Brain, Language, and New Concepts of Learning

New understanding of language helps point the way to startling revisions of ideas about human learning.

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Indications are that within the next few years education may take a "quantum jump" forward. Great advances of this nature are common enough in other fields—television, the computer, atomic energy, antibiotics, the airplane, and space travel—but the experience will be new in education.

Spectacular progress has flourished in technological areas but lagged in "human" affairs—for a simple reason: the directing human organ is the brain. That is where we must look to understand what humans do and why. Most human behavior is learned, and the brain is where learning takes place. Unfortunately, until the last quarter-century or so, the human brain has largely been a mystery.

But that is no longer so. In recent years, findings in many disciplines—not only the neurosciences but also anthropology, primatology, ethology, communication theory, computer science, human and brain evolution, and the newer cognitive or information-processing psychologies—have given us a new and scientifically impressive base. "Standing on the shoulders of giants," I have synthesized some of these findings and unifying concepts into what is known as Proster Theory (Hart, 1975), a comprehensive, brain-based theory of human learning.

Permit me to dramatize a bit the impact of having a usable theory. Imagine yourself as a Peace Corps worker in a remote Andes village. The people, you find, suffer various illnesses, but they have never heard of viruses, bacteria, or microscopic parasites. It would not be easy to explain that such creatures exist and that water, sanitary habits, insect bites, and other activities transmit them and result in disease. No more readily could you explain that some prevalent conditions stem from lack of vitamins in the diet. The village elders might well find your ideas preposterous. (After all, not long ago eminent American doctors went from patient to patient, hands unwashed, indignantly refusing to believe that they were spreading deadly childbirth fever, and attacking and ridiculing those who offered proof of contagion.)[1]

To many educators today, brain-based concepts of human learning sound equally bizarre, and they do indeed turn upside-down many familiar ideas. It is comfortable to cling to them, even when daily teaching effort shows all too obviously that they fail, semester after semester and decade after decade, to produce desired learning.

Linguistics Opens a Door

The rise of psycholinguistics has broken down some of the old barriers. The common sense notion that children acquire language by imitating elders has collapsed, along with elaborate attempts to provide a stimulus-response explanation. We realize now that a child has a deep, genetically-transmitted tendency toward speech; that large, rather well-defined areas of the cerebrum are allocated to language; and that each child builds anew a system of syntax.

When children say "I felled down," or "he hitted me," or "the dentist looked at my tooths" we can hardly claim that these were learned from adults or older siblings. Such utterances attest that children extract subtle rules from exposure to talk. They do this without teaching because the human brain is by nature a powerful pattern-extracting device.

We should note, too, that while parents may modify their direct talk to babies, this soon stops. Most of the speech a child hears (including that on radio and television) is not simplified or "graded," but is adult, complex, unplanned, and unordered. Yet almost all children become quite expert talkers, with even greater comprehension. Again we see demonstrated the power of a magnificent brain that is *born* motivated to learn in its own way. As Smith (1975) and others have pointed out, newborns begin at once a vigorous, aggressive effort to make sense of the world they have entered. If healthy, they probe, explore, examine, investigate, and test until they find themselves captive at a school desk, coerced to sit still and listen, to do only what they are told, and even to start and stop that as ordered.

These are *brain-antagonistic* conditions and under them, learning grinds to a halt. School and brain are at loggerheads, and the consequences are the learning failures, discipline problems, confrontations, frustrations, and boredom we see at every turn.

Where We Went Off the Track

If, as psycholinguistics and other neurosciences now tell us, the human brain is constantly active (even in

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sleep) and highly aggressive, how did we come to have schools that express the opposite: that the teacher should be active and the students passive, usually listening? If a four-year-old can "sort out" the patterns of past tense and plurals from random, adult talk, why in schools do we provide basal readers with tiny, graded vocabularies, and try to break down other subjects into portions of pap in much the same way?

Two explanations can be advanced. For many centuries, schooling implied rote learning. The teacher passed precise knowledge on to students, who were neither to dispute nor explore, but learn by pure memory to give the right answers. Motivation was provided liberally—the teacher carried a stick or switch and applied it with a will, or threatened other punishment.

