The Challenge of Universal Literacy

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Universal literacy has always been a goal of the United States. But literacy has been a moving target: criteria have risen as technology advanced. Comprehension skills well beyond simple decoding are now required. Research by educators and psychologists has laid a scientific foundation on which new pedagogic methods can be based. But even with better teaching, the hope that all adults can attain the highest levels of literacy skills may be unrealistic.

ALTHOUGH WRITING WAS INVENTED MORE THAN 5000 years ago (1), universal literacy is a modern idea. Mass literacy and a means of widespread dissemination did not combine to make mass communication possible until the 19th century (2). But even then the concept of universal literacy was still taking shape: as technology advanced, so did the definition of "literate."

In the 18th century a person able to read aloud familiar passages from the Bible or a catechism would be counted as literate; today someone who could read no more than that would be classified as functionally illiterate—unable to read materials considered essential for economic survival (3). Today any purposeful use of written language (reading, writing, or comprehending print, including an appreciation of tables, maps, diagrams, or mathematical symbols and formulas) may be taken as a criterion defining literacy.

Many people who are not illiterate by the older criteria are not truly literate, either. By the newer criteria, they fall into an intermediate status that has been called semiliteracy.

The Problems of Semiliteracy

The United States now has a semiliterate underclass that is expected to grow throughout the remainder of this century. Semiliteracy is perplexing because it is not a single problem, but is part of several problems.

The human problem. Semiliteracy is a way of life for millions of U.S. citizens—estimates of how many vary depending on the definition of literacy that is used, but the number of these individuals living in poor urban neighborhoods has increased rapidly since 1970 (4). Many of them are unable to follow written instructions, pass a test for a driver's license, answer a help-wanted advertisement, or even understand a pamphlet telling where to go for help. They experience repeated educational failures, and if they find jobs at all, they are usually temporary ones and poorly paid. And when they become parents, they are unable to prepare their children with the minimal competencies needed to succeed in school, so the cycle of marginal literacy and marginal living repeats.

The economic problem. In 1962 Machlup characterized the economic consequences of the growth of something he called the "knowl-

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edge industry" (5). He estimated that in the United States in 1958 knowledge production and distribution accounted for 29% of (adjusted) gross national product and was growing 2.5 times as fast as other components of the total GNP. Machlup's book was the first serious discussion of a basic change in U.S. life, and the concluding chapter stated a clear implication: "If employment opportunities continue to improve for high-level knowledge-producing labor and to worsen for unskilled manual labor, the danger of increasing unemployment for the latter becomes more serious" (5, p. 397).

The trend that Machlup identified has continued (6), with massive changes in resource allocation and income distribution. Today everyone understands references to our increasingly technological culture, or our information economy. Moreover, the consequences that Machlup foresaw have come to pass. Today there are few jobs for people who cannot read: a 1980 survey of workers reflecting a cross section of occupations found that nearly 99% participate in some form of reading every day, with a daily average of nearly 2 hours of reading (7).

The educational problem. One reaction to this situation is to blame the schools: every student should graduate from high school knowing enough to earn a living. Reading is often singled out as the critical educational failure, since reading is the basic enabling skill: it holds the key to all further academic learning. According to that view, the schools are no longer able to impart even basic literacy skills. But this charge is grievously unfair. The best available evidence (8) indicates that schools are doing a good job in providing simple reading skills; critics focus on their failure to equip everyone with advanced reading skills. But it is seldom recognized that we are now asking our schools to do something they have never done before: to educate everyone to a relatively high level of literacy (9). In the past there was always other work for those who could not, or would not, learn to read.

Leaders in business, industry, and government have not been unaware of the growing shortage of workers with adequate literacy skills. Because literacy mistakes (mistakes caused by misunderstanding written instructions, ignoring written warning signs, misspelling and retyping correspondence, and so on) are expensive, training programs have been developed to help adults learn to read more effectively and to use reading materials that are needed in order to perform their jobs (10). But special training programs are also expensive and not always successful.

