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Source: *New Literary History*, Vol. 20, No. 2, Technology, Models, and Literary Study (Winter, 1989), pp. 411-450
Published by: The Johns Hopkins University Press
Stable URL: http://www.jstor.org/stable/469108
Accessed: 03-04-2015 18:52 UTC

Cultural Literacy and the Theory of Meaning: Or, What Educational Theorists Need to Know about How We Read

Gregory G. Colomb

In Arnold Schwarzenegger's first good movie, *The Terminator,* there is a scene in which a perfectly crafted and fiendishly powerful mechanical man faces a moment of decision. The setting is a staple of the Hollywood action-adventure and the TV cop drama: the Terminator sits alone in a seedy hotel room while someone standing in the dirty corridor knocks on the door. The Terminator is a Cyberdyne Systems 101 man-hunting cyborg (cybernetic organism), dispatched by the machine-dominated society of the future to terminate the woman who will mother a rebel hero. At this point in the movie, the indomitable Terminator has suffered significant damage to the flesh covering his combat chassis—so much damage that the flesh has begun to decay. The hotel janitor has noticed the foul smell coming from the Terminator and bangs on the door: "What ya got in there, a dead cat or what?" Puzzled, or at least taken aback, our mechanical thinker pauses to decide what to do. We cut quickly to his mind's eye, a computer screen which is being read—by whom? the inner man? the ghost in the machine? The display lists, under the heading "POSSIBLE RESPONSES," the output of the Terminator's language processor: "YES/NO," "OR WHAT?" "GO AWAY," "PLEASE COME BACK LATER," and so on. The cursor moves down the list as the Terminator considers each in turn, until he lights on "Fuck you, asshole." Whereupon, we cut back to the outside view, he says his response totally without affect, and the janitor laughs and moves on.

Though small, the joke in this scene is an exquisite instance of the old favorite, What's wrong with this picture? Stymied in a way that no true—that is, human—monster could be, this seemingly perfect automaton is suddenly exposed. From the outside view it has been frighteningly human in its inhuman violence, the representative of machines so intelligent that they can rival humanity for domination of the earth. Its language processor has been able to pick up and perfectly imitate the speech patterns of persons as different as a cop and

the heroine's mother. But now, with this glimpse inside, the Terminator becomes as crude an artificial intelligence as those we deal with every day at the bank or supermarket. What's wrong with this picture? That's not how it's done, and we feel the great distance between ourselves and machines as crude as the Terminator.

In his recent book, *Cultural Literacy: What Every American Needs to Know,* E. D. Hirsch, Jr. gives us a glimpse inside the mind's eye as it engages in the complex but apparently automatic process of reading.[1] Though strikingly mechanical, the picture is familiar. Reading is decoding, working word by word and clause by clause to recover the meaning contained in the text. But Hirsch's picture also adds to that familiar account. The first decoding must be supplemented with another. Poor readers are unable to carry the decoding process far enough: "Although disadvantaged children often show an acceptable ability to decode and pronounce individual words, they are frequently unable to gain an integrated sense of the whole" (*CL* 27). Integration comes when meanings are matched to and supplemented by memories: "the reader constantly connects a few words into clauses that have meaning and the clauses to appropriate schemata based on past experience" (*CL* 53).

Here too the question is, What's wrong with this picture? Like the picture of the Terminator thinking what to do about a knock at the door, there is a very great deal right with this picture of the reading process. But like mechanical thinking, this picture is all wrong by being a little wrong. As we shall see, this clause decoding and schemata matching cannot be how it's done. Moreover, this decoding-and-matching picture of the reading process is the only one that makes sense of the cultural literacy project. Just as the glimpse into the mind of the mechanical thinker makes us lose faith in the humanity of his violence, so a glimpse into this picture of reading will make us question the project for cultural literacy. This glimpse also leads us to paint a different picture, one that does not ask us to imagine readers standing outside of a text but somehow inside their minds, running down their list of schemata, looking clause by clause for matches so that they can get the meaning that the text contains.[2] To have a theory of reading is to have a theory of meaning, and Professor Hirsch has the wrong theory of meaning.

