

Chapter

I

BIOLOGY AND HUMAN BEHAVIOR

Reading 1 ONE BRAIN OR TWO?

Reading 2 MORE EXPERIENCE = BIGGER BRAIN

Reading 3 ARE YOU A "NATURAL?"

Reading 4 WATCH OUT FOR THE VISUAL CLIFF!

Nearly all general psychology texts begin with chapters relating to the biology of human behavior. This is due not simply to convention but rather because basic biological processes underlie *all* behavior. The various branches of psychology rest, to varying degrees, on this biological foundation. The area of psychology that studies these biological functions is typically called *psychobiology* or *biological psychology*. This field focuses on the actions of your brain and nervous system; the processes of receiving stimulation and information from the environment through your senses; the ways your brain organizes sensory information to create your perceptions of the world; and how all of this affects your body and behavior.

The studies chosen to represent this basic component of psychological research include a wide range of research and are among the most influential and most often cited. The first study discusses a famous research program on right-brain/left-brain specialization that shaped much of our present knowledge about how the brain functions. Next is a study that surprised the scientific community by demonstrating how a stimulating "childhood" might result in a more highly developed brain. The third study represents a fundamental change in the thinking of many psychologists about the basic causes of human behavior, personality, and social interaction—namely, a new appreciation for the significance of your *genes*. Fourth is the invention of the famous *visual cliff* method of studying infants' abilities to perceive depth. All these studies, along with several others in this book, also address an issue that underlies and connects nearly all areas of psychology and provides the fuel for an ongoing and fascinating debate: the nature-nurture controversy.

Reading 1: ONE BRAIN OR TWO?

Gazzaniga, M. S. (1967). The split brain in man. *Scientific American*, 217(2), 24-29.

You are probably aware that the two halves of your brain are not the same and that they perform different functions. For example, in general the left side of your brain is responsible for movement in the right side of your body, and vice

versa. Beyond this, though, the two brain hemispheres appear to have much greater specialized abilities.

It has come to be rather common knowledge that, for most of us, the left brain controls our ability to use language while the right is involved in spatial relationships, such as those needed for artistic activities. Stroke or head-injury patients who suffer damage to the left side of the brain will usually lose, to varying degrees, their ability to speak (often this skill returns with therapy and training). Many people believe that each half, or *hemisphere*, of your brain may actually be a completely separate mental system with its own individual abilities for learning, remembering, perceiving the world, and feeling emotions. The concepts underlying this view of the brain rest on early scientific research on the effects of splitting the brain into two separate hemispheres.

That research was pioneered by Roger W. Sperry (1913-1994), beginning about 15 years prior to the article examined in this chapter. In his early work with animal subjects, Sperry made many remarkable discoveries. For example, in one series of studies, cats' brains were surgically altered to sever the connection between the two halves of the brain and to alter the optic nerves so that the left eye transmitted information only to the left hemisphere and the right eye only to the right hemisphere. Following surgery, the cats appeared to behave normally and exhibited virtually no ill effects. Then, with the right eye covered, the cats learned a new behavior, such as walking through a short maze to find food. After the cats became skilled at maneuvering through the maze, the eye cover was shifted to the cats' left eyes. Now, when the cats were placed back in the maze, their right brains had no idea where to turn and the animals had to relearn the entire maze from the beginning.

Sperry conducted many related studies over the next 30 years, and in 1981 he received the Nobel Prize for his work on the specialized abilities of the two hemispheres of the brain. When his research endeavors turned to human participants in the early 1960s, he was joined in his work at the California Institute of Technology (Caltech) by Michael Gazzaniga. Although Sperry is considered to be the founder of split-brain research, Gazzaniga's article has been chosen here because it is a clear, concise summary of their early collaborative work with human participants and it, along with other related research by Gazzaniga, is cited often in psychology texts. Its selection is in no way intended to overlook or overshadow either Sperry's leadership in this field or his great contributions. Gazzaniga, in large part, owes his early research, and his discoveries in the area of hemispheric specialization, to Roger W. Sperry (see Sperry, 1968; Puente, 1995).

To understand split-brain research, some knowledge of human physiology is required. The two hemispheres of your brain are in constant communication with one another via the *corpus callosum*, a structure made up of about 200 million nerve fibers (Figure 1-1). If your corpus callosum is cut, this major line of communication is disrupted, and the two halves of your brain must then function independently. If we want to study each half of your brain separately, all we need to do is surgically sever your corpus callosum.