The social problem. What makes semiliteracy especially disturbing is its contribution to the most serious social problem that the United States faces, the problem Myrdal called "the American dilemma" (11). But it is not only the black minority that lacks critical literacy skills. Hispanics are also disproportionately represented at the lower levels. And, although the proportion is lower, the largest number of semiliterates is white.

Many people believe that semiliteracy is merely a symptom—a symptom that will not disappear until much deeper social problems are solved. Although the cause-and-effect relations are extremely complex, it has long been recognized that semiliteracy, poverty, and racial discrimination are inextricably connected. In 1964 President

Johnson called for a War on Poverty that resulted in billions of dollars being spent for programs intended to break the cycle of poverty. And in 1968 the Report of the National Advisory Commission on Civil Disorders called on the government "to mount programs on a scale equal to the dimensions of the problems" (12). Yet today poverty and racial tensions are still widespread and literacy is still a critical part of the problem. The policy of increased spending is now considered to have been largely ineffective.

This is not a review of attempts to solve these problems. In this article I have the more modest goal of raising some scientific and technical questions about literacy. But the motivation for raising them is the possibility that recent research into the nature of reading comprehension has laid a scientific foundation for the development of better educational policies.

Assessment

A rational approach to literacy must begin with an attempt to assess how serious the deficiencies really are. Then feasible goals can be set and policies formulated to achieve them.

The question of ability. Since half the population of the United States is below average intelligence, some have wondered whether semiliteracy is a sign of stupidity. Perhaps the bottom quartile on the intelligence scale and the semiliterate underclass are one and the same. To the extent that psychometric tests of intelligence tap academic knowledge, that is to say, knowledge gained through reading, people who do not read are at a disadvantage. But illiteracy is a form of ignorance, not stupidity. Anyone intelligent enough to master spoken language should be intelligent enough to master written language. No doubt there is a level of intelligence below which reading and writing are impossible to learn, but it is very low.

The measurement of literacy. Two approaches have been taken to the assessment of individual differences in literacy: functional measures and grade-equivalent scales. Functional measures test a person's ability to perform everyday tasks (for example, reading a train schedule, applying for a job, reading a newspaper article). Standardized tests (for example, reading a passage of calibrated difficulty and answering questions about it) are scaled according to the average performance of students at various grades in school.

The definition of literacy. Illiteracy disappears if the line between literate and illiterate is drawn low enough. The United States Census Bureau, using the completion of 6 years of schooling as its criterion, finds literacy universal (13). But raise the criterion and the picture changes.

In 1985 the National Assessment of Educational Progress (NAEP) used functional measures to test the literacy skills of a representative sample of adults between 21 and 25 years of age (14). Using item response theory (15), NAEP constructed three scales of literacy, one each for general prose, work-related documents, and the use of arithmetic. The scales range from 0 to 500. Tasks are placed on a scale at the point at which individuals with that level of proficiency would have an 80% chance of responding correctly. For example, a task at the 250 level on a scale is one that 80% of the persons with a 250 level of proficiency would answer correctly. Carroll (16) has offered a translation of these scores into the more familiar grade-equivalent scale: roughly, 150 corresponds to a first-grade level of reading, 200 to a third-grade level, 250 to a seventh-grade level, 300 to the end of grade 12, and 350 to college seniors.

Some examples of tasks at different levels can give a sense of what these scores mean. On the prose scale, 96% of these young people were at or above the 200 level (they could write a simple description of the type of job they would like to have), 72% were at or above the 275 level (they could write a letter to explain an error that had been made in a billing charge), and 37% were at or above the 325 level (they could synthesize the main argument from a lengthy newspaper column). On the document scale, 99.7% were at or above the 150 level (almost no one failed to locate the expiration date on a driver's license), 57% were at or above the 300 level (they could follow directions using a street map to travel from one location to another), and 20% were at or above the 350 level (they could use a bus schedule to find how long a person who missed the 2:35 p.m. from Hancock to Flintridge on Saturday would have to wait for the next bus). On the quantitative scale, 92% were at the 225 level (they could add two numbers on a bank deposit slip), and 38% were at the 325 level (they could examine a menu and compute the cost of a specified meal and determine the correct change from a specific amount). From such figures it is obvious that the extent of semiliteracy can be anything one likes, depending on how one defines literacy.

