JERRE LEVY

Research Synthesis on Right and Left Hemispheres: We Think with Both Sides of the Brain

"The evidence strongly disputes the idea that students learn with only one side of the brain. . . ."

I have often been astonished to learn of the ideas about human brain organization that surface in educational journals, teachers' newsletters, the popular press, *New Yorker* cartoons, and even advertisements for cars. These notions include:

- Rationality and logic are the sole province of the left hemisphere.
- Intuition and creativity are the sole province of the right hemisphere.
- Standard school curricula educate only the left side of the brain.
- Music and art are reflections of right-hemisphere processes.
- Modern technological civilizations depend on left-hemisphere functions and do not engage right-hemisphere functions; therefore, people with potentially high right-hemisphere capacities are the victims of discrimination in modern, advanced cultures.
- When engaged in any particular activity, people think with only one hemisphere at a time, either the left or right, depending on the activity.
- Some people think only with the left hemisphere; others think only with the right hemisphere.
- Scientists who study brain asymmetry now have all the answers regarding how children should be educated.

These assertions are either known to be false by neuropsychologists or are totally lacking in any supportive scientific evidence. Yet they have been accepted by many in the educational community, and inferences derived from them are currently having an impact on educational practice. Further, certain of these myths contain a strong strain of anti-rationalism in their suggestion that: (1) rationality only characterizes half the human brain and, (2) logical reasoning and creativity are polar opposites. Additional implications are that western concepts of intelligence refer solely to left-hemisphere processes, that standard intelligence tests measure only left-hemisphere competencies, and that any real creative insights derive from the right hemisphere.

The realization that the whole brain is actively participating in perception, encoding of information, organization of representations, memory, arousal, planning, thinking, understanding, and all other mental operations whether it be a social interaction, painting a picture, playing the piano, doing mathematics, writing a story, attending a lecture, or seeing a movie, seems to have escaped many, if not most, popular writers.

Only through misapprehension could some endeavors be attributed to left-hemisphere processes, and others to right-hemisphere processes. The two sides of the brain *do* differ, and they differ in quite important ways. The nature of these differences has little connection with the popularized picture, however, and the implications for human cognition and emotion are not what has been propagated.

Information About Hemispheric Differences

Language. Split-brain investigations and studies of patients with damage to one side of the brain demonstrate that speech is almost entirely confined to the left hemisphere in the vast majority of right handers. There is some evidence that the right hemisphere may occasionally be able to generate spoken words, particularly if these are stimulated by strong emotion, but ordinary language production can be assumed to be almost always under control of the left side of the brain.

Other aspects of language are not nearly so asymmetrically organized as speech. The isolated right hemisphere of split-brain patients understands a

Jerre Levy is Associate Professor of Behavioral Sciences, Department of Biopsychology, University of Chicago, Illinois.

Reprinted with permission from NASSP Bulletin.

great deal of what is said to it, has a comprehension vocabulary equal to that of a normal 12-year-old, and can read at least simple words. Its mechanisms of comprehension almost certainly differ from those of the left hemisphere, since it appears to have little or no comprehension of syntax and grammar, is unable to follow complex verbal instructions if these place too great a burden on short-term verbal memory, and seems to have no capacity for analyzing phonetics and deriving the sound images of words it reads. It knows that the word "cat" refers to a particular creature depicted in a drawing, but it does not know that the word "mat" rhymes with the name of the creature shown in the drawing.

Tachistoscopic investigations of brain asymmetry in normal people reveal that the two hemispheres are equally competent at reading concrete nouns and adjectives, but that the left hemisphere controls processing of verbs, abstract nouns, and adjectives. These findings suggest that when word meanings are susceptible to image or representation, there is little difference between the two sides in their abilities to recognize the word. When an imagistic representation is difficult or impossible, however, an asymmetry in favor of the left hemisphere emerges. A full appreciation of the meaning of concepts, of course, includes elaborate sets of verbal associations as well as sensory and experiential associations. When a normal person hears the word "dog," he or she does not merely derive the dictionary definition, but also generates images of dogs in various postures and activities, recalls the sounds of barks and howling, and probably, recreates the emotions that real dogs elicit. This rich and full meaning of "dog" is derived by an intimate, collaborative integration of the processes of both sides of the brain.

