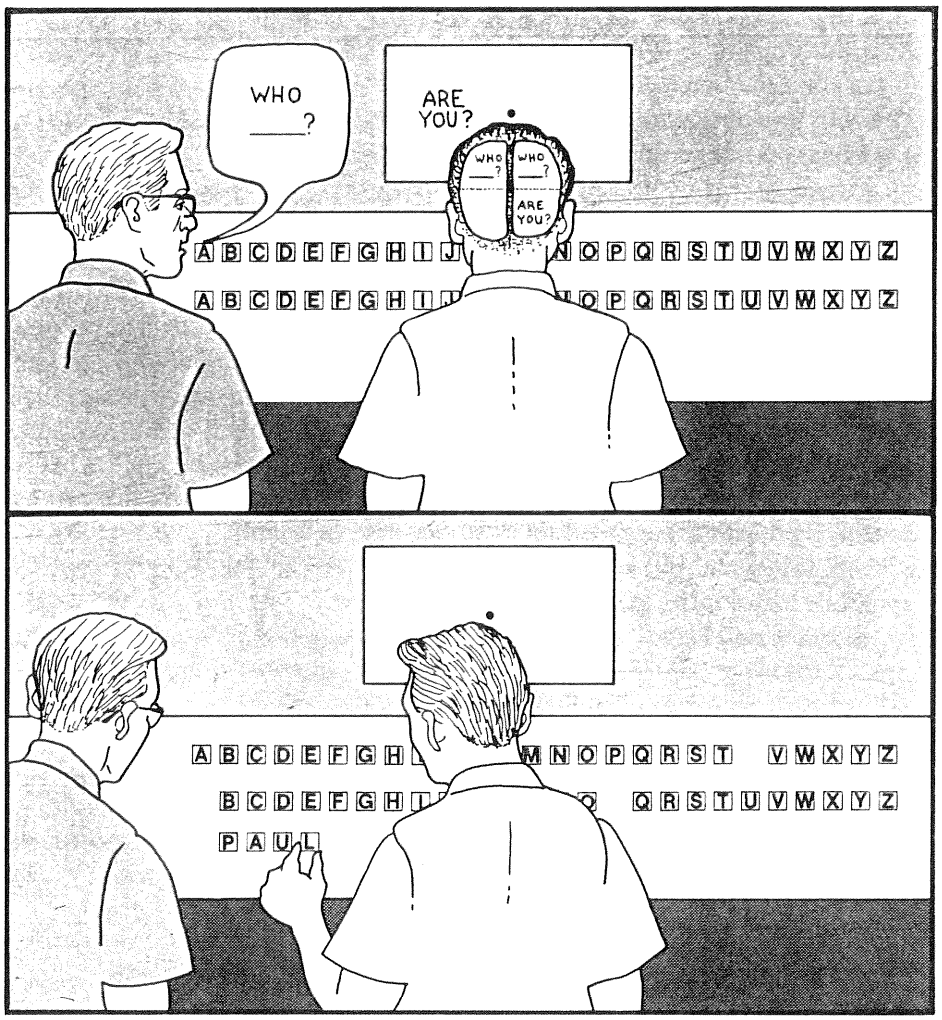

Fig. 1. Volitional expression by the mute hemisphere (see text).

The person is usually engaged in much more activity than can possibly enter consciousness at once, and, in our opinion, much of what does enter is what is registered by the verbal system. It is the one system that is capable of continuously monitoring our overt behavioral activities, as well as our perceptions, thoughts, and moods. In taking note of, integrating, and interpreting these events, we believe that the verbal system provides for a personal sense of conscious reality.

In the following, we will examine how further observation on P. S. shed light on these mechanisms. Again, it is only through the novel experimental situation involved in testing such a patient that these mechanisms, which we feel are basic to man, are exposed.

As a result of having bilateral representation of language comprehension, P. S. is able to act in response to verbal commands exclusively presented to either hemisphere but can only describe verbally the left hemisphere stimuli (Gazzaniga and LeDoux, 1978; Gazzaninga *et al.,* 1977). The observations of relevance here involve the manner in which his left hemisphere dealt with our queries as to why he was responding in a certain way to commands known directly by the right half-brain alone. In brief, when P. S. was asked "Why are you doing that?" his talking left hemisphere was faced with the cognitive problem of explaining a discrete overt movement of great clarity carried out for reasons truly unknown to it.