Where should the line be drawn? How much literacy is enough? It is not a question whose answer can be legislated. Economic and technological considerations keep pushing the criterion higher. One thoughtful commentary on the NAEP survey concluded that "it is clear that there is a compelling need for higher levels of literacy skills in our society, whether most jobs require them or not. If work is to be more fulfilling, if worker productivity is to increase, and if we are to have more democracy in the workplace, we need workers schooled in critical reading and accustomed to independent problem-solving" (17).

It has been proposed (18) that a meaningful national goal would be the attainment of twelfth-grade literacy by all adults. But *can* everyone achieve that level? The NAEP assessment (14) indicates that only 56.4% of young adults now meet it. To bring everyone to a NAEP score of 300 or better would require educational programs much better at teaching high-level literacy skills than those currently in place. That is the present challenge of universal literacy.

Research into what skilled readers do can give a clearer picture of what such educational programs would have to accomplish in order to meet that challenge.

Skilled Readers

During the past 20 years psychologists have studied the component skills of reading in great detail: the perception of letters, the association of letter patterns with spoken words, the interpretation of grammatical sequences of words, and the communicative use of strings of sentences. Although much remains to be done, the component parts of the reading process are now relatively well understood.

Eye movements. It has long been known that eye movements provide a sensitive index of reading skills (19). During reading the eyes fixate at a spot briefly, then jump rapidly to the next spot. When something is not understood, eye movements slow or retrace. A beginning reader may fix on every successive word—sometimes on successive letters—whereas skilled readers seldom gaze directly at function words (*the*, *of*, *as*, for example), and take in several words at a glance. As the technology for tracking eye movements has become more accurate and convenient, it has become feasible to test theories of reading by how well they predict the time a reader will spend gazing at each word of any given passage (20). In general, skilled readers devote less time to decoding the signal than to understanding the message.

Decoding. Writing is sometimes described as a kind of encoding: inscribed patterns are used to stand for segments of the spoken language. Reading is said to reverse the process. The written pattern is decoded: spoken language is recovered from the coded inscrip-

tions. Decoding was once considered to be not only necessary but sufficient for reading. To learn to read was to learn to recover spoken words from their written representations. Consequently, much careful research was done on the visual recognition of letters and words.

Many languages are written with syllabaries (each character stands for a syllable), but English is written with an alphabet (each character stands for a phoneme). The first step that children must take, therefore, is to learn the alphabet (21), which involves learning to recognize visual patterns: discriminating letters from other visual patterns, discriminating letters from one another, and associating names and pronunciations with them (22). It is generally assumed that long-term memory contains descriptions of many kinds of patterns that can be compared with descriptions of any new patterns that we see; when the descriptions are similar, the perceived pattern is recognized. Theorists disagree about the nature of these pattern descriptions, but the details are not important here: semiliteracy is not a problem of visual perception.

In the 1970s this research moved from the perception of isolated letters to the perception of letters in words. A skilled reader's knowledge of words facilitates letter perception: it is significantly easier to identify a critical letter when it is a part of a word than when it is part of a nonword or is presented in isolation (23). Most attempts to explain this "word superiority effect" assume that word knowledge narrows the range of alternatives from which the subject makes a choice. Vocabulary combines with the sensory input to determine the percept.

A complete account of how people recognize words during reading would allow for interactions among several sources of information: spelling, grammar, and meaning all constrain a skilled reader's expectations. The complexity of these interactions can be demonstrated by asking French-English bilinguals to read aloud, rapidly and accurately, such passages as

His horse, followed de deux bassets, faisait la terre résonner under its even tread. Des gouttes de verglas stuck to his manteau. Une violente brise was blowing. One side de l'horizon lighted up, and dans la blancheur of the early morning light, il aperçut rabbits hopping at the bord de leurs terriers.