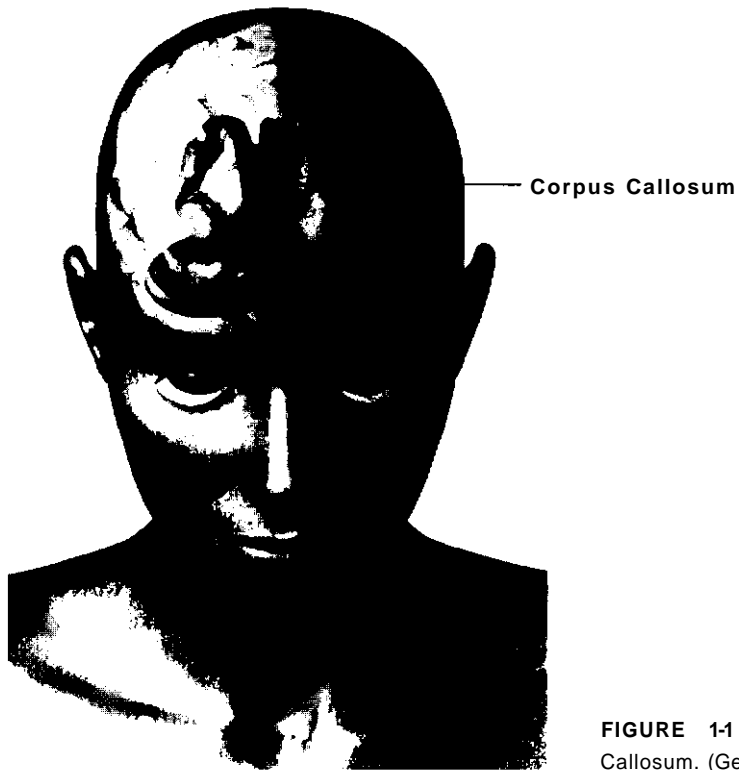


FIGURE 1-1 The Corpus Callosum. (Getty Images, Inc.)

But can scientists surgically divide the brains of humans for research purposes? That sounds more like a Frankenstein movie than real science! Obviously, research ethics would never allow such drastic methods simply for the purpose of studying the specialized abilities of the brain's two hemispheres. However, in the late 1950s, the field of medicine provided psychologists with a golden opportunity. In some people with very rare and very extreme cases of uncontrollable epilepsy, seizures could be greatly reduced or virtually eliminated by surgically severing the corpus callosum. This operation was (and is) successful, as a last resort, for those patients who cannot be helped by any other means. When this article was written in 1966, 10 such operations had been undertaken, and four of the patients consented to participate in examination and testing by Sperry and Gazzaniga to determine how their perceptual and intellectual skills were affected by this surgical treatment.

THEORETICAL PROPOSITIONS

The researchers wanted to explore the extent to which the two halves of the human brain are able to function independently, as well as whether they have separate and unique abilities. If the information traveling between the two

halves of your brain is interrupted, would the right side of your body suddenly be unable to coordinate with the left? If language is controlled by the left side of the brain, how would your ability to speak and understand words be affected by this surgery? Would thinking and reasoning processes exist in both halves separately? If the brain is really two separate brains, would a person be capable of functioning normally when these two brains are no longer able to communicate? Considering that we receive sensory input from both the right and the left brains, how would the senses of vision, hearing, and touch be affected? Sperry and Gazzaniga attempted to answer these and many other questions in their studies of split-brain individuals.

METHOD

The researchers developed three types of tests to explore a wide range of mental and perceptual capabilities of the patients. One was designed to examine visual abilities. They devised a technique that allowed a picture of an object, a word, or parts of words to be transmitted only to the visual area (called a *field*) in *either* the right or left brain hemisphere, but not to both. Normally, both of your eyes send information to both sides of your brain. However, with exact placement of items or words in front of you, and with your eyes fixed on a specific point, images can be fed to the right or the left visual field of your brain independently.

Another testing situation was designed for tactile (touch) stimulation. Participants could feel, but not see, an object, a block letter, or even a word in cutout block letters. The apparatus consisted of a screen with a space under it for the participant to reach through and touch the items without being able to see them. The visual and the tactile devices could be used simultaneously so that, for example, a picture of a pen could be projected to one side of the brain and the same object could be searched for by either hand among various objects behind the screen (see Figure 1-2).