That representations of meaning are incomplete and distorted for each separate hemisphere is apparent from observations of split-brain patients. One of the patients, N. G., asked me one day, "How is Professor Sperry? I haven't seen him for some time." Immediately after being assured that Sperry was well, N. G. passed him in the hallway. Sperry nodded, as did N. G., but neither spoke. When we had returned to the laboratory, she whispered to me, "Who was that man? He looked kind of familiar."

One would think that N. G. possessed a clear representation of who Sperry was, yet her failure to recognize him by visual cues shows that the left hemisphere's representation of the concept "Professor Sperry" did not include how he looked, or at the least, included only a vague and ill-defined image. This image was sufficient for generating a sense of familiarity, but insufficient to permit recognition. Fluent language usage can often mislead the listener into believing that complete and accurate concepts underlie the words and sentences.

Other evidence of role of the right hemisphere in structuring meaning comes from findings that when patients with right-hemisphere damage are asked to provide a synopsis of stories read to them, they selectively omit emotional and humorous content. Obviously, the left hemisphere's memory structure for verbally presented material is incomplete, and the attentional system is biased to respond to only a subset of the information presented. In speech production, the grammar and vocabulary of these patients is normal, but frequently they are unable to convey emotional intonation. Since, in verbal interactions, tone of voice and speech modulation are important sources of communication, far less meaning is conveyed to the listener than would otherwise be the case. If someone tells us in a completely deadpan tone, "He killed the bear," we do not have the foggiest notion whether the person is elated by this fact, shocked, grieved, angry, proud, or surprised. We know a fact, but we do not know its implications, or how we should respond.

Right-hemisphere processes are very important for the apprehension of full meaning from oral or written communications and for the expression of full meaning.

Both hemispheres not only play critical roles in the purposes of language, but also in organizing the perceptual and cognitive processes that are prerequisite to understanding. Although reading disorders occur more frequently with left-hemisphere than with right-hemisphere damage, complete alexia (inability to read) can also occur when damage is restricted to the right side of the brain. I once examined a right-handed patient with massive damage to the right hemisphere whose speech and speech comprehension were fully intact. This patient had no damage to the left hemisphere, but developed a dense alexia; only after months of training was he able to read single letters, and with great difficulty, single words. He could decode one word at a time if all other words in the sentence were covered with his hands. He could "read" an entire sentence if he moved his hands so as to progressively uncover each subsequent word, but upon completion of the sentence, he was unable to report its meaning.

The patient showed similar difficulties with arithmetic. He could add and subtract single-digit numbers, but made many errors with double-digit numbers as well as with single-digit multiplication. Dougle-digit multiplication was impossible for him since he was utterly unable to align numbers on the page in a rational manner. When asked to multiply 7 times 8, he said, "Fifty-eight? Thirty-seven? I can't get an image of what it is." That he was suffering from a rather severe perceptual organizing disorder was affirmed by the observation that his verbal IQ was a normal 110, but his performance IQ was a severely retarded 35, yielding a full-scale IQ of 77. (This demonstrates quite clearly the fallacy of believing that IQ tests assess only left-hemisphere processes.)

Reading and arithmetic are not merely linguistic activities; they depend on perceptual organizing functions and imagistic memory. Research has demonstrated that a normal person's *right* hemisphere actually predominates in initial letter processing or instances when the writing is complex. Longitudinal studies of children reveal that those who prove to be good readers by the time they enter fourth or fifth grade displayed a right-hemisphere superiority at letter and word recognition in first grade that gradually shifted to a left-hemisphere superiority as the recognition process became automatized. These differential superiorities do *not*

mean that the other hemisphere plays no role in reading; they merely reflect the relative predominance of one hemisphere or the other at various stages of reading fluency.