Professor Hirsch's argument for cultural literacy has several layers. Surrounding the argument about how we read are many others: arguments about national languages and cultures, arguments about theories of education and learning, arguments about the social good, arguments about the usefulness of the List.[3] Critics of the cultural

literacy proposal have so far chiefly addressed those other arguments, and most have been mesmerized by the List. This is perfectly understandable. On the one hand, Professor Hirsch has deliberately given us a lot to argue about, raising important questions that need debating and are being vigorously debated. On the other hand, the List gives us a chance to argue the contents of our culture. What picture of American national culture can include Homer (as in the bard) and Homer (as in Winslow) but not homer (as in home run, dinger, tater, four bagger, round trip)?

Despite their value, these questions have nevertheless become a diversion. The key point is the central technical point—that "world knowledge" is a prerequisite to developing reading and writing skills. It is from this claim that Professor Hirsch derives the pedagogical necessity of his project and of its List. Without that technical grounding, the cultural literacy project will have to stand on its political and social merits alone.

There is a measure of truth in the claim that knowledge is necessary. I have argued for some years now that any adequate program of writing instruction must be designed around that essential fact, and I have (with others at the University of Chicago) designed and administered such a program.[4] Too many critics and supporters of cultural literacy are so dazzled by the List that they lose track of the crucial insight that underlies the proposal. Professor Hirsch is right in this key respect. American educators have too often followed the tradition of John Dewey and "placed too much faith in children's ability to learn general skills from a few typical experiences and too hastily rejected 'the piling up of information' " (*CL* xv). The evidence is increasingly clear: skills cannot be learned apart from knowledge. Cultural literacy faces this fact more squarely than most educators are willing to do.

However, the fact that knowledge is necessary is a bare fact that paints an incomplete picture. This fact cannot signify for educational practice until it is placed, in turn, within a theory of meaning and a theory of mind. And the argument for cultural literacy understands that fact through a theory of meaning and a theory of mind that are simply not supportable. Recent research has firmly established the importance of knowledge in reading and writing. But more recent research, the research of the 80s, has increasingly called into question the theory of meaning that gives to the fact that knowledge is necessary the force of cultural literacy. As we learn more about the necessity of knowledge, it becomes increasingly clear that understanding language is a richer, more complex project than cultural literacy en-

visions, and that our educational challenges are far too great to be addressed by the List.[5]

Professor Hirsch's mistake lies in adopting, not only the language, but the conception of mind of those his project would reform. The Deweyite program of education participates in the long tradition of conceiving the mind as a symbol-processing device. On the one hand, we are said to have "general skills," the processing operations by which minds receive, manipulate, and store information. On the other is the information, the raw material over which these operations range. Dewey placed his confidence in the skills: "Development emphasizes the need of intimate and extensive personal acquaintance with a small number of typical situations with a view to mastering the way of dealing with the problems of experience, not the piling up of information."[6] Hirsch places his confidence in the piling up of information. But in the long view, that change is tiny, a shift in emphasis that preserves whole the concept of the mind as an information-processing device—in contemporary terms, as a computer.