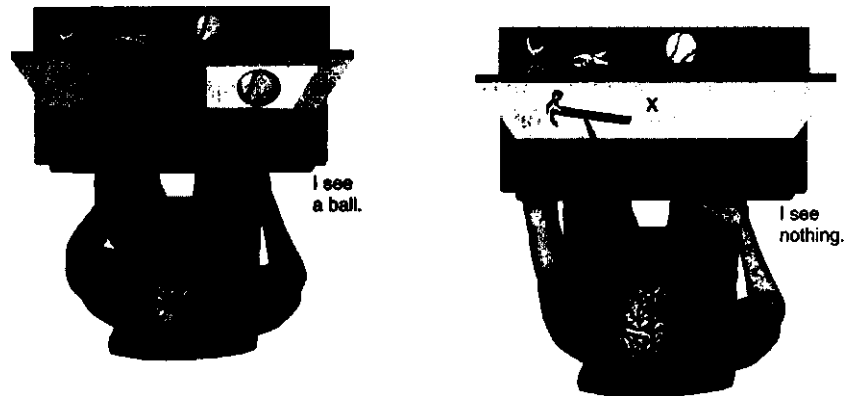


FIGURE 1-2 A typical visual testing device for split-brain participants.

Testing auditory abilities was somewhat trickier. When sound enters either of your ears, sensations are sent to both sides of your brain. Therefore, it is not possible to limit auditory input to only one side of the brain even in split-brain patients. However, it is possible to limit the *response* to such input to one brain hemisphere. Here is how this was done: Imagine that several common objects (a spoon, a pen, a marble) are placed into a cloth bag and you are then asked, verbally, to find certain items by touch. You would probably have no trouble doing so. If you place your left hand in the bag, it is being controlled by the right side of your brain, and vice versa. Do you think either side of your brain could do this task alone? As you will see in a moment, both halves of the brain are not equally capable of responding to this auditory task. What if you are not asked for specific objects but are asked simply to reach into the bag and identify objects by touch? Again, this would not be difficult for you, but it would be quite difficult for a split-brain patient.

Gazzaniga combined all these testing techniques to reveal some fascinating findings about how the brain functions.

RESULTS

First, you should know that following this radical brain surgery, the patients' intelligence level, personality, typical emotional reactions, and so on were relatively unchanged. They were very happy and relieved that they were now free of seizures. Gazzaniga reported that one patient, while still groggy from surgery, joked that he had "a splitting headache." When testing began, however, these participants demonstrated many unusual mental abilities.

Visual Abilities

One of the first tests involved a board with a horizontal row of lights. When a patient sat in front of this board and stared at a point in the middle of the lights, the bulbs would flash across both the right and left visual fields. However, when the patients were asked to explain what they saw, they said that only the lights on the right side of the board had flashed. Next when the researchers flashed only the lights on the left side of the visual field, the patients claimed to have seen nothing. A logical conclusion from these findings was that the right side of the brain was blind. Then an amazing thing happened. The lights were flashed again, only this time the patients were asked to point to the lights that had flashed. Although they had said they only saw the lights on the right, they pointed to all the lights in both visual fields. Using this method of pointing, it was found that both halves of the brain had seen the lights and were equally skilled in visual perception. The important point here is that when the patients failed to *say* that they had seen all the lights, it was not because they didn't see them but because the center for speech is located in the brain's left hemisphere. In other words, for you to say you saw something, the object has to have been seen by the left side of your brain.

Tactile Abilities

You can try this test yourself. Put your hands behind your back. Then have someone place familiar objects (a spoon, a pen, a book, a watch) in either your right or your left hand and see if you can identify the object. You would not find this task to be very difficult, would you? This is basically what Sperry and Gazzaniga did with the split-brain patients. When an object was placed in the right hand in such a way that the patient could not see or hear it, messages about the object would travel to the left hemisphere and the patient was able to name the object and describe it and its uses. However, when the same objects were placed in the left hand (connected to the right hemisphere), the patients could not name them or describe them in any way. But did the patients *know* in their right brain what the object was? To find out, the researchers asked the participants to match the object in their left hand (without seeing it, remember) to a group of various objects presented to them. This they could do as easily as you or I could. Again, this places verbal ability in the left hemisphere of the brain. Keep in mind that the reason you are able to name unseen objects in your left hand is that the information from the right side of your brain is transmitted via the corpus callosum to the left side, where your center for language says, "That's a spoon!"