This brief review of the roles of the two hemispheres in various aspects of language should be sufficient to demonstrate that in the normal child or adult, both hemispheres contribute important and critical processing operations. The final level of understanding or output cannot be allocated to one hemisphere or the other. As the child learns to read, communicate orally, learn history, or engage in any other so-called "verbal" activity, both sides of his or her brain are learning, being educated, participating in the growth of understanding. The child's appreciation of literature depends on his or her ability to synthesize letters into words, words into sentences, sentences into meaning and thought. It depends on the ability to apprehend and respond to the rhythm of language; to imagine and feel the scenes and moods; to empathize with the characters and understand their emotions, values, and personalities; and to integrate all this into a rich and full meaning with structure, configuration, and detail. Such a process cannot be accomplished by either side of the brain alone, but represents so intimate an integrative activity that, in the end, we cannot say which side of the brain contributed what.

Art and Music. Disorders of music and artistic production regularly occur with damage to *either* side of the brain. The composer Ravel suffered a left-hemisphere stroke in mid-career and never produced another piece of music for the rest of his life. If music and creativity were the province of the right hemisphere, unfairly suppressed by an uncreative left hemisphere, one might have expected that once Ravel's left hemisphere was destroyed, he would have produced his best and most creative music.

The fact is that the left hemisphere is critically important in discriminating and in producing temporally ordered sequences. Patients with left-hemisphere damage have grave difficulty saying which of two tones occurred earlier in time—an ability unaffected by damage to the right hemisphere. Clearly, an understanding, appreciation, and expression of music depends on an ability to discriminate time relationships. If such discrimination is disrupted by left-hemisphere damage, it is not surprising to find correlated disruptions in musical ability. Studies of normal people have confirmed that it is the left hemisphere that orders events in time, even when the sensory cues are initially presented to the right hemisphere.

Normative studies show that discrimination and memory for single musical chords is superior in the right hemisphere. This finding is consistent with its general advantage for memorizing sensory experiences that are resistant to verbal, analytical description. Hemispheric asymmetries in the recall of melodies depends on whether temporal, rhythmic elements or chordal tones are of greater importance. Musical training is also a factor. For the musically untrained and unskilled, melodies tend to be perceived as single global configurations—a right predilection—but for the musically trained and skilled, the components of melodies are apparent, a left-hemisphere function.

Music involves sounds, their ordering in time, their loudness and softness, and their form and rhythm. It engages its listeners at the sensory, emotional, and intellectual levels. Neither hemisphere alone possesses all the specializations of music; neither alone can create or appreciate the magnificent compositions of our great composers. No basis exists for believing that music is a specialty of one hemisphere or the other—only overwhelming evidence that both hemispheres are essential for its creation and appreciation.

What of art? Damage to either side of the brain produces disabilities in drawing. With left-side damage, overall configuration continues to be adequate, but detail is radically impoverished. With right-side damage, rich details remain, but overall form is inadequate. We love a Rembrandt painting because of its beauty of color and form, the perfection of a hand, the tiny sparkle in an eye, the fact that every detail is perfectly depicted and part of a whole that is more than itself. It elicits memories, creates imaginations, and has meaning that makes contact with our own experiences. It causes us to think, to reason, to feel.

It is possible to sketch a head, having no eyes, mouth, nose, or ears, yet clearly recognizable as such. Similarly, it is

Highlights of Research on Right and Left Hemispheres of the Brain

Simplified interpretations of brain function portraying rationality solely in the left hemisphere and creativity solely in the right are incorrect, but the two sides of the brain do differ in important ways.