Professor Hirsch is not alone in making this mistake. An all-purpose base for our talk about minds, the mind-as-a-computer metaphor also plays an important, often explicitly theoretical role in the research on which the cultural literacy project draws. While the mind may, at the neurobiological level, be a species of computational device, the mind-as-computer metaphor has led us astray. The consequences for cultural literacy are twofold. First, by envisioning the mind as an *information*-processing device, we misunderstand the crucial fact of cultural literacy—the role of knowledge—and mischaracterize that knowledge as mere information. Second, by envisioning the mind as an information-*processing* device, we hold to a "compositional" theory of meaning, assuming that we arrive at the meaning of wholes by a compositional process that accumulates the meaning of parts.[7] Both positions are wrong, and both are necessary for the List to make educational sense. In the course of testing Professor Hirsch's technical point about reading and confirming the importance of knowledge to cultural literacy, I will discuss the dangers in our habit of thinking of the mind as a computer and explain why the misunderstandings it brings greatly complicate the project of cultural literacy and undermine the value of the List. Since the heart of the problem lies not in particular findings but in the theory of meaning used to make sense of them, I will also offer an alternative story, sketching the outlines of a noncompositional, "top-down" theory of meaning. In doing so, I will touch on some ways in which the need to educate our citizens is more pressing and more difficult than the cultural literacy project envisions.

I. Cultural Literacy

In his key term, cultural literacy, Professor Hirsch has found a happy phrase that speaks to us quite apart from any technical discussion. However, the term does have a quite special meaning derived from the technical research: "Professor Chall is one of several reading specialists who have observed that 'world knowledge' is essential to the development of reading and writing skills. What she calls world knowledge I call cultural literacy, namely, the network of information that all competent readers possess. It is the background information, stored in their minds, that enables them to take up a newspaper and read it with an adequate level of comprehension, getting the point, grasping the implications, relating what they read to the unstated context which alone gives meaning to what they read" (*CL* 2). Given this definition, it seems that Professor Hirsch overdraws the problem. He sees cultural illiteracy as pervasive among those born in the second half of this century, including the seventeen-year-olds surveyed for the NAEP, those college-bound students whose SAT scores have declined, and those students who find top, highly skilled positions in major corporations (*CL* 5). It seems rash to assume, with no hard evidence, that there is a single cause for the communication failures of each of these groups. Nevertheless, Hirsch claims that the alarming ignorance is universal: "The lack of wide-ranging background information among young men and women now in their twenties and thirties is an important cause of the illiteracy that large corporations are finding in their middle-level executives" (*CL* 8).

This claim is, in my experience, false. I have consulted with, taught writing to, and studied more than a thousand of those middle-level executives and their professional peers. When they fail to communicate it is almost *never* because their literacy (or that of their readers and hearers) is too low. Instead, they fail to communicate because they are hyperliterate. Like new professionals of any age, these young executives are typically overwhelmed by their newly gained and hard-won expertise. So immersed are they, not only in the vocabulary or jargon of their expert community, but also in its canons of relevance, habits of mind, patterns of argument, and so on, that they find it very difficult to speak to those who do not share their expertise—to speak *out* of the closed loop of their expertise and experience rather than back into it.

Such failures of new professionals are often not a consequence of a simple inability to communicate. Many young experts prefer the kind of insider talk that makes them communicate poorly, a preference that Professor Hirsch seems to endorse—oddly so, since his own prose

is so admirably open. Using some interesting research on how people give directions to strangers in Harvard Square,[8] he comments: "If [strangers] can take a lot for granted, their communications can be short and efficient, subtle and complex. But if strangers share very little knowledge, their communications must be long and relatively rudimentary" (*CL* 4). Professor Hirsch clearly prefers the ways of "former days": "when business people wrote and spoke to one another, they could be confident that they and their colleagues had studied many similar things in school" (*CL* 8). This is the world of the golden age of educated gentlemen, who went to the same schools together, who know Harvard Square, and who can only benefit from their preference for short and efficient, subtle and complex, insider communication. But we should not be distracted if the diagnosis of the crisis overreaches in this way. The central problem—that many do lack the world knowledge to understand what they read—is real and widespread, even if it is not quite so universal.

II. The Role of Knowledge in Meaning

The heart of the case for the cultural literacy project lies in the role of "world knowledge" in understanding language. Ever since the classic work of Bartlett,[9] cognitive psychologists have understood the "constructive" or "abstractive" character of memory and understanding: meanings, memories, and perceptions are all constructed by processes that abstract from their objects and that contribute their own "additions" to the resulting mental states.[10] These constructive processes have long been a major object of study in cognitive psychology.