Visual Plus Tactile Tests

Combining these two types of tests provided support for the preceding findings and also offered additional interesting results. If participants were shown a picture of an object to the right hemisphere only, they were unable to name it or describe it. In fact, they might display no verbal response at all or even deny that anything had been presented. However, if the patients were allowed to reach under the screen with their left hand (still using only the right hemisphere) and touch a selection of objects, they were always able to find the one that had been presented visually.

The right hemisphere can think about and analyze objects as well. Gazzaniga reported that when the right hemisphere was shown a picture of an item such as a cigarette, the participants could touch 10 objects behind the screen, all of which did not include a cigarette, and select an object that was most closely related to the item pictured—in this case, an ashtray. He went on to explain:

Oddly enough, however, even after their correct response, and while they were holding the ashtray in their left hand, they were unable to name or describe the object or the picture of the cigarette. Evidently, the left hemisphere was completely divorced, in perception and knowledge, from the right, (p. 26)

Other tests were conducted to shed additional light on the language-processing abilities of the right hemisphere. One very famous, ingenious, and revealing use of the visual apparatus came when the word HEART was projected to the patients so that HE was sent to the right visual field and ART was sent to the left. Now, keeping in mind (your connected mind) the functions of the two

hemispheres, what do you think the patients verbally reported seeing? If you said ART, you were correct. However, and here is the revealing part, when the participants were presented with two cards with the words HE and ART printed on them and asked to point with the left hand to the word they had seen, they all pointed to HE! This demonstrated that the right hemisphere is able to comprehend language, although it does so in a different way from the left: in a nonverbal way.

The auditory tests conducted with the patients produced similar results. When patients were asked to reach with their left hand into a grab bag hidden from view and pull out certain specific objects (a watch, a marble, a comb, a coin), they had no trouble. This demonstrated that the right hemisphere was comprehending language. It was even possible to describe a related aspect of an item with the same accurate results. An example given by Gazzaniga was when the patients were asked to find in a grab bag full of plastic fruit "the fruit monkeys like best," they retrieved a banana. Or when told "Sunkist sells a lot of them," they pulled out an orange. However, if these same pieces of fruit were placed out of view in the patients' left hand, they were unable to say what they were. In other words, when a verbal response was required, the right hemisphere was unable to speak.

One last example of this amazing difference between the two hemispheres involved plastic block letters on the table behind the screen. When patients were asked to spell various words by feel with the left hand, they had an easy time doing so. Even if three or four letters that spelled specific words were placed behind the screen, they were able, left-handed, to arrange them correctly into words. However, immediately after completing this task, the participants could not name the word they had just spelled. Clearly, the left hemisphere of the brain is superior to the right for speech (in some left-handed people, this is reversed). But in what skills, if any, does the right hemisphere excel? Sperry and Gazzaniga found in this early work that visual tasks involving spatial relationships and shapes were performed with greater proficiency by the left hand (even though these patients were all right-handed). As can be seen in Figure 1-3, participants who copies three-dimensional drawings (using the pencil behind the screen) were much more successful when using the left hand.

The researchers wanted to explore emotional reactions of split-brain patients. While performing visual experiments, Sperry and Gazzaniga suddenly flashed a picture of a nude woman to either the left or right hemisphere. In one instance, when this picture was shown to the left hemisphere of a female patient:

She laughed and verbally identified the picture of a nude. When it was later presented to the right hemisphere, she said . . . she saw nothing, but almost immediately a sly smile spread over her face and she began to chuckle. Asked what she was laughing at, she said: "I don't know . . . nothing . . . oh—that funny machine." Although the right hemisphere could not describe what it had seen, the sight nevertheless elicited an emotional response like the one evoked in the left hemisphere, (p. 29)