Skilled bilingual readers understand such passages perfectly, but, without realizing it, they make many mistakes: they often utter French where English is written, or English where French is written; they sometimes change from French to English, or English to French, word order (24). Such behavior cannot be explained as simple decoding from letter sequences to sound sequences. Words are treated as symbols and are operated on in terms of their meanings and their relations to other symbols.

By the 1970s it was generally recognized that skilled readers do much more than decode the written signal.

Comprehension. Comprehension is a mental process of central importance for psychology, and reading comprehension is the variety most frequently investigated. One method is to ask skilled readers for their subjective impressions: they rate on a scale how hard it is to understand a passage, or they read a sentence and press a key as soon as they understand it. A less direct, but probably more realiable method is to test readers' memories: the number of ideas that they can recall is taken as a measure of how well they understood the passage.

Many factors influence the outcome of such tests. Comprehension depends on both the text and the reader. For example, a young child's account of an adventure involving two boys might run, "He went over to his house. Then he hit him and his mother came." It is impossible to know which pronoun refers to which boy. Skillful writers, of course, keep their pronominal references distinct. The point is that readers who do not interpret an author's distinctions

correctly will be as confused as if they were reading the child's account. A skilled reader must be able to determine the topic of the passage, to recognize the coreference of any two noun phrases, to recognize rhetorical devices that signal coordinate or subordinate ideas, to distinguish examples from interruptions from reiterations, and so on (25).

An intelligible prose passage unfolds its information in an orderly manner—it is not a haphazard collection of sentences. In particular, the ease with which information in the passage can be integrated (the ease of relating new ideas to old ideas) depends on the order of the sentences (26). Some passages are difficult for anyone to understand. How difficult they are for any particular reader, however, depends critically on that person's prior knowledge of the subject matter.

One way to estimate the relative importance of any given factor is to pit it against some other factor. For example, sixth-graders were asked to read descriptions of two games, one familiar (horseshoes) and the other unfamiliar (an Amerindian game called huta). The descriptions were written to cover the same topics, the grammar and wording were practically identical—only the students' prior knowledge of the games was different. Then the difficulty of the words was varied: all the words in the easy versions were known to sixth-graders; uncommon synonyms were substituted for a third of the content words in the hard versions. Tests with these four texts showed that familiarity with the topic accounted for almost three times as much variance in comprehension as did vocabulary (27). Prior knowledge of the topic is a potent determiner of a reader's comprehension. It even facilitates word recognition (28).

Schema theories have been proposed to explain how prior knowledge contributes to comprehension (29). A schema is a set of expectations. More specifically, a schema is an abstract knowledge structure stored in long-term memory: abstract in the sense that it can fit texts that differ only in details, and structured in the sense that it preserves relations among its constituent concepts. The sixth-graders, for example, had learned a "horseshoes schema" that helped them to organize and remember the information in the text about the game of horseshoes. Readers are said to comprehend a text when they can activate or construct a schema into which all the people, objects, and events described in the text will fit to yield a coherent mental representation.

Schemata that represent familiar sequences of events have been called scripts (30). The events in a script can provide a framework for understanding narratives. Scripts deal with goal-oriented activities, and the more central some activity is to attaining a goal the more important it is to a narrative. Goal-directed actions are linked together by an "in-order-to" relation (31): for example, you buy a newspaper in order to read the news; buying is goal-directed, but what you do with the newspaper after the goal is achieved is less goal-directed and can be omitted from a narrative account. Skilled readers constantly try to identify goals and to organize the events in the narrative around those goals. Moreover, since the events in a script are expected, they are themselves uninteresting. That is to say, it is the unexpected obstacle or distraction that merits description and interests a reader. When people read stories that are constructed to contain equal numbers of routine (script-based) actions, interruptions, and irrelevant actions, the interruptions are recalled best of all (32). Readers regard the interruption of a script as the whole point of the story.

In general, the more that readers know about the subject matter of a text, the better they will understand it. As psychologists have come to appreciate how critically comprehension depends on the reader's knowledge, their characterizations of schemata have grown increasingly complex. Whereas schemata were initially imagined to be relatively fixed knowledge patterns, complete with expected, or

"default," slot-fillers, it soon became apparent that a much richer and more flexible characterization is needed to account not only for skilled readers' ability to understand novel events, but also for their ability to explain events or characters' intentions, and to interpret them from alternative perspectives.