In trial after trial, the left hemipshere proved extremely adept at immediately attributing cause to the action. When "laugh," for example, was presented to the right hemisphere, P. S. commenced laughing, and when asked why, said, "Oh, you guys are really something" (Fig. 2). When the command "rub" was flashed, the subject, with the left hand, rubbed the back of his head. When asked what the command was, he said "itch." Here again, the response was observed by the left hemisphere, and the subject immediately characterized it. Yet that he said "itch" instead of "rub" shows that he was guessing. In the same way, he could be quite accurate when the command had less leeway for multiple description, as in the case of the word "boxer." The test instruction was to "assume the position of . . ." P. S. correctly assumed the pugilistic position, and when asked what the word was, he said "boxer." But on subsequent trials, when he was restrained, and the word "boxer" was flashed, the left hemisphere said it saw nothing. Moments later, when released, however, he assumed the position, and said, "OK, it was 'boxer.'"

Similar responses were observed in other tests. Pictures of objects were lateralized to his right hemisphere and P. S. was required to spell out the name of the object by selecting and arranging "Scrabble" letters, as described earlier. If while spelling the word he was asked to name the object he had seen, the left hemisphere's verbal response was consistent with the information available externally, but inconsistent with the true state of affairs known only by the right hemisphere. For example, after the picture of a playing card was flashed to his right hemisphere, and he began to select letters, we asked P. S. what the object was. Looking down at the letters "c," "a," and "r," he said "car." However, as this response was being emitted by the left hemisphere, the left hand and the right hemisphere completed the word by adding the final letter "d." The left hemisphere then said, "Oh, it was a card," and P. S. smiled.

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.

These varied observations on P. S. offer us the opportunity to consider whether we were not observing a basic mental mechanism common to us all. We feel that the conscious verbal self is not always privy to the origin of our actions, and when it observes the person behaving for unknown reasons, it attributes cause to the action as it it knows, but in fact it does not. It is as if the verbal self looks out and sees what the person is doing, and from that knowledge it interprets a reality. This notion is reminiscent of the well-known theory of cognitive dissonance, which suggests how one's sense of reality, one's system of beliefs about the world, arises as a consequence of considering what one does (Festinger, 1957).

Implicit in the idea that self-consciousness involves, at least in part, verbal consideration of sensory-motor activities is the assumption that the person or self

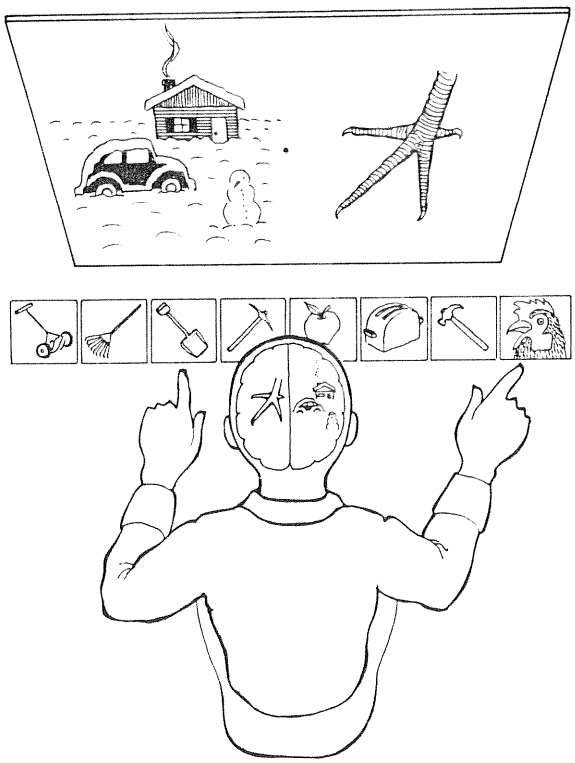

Fig. 3. The method used in presenting two different cognitive tasks simultaneously, one to each hemisphere. The left hemisphere was required to process the answer to the chicken claw, while the right dealt with the implications of being presented with a snow scene. After each hemisphere responded, the left hemisphere was asked to explain its choices. See text for implications.

the verbal system is capable of monitoring internal psychological states, in addition to overt behavioral activities.