Researchers have discovered that:

- **In the vast majority of right handers, speech is almost entirely confined to the left hemisphere.**
- **Right hemisphere processes add emotional and humorous overtones important for understanding the full meaning of oral and written communication.**
- **The two hemispheres differ in their perceptual roles but both sides are involved in the creation and appreciation of art and music.**
- **Both hemispheres are involved in thinking, logic, and reasoning.**
- **The right hemisphere seems to play a special role in emotion. If students are emotionally engaged, both sides of the brain will participate in the educational process regardless of subject matter.**

Resource Information Service (RIS) provides ASCD members access to research and sources of information on selected topics. The information is available through RIS-sponsored research syntheses, the RIS column in *Update*, and the quarterly publication *Curriculum Update*.

possible to draw features, clearly representative of a human face, but with no unifying outline or form. Real art is neither pure configuration nor pure detail; it is a brilliant synthesis of the two together. A barely discriminable change in the line of a mouth makes a Mona Lisa or not. Art is no more a right-hemisphere process than it is a left-hemisphere process. When it achieves lasting value it is an intimate synthesis of both. It is intellect and feeling; perfection of detail and perfection of form; color that calls up multiple associations and color that calls attention to itself alone.

Studies of perception show that for memory for faces, deciding whether an array of dots is aligned in columns or in rows as defined by relative dot distances, locating a briefly exposed dot in space, discriminating line orientation, or matching arcs with circles of the same diameter, the right hemisphere surpasses the left. This is not true for matching two identical arcs or two identical circles, discriminating depth from binocular cues, mentally folding drawings into their three-dimensional forms, or remembering random shapes that have no verbal labels. These perceptual memory and organizing capacities are obviously important in art, but they certainly do not point to any special "creative" capacity of the right hemisphere. One might as well say that the absolute superiority of the left hemisphere at phonetic analysis, understanding rhymes, and deriving meaning from syntactical construction of sentences is indicative of a special "creative" ability of the left hemisphere!

These and other studies demonstrate that the two hemispheres differ in their perceptual roles, but none supply any evidence that one side is more "creative" than the other, more responsible for music and art, more capable of a truly creative act, more "intuitive."

Logic and Mathematics. Very little data is available about hemispheric asymmetries in mathematical and logical function, although arithmetical disorders can occur with either right-side or left-side damage. The right hemisphere of split-brain patients can do simple single-digit addition, subtraction, and multiplication and it surpasses the left at discriminating line orientation, orientation of other objects in space, and at discriminating the direction in which a point moves. These capacities, as well as the spatial-perceptual superiorities noted earlier, are of major importance in geometric understanding, which, itself, is necessary for a real understanding of algebraic relationships.

Given the left hemisphere's superiority in extracting meaning from syntactical structure, it might be expected to surpass the right hemisphere in derivation of meaning from algebraic structure and manipulation and reordering of algebraic symbols, but we have no direct evidence on this. The indirect evidence inferred from greatly superior symbol manipulation is so strong that I would be extremely surprised if the prediction were not borne out. Algebraic ability in manipulating symbols is not, of course, the defining characteristic of logic. Logical operations emerge in many endeavors—some involving mathematics, others involving verbal and symbolic manipulation.

In geometric reasoning, the right hemisphere is clearly superior, greatly surpassing the left hemisphere in operations such as viewing an "opened-up" drawing of an unfolded shape and mentally folding the drawing into a three-dimensional object. This mental manipulation of spatial relationships involves not only visualization abilities, but a rule-governed plan of transformation. I would call such rule-governed transformations highly *logical*. An even more striking example of right-hemisphere reasoning comes from split-brain studies showing that the right hemisphere can inspect a set of geometric shapes, extract the defining characteristic property of the set, and identify the shape within the set that does not belong. The right hemisphere does this at a far better level than the left. Given any reasonable definitions, this right-hemisphere ability reflects abstraction, generalization, and logic.

Patients with right-hemisphere damage very often show severe deficits in appreciating their current states, in integrating the various aspects of their lives, and in deriving reasonable expectations for their futures. They often deny that anything is the matter with them, that they are paralyzed, and they confabulate reasons why they are in wheelchairs. In a word, they behave illogically. Former Supreme Court Justice Douglas suffered a right-hemisphere stroke and returned to the Court in a wheelchair. When asked how he was doing, he responded, "Great! I'm just great. Everything's wonderful, and there's nothing the matter with me!" Taken aback, the reporter noted that Douglas was in a wheelchair. Douglas laughed. "The wheelchair? Oh, well, I tripped in the garden this morning and hurt my leg. It'll be well in a few days." If logic were the sole province of the left hemisphere, we would expect *not* to see such disorders with right-hemisphere brain damage.