Until relatively recently, however, studies of language understanding were largely confined to nonsense syllables, word lists, and other bits of language without syntax—all unlikely to highlight the role of knowledge in understanding. Traditional linguistics had argued that understanding involved only linguistic knowledge, so psychologists focused their efforts on the processes for understanding and combining words. But as research shifted to look at language with syntax—sentences and very brief passages—and as other disciplines became involved in the research, it became evident how much the reader's knowledge contributed to the process of understanding and remembering texts. A sentence as ordinary as "The police officer raised her hand and stopped the car" calls into play knowledge that is not explicitly a part of the semantic representation of any word in the sentence. We know, for example, that a raised hand can be a stop sign,

that police offers use such signs in directing traffic, and that directing traffic is a common activity for police officers. How much more does it take to understand even a short sequence of sentences: "The beach had this extrafine, pure white sand that was just gorgeous. But when we got home, everyone had to shower and change clothes. And Johnny had to vacuum the car twice."

Soon most disciplines recognized that understanding language requires knowledge, not just of language but of the world represented in the language. Once again traditional linguistics tried to contain the role of knowledge by arguing that understanding involved two kinds of meaning, *semantic* meaning (which is supposed to involve only our linguistic knowledge—thus preserving intact linguistics as it had been) and *pragmatic* meaning (to which all "extralinguistic" knowledge was relegated). Such a stopgap measure could not hold for long, and this picture was assailed on at least two related fronts, the cognitive research conducted by reading specialists, text linguists, and psycholinguists and that conducted by computer scientists and others interested in artificial intelligences.

The story of research into the language processes of human intelligences began in earnest in the mid 1960s. The findings of this research were strikingly consistent.[11] It determined that once the syntactic structures of a clause are processed, the information is stored in a more abstract form and the syntactic information is immediately lost; that readers make inferences to fill in the gaps in the world picture represented in sentences; that readers use external clues about concrete topics (for example, titles or illustrations) to construct specific understandings of highly abstract stories, filling in concrete detail drawn from the mental models activated by the topic cues; that contextual cues can lead hearers away from typical or literal meanings of words; that children who have more knowledge about a topic are better readers about that topic. Related research investigated the *form* of knowledge, determining that, as Gestalt psychologists and Bartlett had predicted, usable knowledge seems to exist in the form of associative networks or schemata.

Research in natural language processing by artificial intelligence (AI) begins at about the same period, when AI researchers tried to implement the grammars that linguists were producing. This experience very quickly led them to abandon as untenable the distinction between semantics and pragmatics.[12] They attempted to overcome one inadequacy of traditional linguistic models by developing systems capable of the kinds of inference and prediction that cognitive psychologists were finding in their human subjects.[13] When linguistic inference and prediction proved too anemic to the task of under-

standing, AI designers built knowledge into the system in ways that did not distinguish so-called semantic and pragmatic knowledge. This knowledge was formulated into schematized scenarios, called frames, which were intended to embody the kind of world knowledge that the machines, like people, needed in order to process the language they were trying to understand.[14] When frames also proved too limited, too little able to inform the mechanism about the world of the language it was trying to understand, researchers developed frame-like structures called scripts, which were even more full of the necessary background information.[15] Finally, researchers concluded that the machine would have to model more than the knowledge in its scripts. Taking a cue from suggestions in cognitive research, they looked to model goal-based planning behavior, processing texts in terms both of the background knowledge in scripts and of the plans that might lead to a goal.[16]