As life has grown more complex and faster-changing, the idea of "precise knowledge" has given way to our information explosion. Apart from religion (which dominated earlier schooling), few official doctrines remain. New knowledge constantly pushes aside old. Thus learning right answers has become inadequate and even harmful, and rote instruction is avoided—we are told. If we observe classrooms in action, however, we see that most tests still ask for "right answers" or regurgitation of some kind. Since the time and effort given to rote has been reduced, the test results keep falling off. Teachers struggle, caught in an absurd bind: the system they are in was designed for rote learning, and has never been changed, and the testing, though less attuned to "parroting," still measures largely what has been remembered. Given the problem 24 x 105, students may be able to recall the algorithm signalled by "x" and apply it; but given a two-step problem or a word problem, most have no notion of what to do.

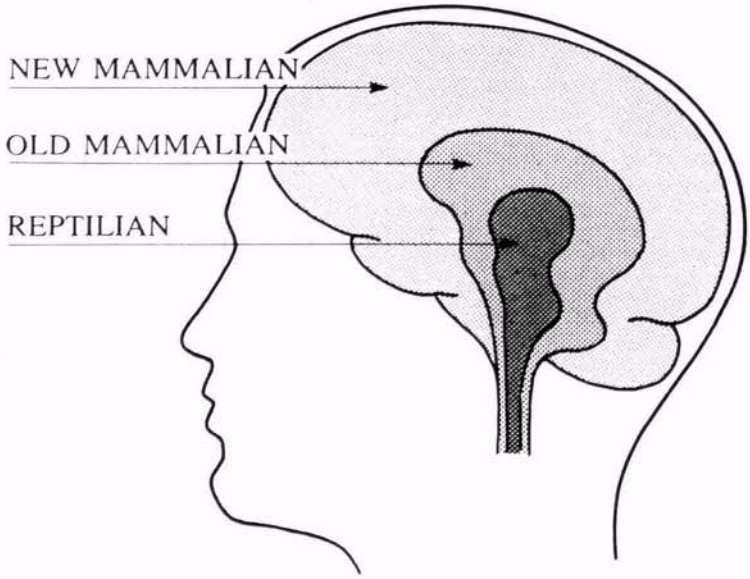
After 135 years, we still try to use the "factory" scheme of age-graded classes that Horace Mann popularized, though it never did work well. It has always produced huge proportions of student failure, drop-out, and push-out . . . and still does!

The Influence of Rats

The second explanation stems from the behaviorist laboratory, where for a century small animals, most commonly rats, have been locked in some kind of cage where things were then done to them, after which they might be given food or drink or allowed to mate as "reward." Not until the rise of ethology did it occur to investigators to ask, "What is the natural lifestyle of this animal? What does it do in its normal setting? What will it do on its own, without artificial stimulus or reward?"

Unfortunately, educational psychology became heavily based on behaviorist experiments with captive animals, which were extrapolated all too readily to dealing with captive students. Endless effort was made to explain learning in rat terms, with conspicuous lack of success.

Behaviorism deliberately avoided the brain. That made sense when little was understood about the brain anyway. But as we turn to the brain with our present knowledge, we see that the human brain is about 600 times as large as a rat's, millions of times more complex, and very different in design. The human brain consists of three brains that reflect millions of years of evolution (MacLean, 1978). The smallest and oldest, the *brain stem,* has over and



This drawing (diagrammatic, not anatomical) suggests the "onion" arrangement of the three brains. The oldest lies deepest. The Old Mammalian brain developed over and around it, and the New Mammalian brain in turn over and around the middle brain. The newest brain constitutes about 85% of the whole. All parts of the entire brain are elaborately interconnected. This diagram is an extreme simplification, to suggest the general structure that has evolved. (After MacLean.)

around it a much larger, newer brain, the *limbic system*. Above and around this in turn is the *cerebrum*, which in humans accounts for about five-sixths of the total brain, and consists of (in evolutionary terms) extremely new, sophisticated tissue. The rat has nothing remotely like this cerebrum, and only a trace of this new kind of tissue. Obviously, trying to discover much about the cerebrum by studying rats presents problems; and applying rat experiment findings to humans, especially noncaptive humans, has produced some grievous wrong answers, many of which most teachers-in-training are obliged to learn.