Metacognitive control. Good readers understand the skills that they use in reading. Their awareness of their own cognition is called metacognition. Metacognitive control is critically important for successful reading (*33*). Skilled readers make an active effort after meaning. They know various procedures or strategies for monitoring their reading and extracting what they want from a text. They can plan a strategy for reading, adjust their level of effort, and evaluate how successful they have been in comprehending what they have read. Discovering what an author had in mind is a kind of problem-solving, and requires the same kind of metacognitive control as does any other kind of problem-solving.

It was once assumed that reading comprehension must proceed from the bottom up: letters combine to form words, word meanings combine to form sentence meanings, sentences combine to tell stories. This linear, text-driven conception of skilled reading is now recognized to be inadequate. Skilled readers perform a highly sophisticated act, drawing on a hierarchy of options based on prior knowledge and metacognitive skills. Those are the kinds of skills that we must learn to teach if the challenge of universal literacy is to be met.

Decoding Difficulties

The description of skilled reading provides a target to aim at, but does little to explain why so many people miss the target. Attempts to characterize individual differences in reading ability have considered (i) visual decoding processes, (ii) cognitive processes that integrate the information in a text, and (iii) metacognitive processes that relate textual information to general knowledge (*34*). Of these, only decoding is specific to reading.

Consider some of the decoding difficulties that will have to be overcome along the road to universal literacy.

Bilingualism. Some 4.5 million children of school age in the United States come from families where the home language is not English (*35*). For many of these children, reading is the beginning of school failure. Their lack of familiarity with the syntactic and semantic constraints of English puts them at a disadvantage relative to monolingual children. The problems of learning a new language, the effects of linguistic and cultural differences between home and community, the lack of suitable teaching materials, the uncertain diagnoses of learners' problems—these and other factors contribute to the difficulty of doing research in this area.

Dialect. Some authorities believe that serious problems arise from dialect differences between students and teachers. This claim has been offered as an explanation of the decoding difficulties that some blacks have, but the importance of dialect may have been exaggerated. After several years of working with nonstandard English spoken by black children in urban ghettos, Labov concluded, "The primary cause for this failure appears to be the conflict between the vernacular culture and the middle-class culture of the schoolroom rather than any linguistic differences between their dialect and standard English" (*36*).

Dyslexia. The term "dyslexic" is sometimes used by educators to denote anyone who has difficulty reading. Used so broadly, the term is almost meaningless (*37*). In medical usage, where the term originated, "dyslexia" refers to an inability to read that is attributable to neurological dysfunction. When the educational usage is mistaken for the medical usage, emotional despair is often the result. A careful discussion of dyslexia is beyond the scope of this article, but it should be noted that the fraction of people suffering from this neurological condition is extremely small, particularly when compared to bilingualism.

Segmentation and blending. Alphabetic writing systems presuppose an ability to match the sounds of a word to the letters used to spell it. Since English spelling rules are notoriously irregular, acquiring this ability is never a simple task. But some students have a special problem: apparently they are unable to divide spoken syllables into segments—into the consonants that turn them on, the vowels that sustain them, and the consonants that turn them off (*38*). For such students, alphabetic writing is a mystery. Only recently has this difficulty been identified and special tutoring designed to overcome it.

Nearly every student has a problem with blending, however. Blending is the opposite of segmentation: given a string of letters, how is the spoken word to be synthesized? A reader who looks at DOG and says "de ow gee" or "duh aw guh" may not hear a resemblance between those trisyllabic utterances and the familiar monosyllable, "dog." Most reading teachers recognize this problem and are prepared with instructional aids to help learners blend the sounds correctly.

Automaticity. Reading teachers frequently observe students who are able to decode accurately—they can read a passage aloud—yet they remember little or nothing of what they read. Such students seem to have comprehension difficulties, but the real problem may be one of decoding. It is not enough to decode accurately. Decoding must be sufficiently automatic to go on outside conscious awareness. Only then can the focus of attention remain on the meaning of the text (*39*). That degree of automaticity is achieved only after much practice, yet if too much time is spent drilling students on decoding skills, they may never come to enjoy the pleasures of reading.