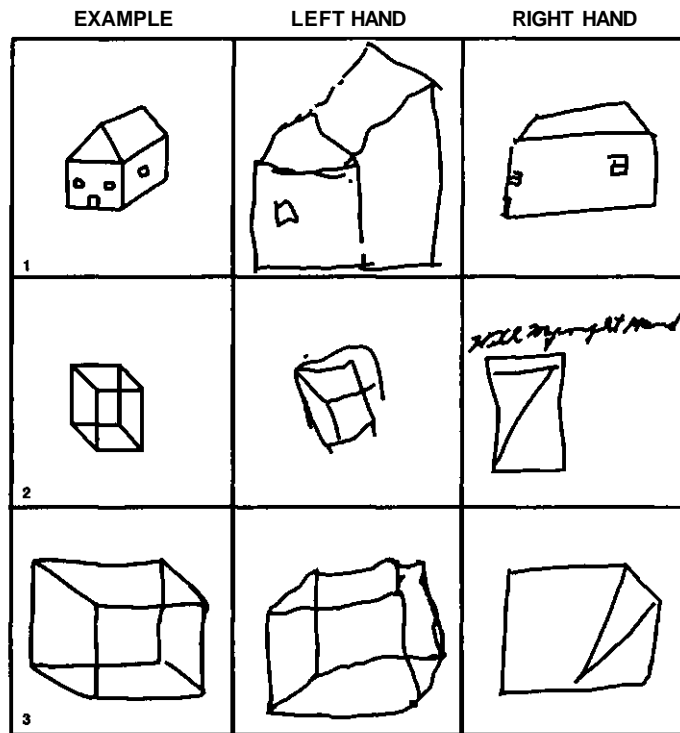


FIGURE 1-3 Drawings made by split-brain patients. (Adapted from p. 27, "The Split Brain in Man," by Michael S. Gazzaniga.)

DISCUSSION

The overall conclusion drawn from the research reported in this article was that two different brains exist within each person's cranium, each with complex abilities. Gazzaniga notes the possibility that if our brain is really two brains, then perhaps we have the potential to process twice as much information if the two halves are divided. Indeed, some research evidence suggests that split-brain patients have the ability to perform two cognitive tasks as fast as a normal person can carry out one.

SIGNIFICANCE OF FINDINGS

These findings and subsequent research carried out by Sperry, Gazzaniga, and others were extremely significant and far-reaching. They demonstrated that the two halves of your brain have many specialized skills and functions. Your left brain is "better" at speaking, writing, mathematical calculation, and reading, and it is the primary center for language. Your right hemisphere, however, possesses superior capabilities for recognizing faces, solving problems involving spatial relationships, symbolic reasoning, and artistic activities. In the years

since Sperry and Gazzaniga's "split-brain" discoveries, psychobiological researchers have continued to uncover the amazing complexities of the human brain. Our brains are far more divided and compartmentalized than merely two hemispheres. We now know that a multitude of specific structures within the brain serve very specialized cognitive and behavioral functions.

Our increased knowledge of the specialized functioning of the brain allows us to treat victims of stroke or head injury more effectively. By knowing the location of the damage, we can predict what deficits are likely to exist as a patient recovers. Through this knowledge, therapists can employ appropriate relearning and rehabilitation strategies to help patients recover as fully and quickly as possible.

Gazzaniga and Sperry, after years of continuous work in this area, suggested that each hemisphere of your brain really is a mind of its own. In a later study, split-brain patients were tested on much more complex problems than have been discussed here. One question asked was "What profession would you choose?" A male patient verbally (left hemisphere) responded that he would choose to be a draftsman, but his left hand (right hemisphere) spelled, by touch in block letters, *automobile racer* (Gazzaniga & LeDoux, 1978). Gazzaniga has taken this theory a step further. He has proposed that even in people whose brains are normal and intact, the two hemispheres may not be in complete communication (Gazzaniga, 1985). For example, if certain bits of information, such as those forming an emotion, are not stored in a linguistic format, the left hemisphere may not have access to it. The result of this is that you may feel sad and not be able to say why. As this is an uncomfortable cognitive dilemma, the left hemisphere may try to *find* a verbal reason to explain the sadness (after all, language is its main job). However, because your left hemisphere does not have all the necessary data, its explanation may actually be wrong!

CRITICISMS

The findings from the split-brain studies carried out over the years by Sperry, Gazzaniga, and others have rarely been disputed. The main body of criticism about this research has focused instead on the way the idea of right- and left-brain specialization has filtered down to popular culture and the media.

A widely believed myth states that some people are more *right-brained* or more *left-brained*, or that one side of your brain needs to be developed in order for you to improve certain skills. Jerre Levy, a psychobiologist at the University of Chicago, has been in the forefront of scientists trying to dispel the notion that we have two separately functioning brains. She claims that it is precisely because each hemisphere has separate functions that they must integrate their abilities instead of separating them, as is commonly believed. Through such integration, your brain is able to perform in ways that are greater than and different from the abilities of either side alone.