From this source flows much of the belief that children who have a tremendous drive to learn in their early years somehow become resistant dullards by the act of entering first grade, and now require motivation, stimuli, and rewards such as gold stars, marks, praise, or—heaven help us—M&M's or the privilege of playing games at school.

The Skittish Cerebrum

The huge cerebrum, which is divided into left and right hemispheres, is the seat of language, and the part of the brain that does elaborate "intellectual" processing. In short, it is this "brand new" brain that we are primarily concerned with in academic learning or any complex kind of intentional behavior. But because of its vast size (it has at least 25 billion neurons, or switches) it works far too slowly to have kept us alive in a dangerous earlier world. Under threat, it downshifts. The limbic system brain takes over, while the giant cerebrum shuts down much of its normal processing. In sudden fright, for example, we become literally speechless.

Remarkably, rote learning is a much simpler process, leading to direct memory storage. Pure rote learning *can* go forward under threat (short of actual, paralyzing terror). The implication of this for education is only now beginning to emerge. The conventional classroom is drenched in threat—students feel that punishment or embarrassment of some kind may be no more than seconds away—and consequently acts as a sort of filter, *permitting rote learning but inhibiting anything more complex*. In today's education, that is exactly what we don't want.

Once we can put aside ancient forms of schooling, and rat psychology, we can become receptive to the new understandings of the human brain, however startling and unexpected they may prove. Some of the major findings include:

1. Humans operate by *programs*. We do not sit waiting for stimuli to move us to action, but carry out goal-oriented plans by means of learned sequences of action. Our capacity to deal with the world increases as we build and store huge numbers of programs. Language alone requires many tens of thousands of programs to utter, or write, or type, or listen to syllables, words, phrases, sentences. Learning can be usefully defined as "the acquisition of useful programs."

2. The brain is by nature a subtle, flexible computer that detects and recognizes *patterns* by noting similarities and differences. (We cannot learn to identify cats by looking only at cats—we must examine non-cats, too.) Pattern recognition tells us what programs to use, from those we have stored. The process of learning can be defined as "the extraction from confusion of meaningful patterns."

3. Instruction that presents information logically, in an orderly way, in small increments, clearly and simply explained, is likely to prove ineffective—all the more so if it is heavily oral. What we have considered to be "good teaching" simply does not fit the brain, which is why it is so hard to find instances of supposed good teaching producing substantial learning outcomes. As Horton and Turnage have observed: "Man is no longer viewed as a passive sponge soaking up a flood of information. Instead, he is seen as an active seeker of information which he then filters, processes, encodes, and organizes into complex hierarchical schemes" (1976, p. 223). As we often see in reading instruction, what is well-intended and "logical" may actually have a negative effect, frustrating and confusing natural learning.

4. Luria and Yudovich (1959) showed that children *must* talk to learn best. A "stop talking" environment is likely to be a "stop learning" environment.

5. As Dewey and others long ago saw—but without the brain knowledge to guide practical applications—children must *do*. "Telling" has long been widely criticized, but telling is still what goes on most of the time in most classroom instruction. The nature of the conventional classroom forces teachers into this futile role and into demanding that students "stop talking!"

6. If the slow cerebrum is to function well, *"threat" must be minimal*. We have long recognized that learners do not play, or explore, or experiment, or take risks, unless they feel relaxed and secure. In the conventional classroom, most children feel scared and threatened most of the time.

7. The raw material of learning from which patterns may be extracted (I use the term "input") is needed in huge quantity and variety for best learning. Outside the classroom, input is a deluge; inside, it is a trickle.

To move from the *brain-antagonistic* approaches now in wide, unhappy use to *brain-compatible* settings and methods will mean a large shift. But present staff and buildings can still be used. Organization, concepts of learning, settings, and techniques need sweeping change.

If we use the knowledge of the brain now available, I believe we can make quantum jumps in achieved learning. Present failure can be virtually eliminated. Teaching and administering schools could become enormously more pleasant, rewarding, and respected. For those willing to scrap an outworn past, an appealing, exciting future is waiting. ■

[1] Oliver Wendell Holmes, the physician and poet, was one of the chief targets, despite his family and personal prestige.

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