Because the rules relating print to sound are so complex for English, it is hardly surprising that many readers are derailed by decoding difficulties. But suppose that all such difficulties could be overcome. It is not too farfetched to imagine a technological fix: some kind of hand-held, print-to-speech transformer that would make decoding skills as superfluous as long-division skills are today. All the user would have to do would be to place the device over the text and listen to it. Would such a device solve the literacy problem?

Many psychologists believe it would not. They claim that listening comprehension is no better than reading comprehension—that a person cannot be a good decoder, a good listener, and a poor reader (*40*)—and there are data to support the claim. When measures of reading comprehension, listening comprehension, and reading speed were taken on a sample of college students, it was found that reading comprehension ability and listening comprehension ability were indistinguishable. Reading speed varied with visual word decoding ability, but was only moderately correlated with reading comprehension (*41*). Such observations on college students cannot be generalized to illiterate or semiliterate individuals, but they do suggest that semiliteracy is more complicated than a mere absence or weakness of decoding skills.

Comprehension Difficulties

Comprehension difficulties are not limited to reading. Problems of integrating and interpreting information are just as difficult for spoken as for written language (*42*).

Perhaps the clearest outcome of research on reading comprehension is that it presupposes a knowledge base. Given successful decoding, the most frequent cause of failure to understand compre-

hensible passages is not that the ideas cannot be related to one another, but that they cannot be related to prior knowledge—because prior knowledge is either inaccessible or nonexistent.

Word knowledge. Not knowing the meaning of a word is probably the simplest case of comprehension difficulty attributable to ignorance. The problem occurs more frequently with written than with spoken language because the writing vocabulary is much larger than the speaking vocabulary. But a satisfactory interpretation of an unfamiliar word can frequently be inferred from the context in which it is used.

Reliance on context is a basic learning strategy. Children can enlarge their vocabularies by, first, constructing interpretations for speech acts on the basis of a general understanding of the communicative situations in which they occur; then, second, by assuming that unfamiliar words encountered during that speech act have meanings consistent with that interpretation (43). This learning strategy sometimes results in misinterpretations, but errors can be corrected in subsequent encounters. And it works surprisingly well.

This strategy is not abandoned when reading begins. The average high school graduate recognizes the meanings of about 40,000 different words (44), corresponding to a learning rate of 2700 words per year, or 7 to 8 words per day, and many of those 40,000 words were learned from context while reading (45). Children are first taught to read words that they already know from spoken language, but starting around the fourth grade they encounter unfamiliar words, words that they have never heard in conversation. From their general understanding of the contexts in which these unfamiliar words appear, children can surmise their meanings.

One problem, of course, is that the learner must already have a recognition vocabulary to build on before this strategy can succeed. Readers without an adequate recognition vocabulary cannot read with understanding; if they do not read with understanding, they cannot learn new words from context; if they do not learn new words from context, their recognition vocabulary cannot grow; if their vocabulary does not grow, reading will continue to be difficult and they will eventually quit (46).

A second problem is that incidental learning is relatively inefficient. It has been estimated (45) that the probability of learning a word from context is about 0.05. On the assumption that a fifth grader would encounter 20,000 unfamiliar words in a million words of reading, 1,000 new words would be learned. Obviously, the more that children read, the more words they can pick up this way. And, since vocabulary tests provide the most reliable psychometric measures of verbal intelligence (47), the more children read, the higher their IQ scores will be.

Probably the most important factor in learning words from their contexts of use is the ability to integrate information in a passage into a coherent schema consistent with the reader's prior knowledge. It is much easier to guess the meaning of an unfamiliar word when it is used in a discussion of a familiar topic.