Lest you think that the mythology is backwards, note that logical disorders also occur with left-hemisphere damage. Even in patients who have not lost speech, verbal reasoning is quite diminished. The ability to interpret proverbs, to recognize verbal analogies, to identify how two things are alike, and to perform other verbal reasoning tasks shows clear disorder. Patients tend to become overly concrete and less capable of drawing abstract generalizations.

The direct implication of these observations is that both hemispheres are involved in thinking, logic, and reasoning, each from its own perspective and in its particular domains of activity. Thinking and logic in the normal person derive from the specialized processes of both sides. Each hemisphere appears to have a limited and biased perspective and a restricted set of competencies that may allow adequate (but not excellent) performance in a highly restricted cognitive domain, but a deep grasp of or insight into language, music, mathematics, or any other field of human endeavor. The creations of human culture derive from the fully integrated actions of the whole brain, and any further advances will require an intimate and brilliant collaborative synthesis of the special skills of both sides of the brain. All of the available data point to the validity of this conclusion; none supports the idea that normal people function like split-brain patients, using only one hemisphere at a time.

Interhemispheric Integration

What is the direct evidence that two hemispheres working together are better than either alone or even the sum of the capacities of the two sides? In contrast to normal people, the two hemispheres of split brain patients cannot be simultaneously active. Only one hemisphere at

a time is capable of attending to the sensory world. With bilateral sensory input, half the sensory world is missed. It is simply not perceived. This implies that the severed *corpus callosum, the massive bridge of fibers interconnecting the two hemispheres, normally plays a highly important role in facilitating arousal of both* hemispheres, in making it possible for both hemispheres to process information and to derive perceptions at the same time. Why would the brain be built this way if the corpus callosum did not also serve to integrate the cognitive activities of the two simultaneously thinking hemispheres?

Split-brain studies lead to a prediction of normal brain function. If dual tasks require interhemispheric communication, the imposition of a dual task in normal people should increase bilateral hemispheric engagement, even if both tasks are specialized to a single hemisphere. Further, if increased hemispheric engagement promotes optimal functioning of the brain, then subjects should be able to perform the dual task as well as a single task, perhaps even better, if the dual task requirements do not place too great a burden on operating capacities.

Joseph Hellige of the University of Southern California and his associates have shown that as task complexity increases, bilateral hemispheric engagement increases, and performance is, consequently, enhanced. Interestingly, it appears that even split-brain patients attempt to engage both hemispheres as task complexity increases. When two different colors are presented—one to each side of the brain—and patients are asked to match the color they see from among a set of choices in free vision, a single hemisphere controls the match through all trials. For some patients this is the left hemisphere, for others, the right, but the dominating hemisphere retains control of processing throughout all stimulus presentations. If colors are presented in varying geometric shapes, with the shapes irrelevant to the color-match required, unihemispheric dominance decays. It is as if a single hemisphere is unable to retain dominance with the increase in task complexity—a change that, in normal people, might be reflected as an increase in bilateral hemispheric engagement.

These observations suggest that normal brains are built to be challenged, that they only operate at optimal levels when cognitive processing requirements are of sufficient complexity to activate both sides of the brain and provide a mutual facilitation between hemispheres as they integrate their simultaneous activities. When tasks are at a very simple level, bilateral activation may be at a low level, with reliance on a single hemisphere that receives only weak facilitation from the other side. Generalizing from the split-brain findings, this would mean that attentional capacity would be low. The capacity to sustain attention over more than the briefest periods would be greatly diminished. Psychologically, this would be manifested as boredom and poor attention. Educationally, it would mean that simple, repetitive, and uninteresting problems would be poorly learned, with little benefit for either side of the brain.