On the verbal commands test described earlier, where a word was lateralized to the right hemisphere and P. S. was instructed to perform the action described by the word, his reaction to the word "kiss" proved revealing (Gazzaniga and LeDoux, 1978; Gazzaniga *et al.*, 1977). Although the left hemisphere of this adolescent boy did not see the word, immediately after "kiss" was exposed to the mute right hemisphere, the left blurted out, "Hey, no way, no way. You've got to be kidding." When asked what it was that he was not going to do, he was unable to tell us. Later, we presented "kiss" to the left hemisphere and a similar response occurred: "No way. I'm not going to kiss you guys." This time, however, the speaking half-brain knew what the word was. In both instances, the command "kiss" elicited an emotional reaction that was detected by the verbal system of the left hemisphere, and the overt verbal response of the left hemisphere was basically the same, regardless of whether the command was presented to the right or left half-brain. In other words, the verbal system of the left hemisphere seemed to be able to accurately read the emotional tone of the word seen by the right hemisphere alone.

This observation, which suggests that emotion is encoded in a directionally specific manner, is inconsistent with the currently accepted cognitive theory of emotion (Schachter, 1975). According to the cognitive theory, emotional arousal is nonspecific. The affective tone of emotion is viewed as being determined by the cognitive apprehension of the external situation in which the arousal occurs. However, in P. S., the left hemisphere appeared to have experienced emotion in the absence of cognition. The following experiment was thus aimed at evaluating the reality of this phenomenon (LeDoux and Gazzaniga, 1978).

We selected a number of words that repeatedly appear in P. S.'s verbal behavior. It was assumed that personal words would be more likely to elicit measurable emotional responses than neutral words. Following the lateralized visual exposure of a word, P. S. was encouraged to verbally rate the word on a preference scale. The scale values included "like very much," "like," "undecided," "dislike," and "dislike very much." When the word was presented to the left hemisphere, the verbal judgment was made by the hemisphere that saw the word. However, when the word was lateralized to the right hemisphere, the left hemisphere had to verbally respond to a word it did not see.

We obtained 21 left hemisphere ratings of words lateralized to the right hemisphere. Twelve right hemisphere words were rated, some as many as three times, others only once.

Figure 4 compares the left hemisphere rating of each word on the first left hemisphere trial with the first successful right hemisphere trial (an unsuccessful right hemisphere trial was one on which the word could be named; such ratings were counted as left hemisphere trials). In only one instance ("Nixon") did the left hemisphere rating of right hemisphere words differ by more than one scale value from the left hemisphere rating of the same words after left hemisphere exposure.

It thus appears that the emotional value of a stimulus is encoded in a

1973). Also concentrated in the amygdala are nerve terminals utilizing morphine-like peptides (enkephalins) as the neurotransmitter (Snyder, 1977). These peptides bind to the opiate receptor sites, and this action has been linked with emotional mechanisms. Thus it is possible that the neural mechanisms of emotional encoding seen in P. S. involve the opiate receptor sites in the amygdala and the interamygdala connections of the anterior commissure.

At the psychological level, the observation that the verbal system can accurately read the emotional tone precipitated by an external stimulus without knowing the nature of the stimulus allows speculation concerning the nature and variability of our mood states. The idea that we are intrigued with is that the person is not always aware of the origin of his moods, just as he is not always aware of the origin of his actions. In other words, the conscious self appears to be capable of noticing that the person is in a particular mood without knowing why. It is as if we become subtly conditioned to particular visual, somatosensory, auditory, olfactory, and gustatory stimuli, and while such conditioning can be, it is not necessarily within the realm of awareness of the conscious self. When in Florence, for example, one can be focused on David and feel so aroused, awed, and inspired that unbeknownst to the verbal system the brain is also recording the scents, noises, and the total gestalt of that remarkable city. The emotional tone conditioned to these subtle aspects of the experience might later be triggered in other settings because of the presence of similar or related stimuli. The person, puzzled by his affective state, might ask himself, "Why do I feel so good today?" At this point, if the Florentine experience is not recalled (registered by the verbal system), the process of verbal attribution may take over and concoct a substitute, although perhaps very plausible, explanation. In short, the environment has ways of planting hooks in our minds, and while the verbal system may not know the why or what of it all, part of its job is to make sense out of the emotional and other mental systems and in so doing allow man, with his mental complexity, the illusion of a unified self.

We thus feel that the verbal system's role in creating our sense of conscious reality is crucial and enormous. It is the system that is continually observing our actual behavior, as well as our cognitions and internal moods. In attributing cause to behavioral and psychological states, an attitudinal view of the world, involving beliefs and values, is constructed, and this becomes a dominant theme in our own self-image.

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