General knowledge. Most authors presuppose that a reader will have some familiarity with their topic. When more is presupposed than the reader possesses, comprehension difficulties result. Indeed, some authors have concluded that the reader's background knowledge is so important that the whole problem of semiliteracy in the United States can be attributed to a national decline in "literate knowledge" (48). If someone does not share the general knowledge that writers assume all readers will acquire as part of living in the same culture, then that person will not understand what the writers have written. According to this view, semiliteracy is not a failure of reading instruction, but rather a general failure of the educational system to teach what every U.S. citizen should know.

Of course, no one can be familiar with—have prestored schemata for—every topic that an author might treat. Someone who follows technical articles on astronomy may not understand technical articles on biochemistry, and vice versa. That kind of comprehension difficulty is not a reading deficit, except in the sense that the necessary schemata might have been acquired through reading. The point is that someone can be a skilled reader in one domain and semiliterate in another.

Megacognitive knowledge. Beginning readers frequently have trouble because they do not understand what they are learning to do. They may believe that a list of random words is as easy to read as a connected text, or that skimming means reading only the easy words, or that the purpose of reading is to sound out words. Such misconceptions of the task are particularly common for children of illiterate parents.

Palincsar and Brown (49) describe the metacognitive difficulties of some seventh graders from low socioeconomic backgrounds who were participants in remedial reading classes. Palincsar and Brown developed a technique called "reciprocal teaching" in which teacher and students take turns asking and answering questions about sections of a text. At first the students could not participate in the dialogue: they could not summarize a text they had just read or formulate questions about it. Initially, the teacher modeled these metacognitive activities, and the students were passive observers. Only with repeated examples were the children able to lead a dialogue themselves. But they did learn—and not only did their reading comprehension improve, but the improvement generalized to other learning tasks.

The central message one takes away from this review of reading problems—both decoding and comprehension problems—is that reading is a skill and, like any skill, requires practice. Extensive reading strengthens decoding skills, builds the knowledge base, and instills the control essential for understanding new reading. But that development takes time. As Carroll has said, "reading comprehension ability is, on the average, rather slow to develop" (16, p. 426). No one achieves high levels of reading comprehension without many years of reading. The challenge of universal literacy cannot be met overnight.

Is There a Problem?

Given the catalogue of difficulties that must be avoided or overcome on the road to adult literacy, the remarkable fact is not that so many people failed, but that so many make it. Not everyone makes it, however, and that fact has become part of a national debate over literacy.

One position holds that everyone must attain a high level of literacy. National surveys are interpreted as indicating a general decline in literacy in the United States, presumably because schools are no longer doing their job. Those who hold this view are also inclined to the opinion that the failure of the schools has created a semiliterate underclass that lives on welfare or crime. Universal literacy, according to their rhetoric, is an economic necessity and something must be done.

Alternatives to this position have not been well organized, but some scientists and educators who have studied the problem for many years are inclined to feel that the current level of alarm may be excessive. Before concluding that universal literacy would resolve all of the country's social problems, a number of assumptions should be questioned.

A single standard? Must everyone be held to the same standard of literacy? In particular, should that standard be conceived in terms of educational reading programs that emphasize the understanding and enjoyment of fine literature? The alternative to a grade-equivalent standard of literacy is a functional standard. Economic consider-

ations argue for an ability to read and understand textual materials needed to perform particular tasks. But if universal literacy were to be defined in terms of job-specific reading skills, educational programs would have to be revised extensively. Neither standard meets everyone's needs.

Is literacy declining? The line between literate and illiterate is being pushed steadily upward by economic and technological pressures. When judged against this moving standard, literacy has indeed declined. But if criteria are held fixed, the number of illiterate and semiliterate individuals is slowly declining (*3*). That is to say, lower level skills are improving, although upper level skills may not be.

Are schools failing? Are high school graduates semiliterate? The answer is, fewer than might be expected, in part because most students with literacy problems drop out as soon as possible. Apparently the schools are simply unable to meet the needs of a certain percentage of their students. But students who are likely to drop out can be identified in advance—they are those who have repeated one or more grades (*3*). That is to say, there is a clearly defined population in need of special assistance. For the vast majority of students, however, the schools are not failing.