Considerable evidence now suggests that the right hemisphere plays a special role in emotion and in general activation and arousal functions. If this is so, if a student can be emotionally engaged, aroused, and alerted, both sides of the brain will participate in the educational process regardless of subject matter. With maximum facilitation of both hemispheres, the result will be an integrative synthesis of the specialized abilities of the left and right into a full, rich, and deep understanding that is different from and more than the biased and limited perspectives of either side of the brain.

Implications for Learning Styles and Educational Practice

What does all this have to say regarding individual differences in learning styles? The evidence strongly disputes the idea that students learn with only one side of the brain, but we do have evidence that there are individual differences among people to the extent that one hemisphere is more differentially aroused than the other. Gur and Reivich, for example, have found that people differ in the asymmetry of blood flow to the two sides of the brain, and that those having an asymmetric flow in favor of the right hemisphere perform better on perceptual completion tasks (thought to be right-hemisphere specialized). Individual differences exist in the extent to which people show a biased attention to the left or right side of space. Persons with a leftward bias tend to perform better on face-recognition tasks; those with a rightward bias, on phonetic analysis of nonsense syllables.

These differences suggest that whole-brain learning may be better accomplished for different people with different methods. In other words, the child with a biased arousal of the left hemisphere may gain reading skills more easily through a phonetic, analytic method, while the child with a biased arousal of the right hemisphere may learn to read better by the sight method. I am suggesting only that the *gateway* into whole-brain learning may differ for different children, *not* that one hemisphere or the other should be the object of education. Ultimately, our aim should be to ensure that the child who learns to read through phonics will develop a fluent skill in sight reading, and that one who learns through the whole-word method will develop excellent skills at phonetic analysis so that any new word can be decoded.

Similarly, some children may better gain mathematical understanding if they are first taught the structure of algebraic equations and the methods of symbol manipulation. In the end, however, we want these children to appreciate the geometric, spatial functions specified by equations. We want them to understand *why* we say an equation of the form, $X = A + BY$ is called "linear," while one of the form, $X = A + BY + CY^2$ is called "quadratic." We want them to visualize a straight line defining the function between X and Y for the linear equation, and a quadratic curve defining the function between X and Y for the quadratic equation. Other children better understand if they are first taught the visual, geometric relationships, but ultimately we also want them to be able to specify these geometric forms in a symbolic equation.

From this perspective, "learning styles" refer to the method of introducing material, not to the type of understanding we ultimately want the child to gain, nor to the hemisphere we seek to educate. Standard school curricula, in contrast to some prevailing mythology, are *not* biased in favor of the left hemisphere. Reading, writing, grammar, literature, history, science, mathematics, music, and art all equally depend on both hemispheres and on the synthesis of their specialized abilities. Advanced societies and their technological and cultural accomplishments are reflec-

tions of brilliant syntheses of the partial perspectives of each hemisphere. Great men and women of history did not merely have superior intellectual capacities within each hemisphere, but phenomenal levels of emotional commitment, motivation, attentional capacities, and abilities for long-sustained interest in their particular areas of endeavor—all of which reflect the highly integrated brain in action.

The research is not yet available to demonstrate conclusively what all this means for educational practice, but at least certain inferences seem to me to follow directly from current research. Since these are merely inferences, without direct data for corroboration, I may be wrong. Educators are cautioned to use their own experiences and wisdom to check the validity of my conjectures. They should also be aware that my interpretations may not be accepted by all researchers, and that future research within a classroom setting may yield a different picture. Nevertheless, I feel some obligation to communicate the educational implications as I see them at the present time.

First, the popular 1960s idea that the educational experience should, under all circumstances, be "nonthreatening" to the child often meant that the educational experience should be nonchallenging, that children should not be confronted with material that stretched the limits of their capacities. This viewpoint indicated that the child should be prevented at all costs from gaining any notion of his or her abilities relative to others. To learn of his or her own special weaknesses or special skills supposedly generated either a poor self-concept or produced an unappealing arrogance. Yet challenges are what appear to engage the whole brain, to generate excitement and interest and attention, to provide the substrate for optimal learning.