When you read a story, for example, your right hemisphere is specializing in emotional content (humor, pathos), picturing visual descriptions, keeping track of the story structure as a whole, and appreciating artistic writing

style (such as the use of metaphors). While all this is happening, your left hemisphere is understanding the written words, deriving meaning from the complex relationships among words and sentences, and translating words into their phonetic sounds so that they can be understood as language. The reason you are able to read, understand, and appreciate a story is that your brain functions as a single, integrated structure (Levy, 1985).

In fact, Levy explains that no human activity uses only one side of the brain. The popular myths are interpretations and wishes, not the observations of scientists. Normal people have not half a brain, nor two brains, but one gloriously differentiated brain, with each hemisphere contributing its specialized abilities" (Levy, 1985, p. 44).

RECENT APPLICATIONS

The continuing influence of the split-brain research by Sperry and Gazzaniga echoes the quote from Levy. A review of recent medical and psychological literature reveals numerous articles in various fields referring to the early work and methodology of Roger Sperry, as well as to more recent findings by Gazzaniga and his associates. For example, a study from 1998 conducted in France (Hommet & Biliard, 1998) has questioned the very foundations of the Sperry and Gazzaniga studies—namely, that severing the corpus callosum actually divides the hemispheres of the brain. The French study found that children who were born without a corpus callosum (a rare brain malformation) demonstrated that information was being transmitted between their brain hemispheres. The researchers concluded that significant connections other than the corpus callosum must exist in these children. Whether such subcortical connections are indeed present in split-brain individuals remains unclear.

Later that same year, a study was published by a team of neuropsychologists, including Gazzaniga, from several prestigious research institutions in the United States (University of Texas, Stanford, Yale, and Dartmouth). The study demonstrated that split-brain patients may routinely perceive the world differently from the rest of us (Parsons, Gabrieli, Phelps, & Gazzaniga, 1998). The researchers found that when participants were asked to identify whether drawings presented to only one brain hemisphere were drawn by right- or left-handed people, the split-brain patients were able to do so correctly only when the handedness of the artist was the *opposite* of the hemisphere to which the picture was projected. Normal control subjects were correct regardless of which hemisphere "saw" the drawings. This implies that communication between your brain hemispheres is necessary for imagining or simulating in your mind the movements of others—that is, "putting yourself in their place" to perceive their actions correctly.

Researchers continue to explore the idea that our two brain hemispheres have separate, yet distinct, functions and influences. One such study (Morton, 2003) demonstrated how your dominant hemisphere may lead you toward specific interests and professions. Morton's research made two discoveries in this regard. Using a special written test called The Best Hand Test," which measures *hemispheriáty* (whether a person is right- or left-brain oriented), Morton found that among 400 students enrolled in first-year, general college courses,

56% were left-brain oriented. However, when the same methods were applied to 180 students in various, *specialized* upper-level courses, the range of left brain students ranged from 38% to 65%. This difference indicated that something about a person's brain hemispheres was associated with spreading students out over a variety of college degrees and interests. Second, and more revealing, Morton employed the same method in determining the hemispheric orientation of members of various professions in university settings. The findings indicated that hemispheric specialization appears to be predictive of professional choices. For example, among biochemists Morton found that 83% were left-brain oriented, while among astronomers only 29% showed a left-brain preference (p. 319). You can see how this would make sense in relation to Sperry and Gazzaniga's work. Biology and chemistry rely more heavily on linguistic abilities, whereas astronomers must have greater abilities in spatial relationships (no pun intended).

CONCLUSION

Some have carried this, separate-brain idea a step further and applied it to some psychological disorders, such as dissociative, multiple personality disorder (e.g., Schiffer, 1996). The idea behind this notion is that in some people with intact, "nonsplit" brains, the right hemisphere may be able to function at a greater-than-normal level of independence from the left, and it may even take control of a person's consciousness for periods of time. Is it possible that multiple personality disorder might be the expression of hidden personalities contained in our right hemispheres? It's something to think about... with *both* of your hemispheres.

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Reading 2: MORE EXPERIENCE = BIGGER BRAIN

Rosenzweig, M. R., Bennett, E. L., & Diamond, M. C. (1972). Brain changes in response to experience. *Scientific American*, 226(2), 22-29.

If you were to enter the baby's room in a typical American middle-class home today, you would probably see a crib full of stuffed animals and various colorful toys dangling directly over or within reach of the infant. Some of these toys