Are semiliterates unemployable? Much of the anxiety about literacy stems from the fear that semiliterates are unemployable. But the definition of "unemployable" depends more on the national need for manpower than on any test scores.

The most extensive and best documented attempts to employ low-aptitude and illiterate youths in this country have been conducted by the military. During peacetime, standards for enlistment are set to exclude such individuals, but in times of war they must be accepted, and special training methods have evolved to deal with them. According to a review of the military experience (*50*), literacy training modeled after the practices of the schools—first learn to read, then read to learn—have had limited success. More successful are programs in which reading is learned in the course of learning the job skills that are presupposed by technical training courses. These literacy training programs were deliberately designed to exploit what has been learned about the importance of a knowledge base for reading comprehension.

Analysis of the jobs that personnel were being trained to perform led to the identification of two types of reading tasks: reading to do something and reading to learn something. "In reading-to-do, the person is doing a job task, needs some information from a document, looks up the information, holds it in working memory long enough to apply it, and can then forget it. In reading-to-learn, the person reads information to be stored in long-term memory as part of the knowledge base, and then retrieves it (or a reconstruction of it) for use later" (*50*, p. 130). In school, reading-to-do and reading-to-learn are equally important, but on the job, most reading is reading-to-do. Moreover, the information-processing skills needed in reading-to-do are less complex. And since tasks that a person must read about are sometimes repeated, the reading becomes progressively easier.

All indications are that, by using task-specific training methods, it is possible to employ the unemployable in technical jobs that require limited literacy skills. Educators may deplore the narrowness of such training, which differs sharply from the broader education that the schools offer, but literacy develops by reading, studying, and learning; it can develop by reading task-specific materials as well as by reading history, literature, and social studies.

Thus, a plausible case can be made that universal literacy is not the ultimate test of our society. According to this view, literacy does not head the list of serious problems that the country faces. Although educational progress may not be keeping pace with the information revolution, the answer is not to turn the schools upside down. Better methods are needed to deal with students likely to drop out of school, and better use should be made of young adults with limited literacy skills, but those are manageable problems. All that is needed is the will to manage them.

Whatever one's assessment of the urgency of universal literacy, it should be remembered that, in the eyes of history, our present situation has developed rather suddenly. We are suffering acute displacements resulting from the rapid transition to an information economy. But this is not the first time in our history that the demand for literate workers has exceeded the supply. In the past, the demand has been met by providing better education for increasing numbers of people. A basic question for policy-makers, therefore, is to determine whether that strategy can continue to succeed— whether better education based on reading research can be developed rapidly enough to keep pace with the growing need for highly literate workers.

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Computational Neuroscience

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The ultimate aim of computational neuroscience is to explain how electrical and chemical signals are used in the brain to represent and process information. This goal is not new, but much has changed in the last decade. More is known now about the brain because of advances in neuroscience, more computing power is available for performing realistic simulations of neural systems, and new insights are available from the study of simplifying models of large networks of neurons. Brain models are being used to connect the microscopic level accessible by molecular and cellular techniques with the systems level accessible by the study of behavior.

UNDERSTANDING THE BRAIN IS A CHALLENGE THAT IS attracting a growing number of scientists from many disciplines. Although there has been an explosion of discoveries over the last several decades concerning the structure of the brain at the cellular and molecular levels, we do not yet understand how the nervous system enables us to see and hear, to learn skills and remember events, to plan actions and make choices. Simple reflex systems have served as useful preparations for studying the generation and modification of behavior at the cellular level (1). In mammals, however, the relation between perception and the activity of single neurons is more difficult to study because the sensory capacities assessed with psychophysical techniques are the result of activity in many neurons from many parts of the brain. In humans, the higher brain functions such as reasoning and language are even further removed from the properties of single neurons. Moreover, even relatively simple behaviors, such as stereotyped eye movements, involve complex interactions among large numbers of neurons distributed in many different brain areas (2–4).

Explaining higher functions is difficult, in part, because nervous systems have many levels of organization between the molecular and systems levels, each with its own important functions. Neurons are organized in local circuits, columns, laminae, and topographic maps for purposes that we are just beginning to understand (5–8).

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