Indeed, in spite of the best efforts of teachers and parents to hide the truth, children are remarkably adept in discovering where they stand with respect to other children, in understanding their own special skills and recognizing their own special difficulties. Students select fields of endeavor in accordance with their self-recognized abilities, tending to go into areas where their skills are high and avoiding areas where their skills are low. If students are so aware of their differential abilities in different areas, what might be the psychological/emotional consequences of trying to hide their strengths and weaknesses from them? We might unintentionally communicate to them that there is something shameful in being more or less apt than others in certain areas. How much better and healthier it would be to be truthful with children, to let them know that people are highly diverse in their skills and abilities, and that this diversity is what makes societies possible at all. They should be grateful for and appreciate the special skills that others have while acknowledging their own personal skills as gifts to be developed to their highest level.

Even small children can and should understand something about human brains. They can understand that the two hemispheres differ, that within each side there are many different processes, that all children use whole brains but use them in different ways, so that some people understand how cars work, while others find them very confusing. They can understand that some can write stories that everybody loves to hear, while others find writing a difficult chore. The child *needs* to learn how he or she thinks. The child *needs* to learn what constitutes a challenge in each area of endeavor, and *needs* to take comfort in the fact he or she lives in a world where an individual need not be perfect in all things because other people who have different ways of thinking will contribute to his or her life, just as he or she contributes to theirs. The child *needs* to appreciate people who are different, not resent that they may be better in some things or be ashamed at his or her particular weaknesses. The child *needs* to know where he or she is especially good and can achieve satisfaction and accomplishment, not only for the sake of his or her own emotional well-being, but for the sake of the world.

Formal education is only the beginning; if it is good, it teaches people how to educate themselves throughout their entire lives. And for this continuing self-education, individuals need to learn their own special pathways to learning, the ways they organize their thinking and identify their interests. They need to learn those things that engage their emotions, that are seen as thrilling challenges to understanding, that capture their attention, and that hold through years of effort. They need, in other words, to learn how to engage their whole brains in feeling, thinking, understanding, and achieving satisfaction.

So, in brief, the first of my inferences from current brain research is that challenges are not threats. Recognizing diversities does not lead to shame or arrogance; human brains are built to be challenged and built to understand themselves. In the classroom, I believe that children will learn best if their limits are stretched, if their emotions are engaged, and if they are helped to understand themselves and their own special ways of thinking and seeing the world.

A second inference that I draw is that all subject matters necessarily engage the specialties of both sides of the brain, and that the aim of education is to guide the child toward a deep synthesis of these differing perspectives. Regardless of how the subject matter may be best introduced for a given child, whether through left- or right-hemisphere processes, this is only the initial step, a gateway into the whole brain. The synthesis we seek is not merely the sum of understanding of each side. This would yield merely two biased and incomplete representations of reality. We seek something that is more than and different from a simple addition, that is the real power of the human mind. How is such a synthesis to be achieved? We do not yet know. The research has not been done. Yet knowing the goal, perhaps it will be possible for teachers with sensitivity to find a way long before scientists can supply specific recommendations.□

References

Dimond, S. J., and Beaumont, J. G., eds. *Hemispheric Function in the Human Brain*. New York: John Wiley & Sons, 1974.

Schmitt, F. O., and Worden, F. G., eds. "Hemispheric Specialization and Interaction." In *The Neurosciences: Third Study Program*, pp. 3–89. Cambridge, Mass.: The MIT Press, 1974.

Segalowitz, S. J., and Gruber, F. A., eds. *Language Development and Neurological Theory*. New York: Academic Press, 1977.

Vinken, P. J., and Bruyn, G. W., eds. *Handbook of Clinical Neurology*, vol. 4. *Disorders of Speech, Perception, and Symbolic Behavior*. New York: John Wiley & Sons, 1969.

Wittrock, M. C., ed. *The Brain and Psychology*. New York: Academic Press, 1980.

Copyright © 1983 by the Association for Supervision and Curriculum Development. All rights reserved.