All of these developments have not made computers very good understanders of language. But the failures have been especially instructive. Unlike the largely untestable models that many others have proposed, AI models had to work to pass muster. By *implementing* its theories, AI kept its game honest and uncovered the failings of a variety of theories and processing models. This is an important point. AI does not allow itself the luxury of "black boxes"—places in the theory where the analyst's intelligence intervenes to supply what the mechanism of the model cannot. When an AI system analyzes a text, the system is left to do the whole of the work on its own. Whenever a human intelligence must intervene in the process, that intervention is rightly regarded as a failure or a trick. Few other kinds of research are as rigorous. So important have been the example and the lessons of AI research that cognitive psychology has adopted "computability" as a primary standard for evaluating processing models: "Is the mind a computational phenomenon? No ones knows. . . . *Theories* of the mind, however, should not be confused with the mind itself . . . and what is clear is that computability provides an appropriate conceptual apparatus for theories of the mind."[17]

Out of these researches emerged a story that seemed, by the end of the 70s, to be clear, consistent, and reliable. In the study of both reading and writing, the contribution of knowledge was securely at the center of a constructive process. Rand Spiro's survey of the state of the art in an important collection of 1980 selected the 1970s as a watershed in understanding reading as a constructive process:

> Meaning does not reside in words, sentences, paragraphs, or even entire passages considered in isolation. It will be argued that if connected discourse

is analyzed at each of those levels taken out of context, the result is an incomplete understanding of the level's meaning in use. What language provides is a skeleton, a blueprint for the creation of meaning. Such skeletal representations must then be enriched and embellished so that they conform with the understander's preexisting world views and the operative purposes of understanding at a given time. This process of knowledge-based, contextually influenced, and purposeful enrichment in comprehending language is what is referred to as "construction."[18]

III. The Mind as a Computer

It is an important advance to recognize that knowledge is necessary for such skills as reading and writing and that reading and writing are constructive activities. These facts alone warrant some hard questions about our educational practices. However, for these bare facts to signify as a basis for Professor Hirsch's large-scale educational and social reform, we need a proper context within which to understand them. We need a clear sense of what this necessary knowledge consists in. We need a coherent theory of mind to understand how this knowledge might be deployed. And we need a theory of meaning to understand how this knowledge contributes to understanding language.

The proposal for cultural literacy finds its answers for these questions chiefly in the cognitive psychology of the 1970s. It holds that the knowledge we derive from and bring to bear on a text is propositional, that is, information connected by a schema of associations. It holds that the mind is an information-processing mechanism, which is to say, a computing device. And it holds that meaning is compositional: that is, the meaning of any given unit is the sum of the meanings of its parts and the meanings of the interrelations signaled by their combination. Although conventional, these positions are false. They offer a context for understanding the role of knowledge that is misleading at best.

Knowledge or Information. In order for the project of cultural literacy to succeed, the "world knowledge" necessary for reading must be information.[19] Only if knowledge is information can it be represented by the List or provided to students in the form of a lexicon. Professor Hirsch makes much of the claim that "the information essential to literacy" is hazy, vague, confused, rarely detailed or precise (*CL* 14–15), and most of all that it comprises a short list: "only a few hundred pages of information stand between the literate and the illiterate, between dependence and autonomy" (*CL* 143). But it is significant that literate persons produce only vague sentences about

their knowledge *only* if that knowledge is information exhausted by those sentences. If, however, the propositions we produce about our knowledge are only as the tip of an iceberg, then we are in no position to rest the success of our educational practice on the "superficiality of the knowledge we need for reading and writing" (*CL* 15). The fact is, we have had for several years now good reason to believe that the knowledge needed for reading and writing is more complex than any list or even network of propositions and that literate persons are vague about their knowledge because producing isolated propositions is a poor way to access that knowledge.

The question of whether knowledge can be propositional involves a group of difficult philosophical issues at the heart of cognitive science. In 1949 the philosopher Gilbert Ryle, following a Wittgensteinian line of argument, argued that one prominent, traditional picture of mental activity was all wrong. According to that view, we govern our behavior by consulting rules, recipes, and other kinds of verbal formulas and directions; by applying general truths to particular circumstances; by calling up propositional beliefs and attitudes (knowledge)—in short, by processing information. Ryle argued that to take these schoolroom procedures as the whole of thinking is to miss the point rather badly. Such schoolroom procedures, Ryle argued, are only possible for persons who are already thinkers, with significant knowledge and abilities. And, he went on, if we tried to explain *these* abilities as yet another, inner kind of information-processing, we would immediately fall into a hopeless regression.

Ryle's argument is powerful and intuitively appealing. (While I may be said to have followed rules and relied upon my lexicon to produce that sentence, I would not say that I have *consulted* any rule or any lexicon.) Nevertheless, our best research on those mental activities has often adopted the very view that Ryle seemed to discredit. This research—much of which is used to support the proposal for cultural literacy—pictures the mind in terms of inner representations, both rules and data (information), and of calculations performed on those representations.[20] Researchers embraced the metaphor of the mind as a computer and proclaimed "no computation without representation."[21] They assumed that conscious activity was precisely a matter of calling up information, consulting rules, applying rules to that information, and acting on the results. And for those processes where we have no sense of any such activities (such as writing sentences), researchers proposed inner calculations so quick and so automatic that persons could find no conscious access to them. Cognitive research often had to take out promissory notes to make the research go—limiting the calculations of their models to a narrow range of

activities and presuming on all the rest of the mental abilities of their subjects.[22] But they still produced important and impressive results, results such as the crucial fact that reading and writing rely on knowledge.

The problems with models that employ computations on mental representations were evident by the beginning of the 70s: "Any time a theory builder proposes to call any event, state, structure, etc., in any system (say the brain of an organism) a *signal* or *message* or *command* or otherwise endows it with content, he *takes out a loan* of intelligence. He implicitly posits along with his signals, messages, or commands, something that can serve as a signal-*reader,* message-*understander,* or *commander,* else his 'signals' will be for naught, will decay unreceived, uncomprehended."[23] Throughout the 70s, even as psychologists collected impressive bits of evidence on how persons read, AI researchers and others who tried to model the reading process collected an impressive catalogue of computational dead ends. AI knew early on that mental representations could not be simple propositions: "a memory that merely stores *propositions* leads to technological, or organic, monstrosities and frustrates, rather than facilitates inductive operations."[24] Yet they fared little better in their efforts to build more complex frame- and script-based models, models that seemed the best way to take into account the evidence gleaned from testing human reading processes. These models were knowledge-based, but they were also proposition-based,[25] and so engineering monsters. Cognitive psychology's efforts to model the mind as computations on representations were utterly stymied. In 1983 Jerry Fodor, still a devoted defender of computations, had to admit that years of research had produced no computational formalisms that worked and that "we have no idea of how such formalisms might be developed."[26]

How can we reconcile the success in discovering important facts about how we read with the total failure to find workable models of the reading process? One important factor is the nature of the evidence gleaned from research on human subjects. In order to build adequate models of mental processes, we need evidence of the *syntax* of those processes, evidence of the constituents and their interrelations. But the evidence of empirical research has consistently been only *semantic* evidence, evidence of the beginning and end states of those processes.

Consider, for example, two bits of evidence already discussed. First, readers contribute meaning to the texts they read. Or, more precisely, when readers remember and recall a text, the semantic representation of the recalled texts contains information not present in the semantic representation of the text they read. Second, readers read texts faster

and recall them better when they have knowledge of the texts' contents. Or, more precisely, texts are read faster and recalled better by readers who, when tested, can produce true sentences about the major referents of a text. Using the large-scale descriptions of folk psychology, we can fairly say that readers construct meaning from their knowledge. This is useful information, but it nevertheless remains entirely semantic information. The *only* syntactic information we have is that there is *some* process between the reading and the recalling that changes the text read into the text recalled. How, exactly, do readers "construct" meaning? We have little or no evidence. We are as warranted in concluding that the semantic representation in our grammatical analysis of the target text is too weak (that is, that readers are finding semantic information that the grammar misses) as in concluding that readers "add" anything to the text. What, exactly, is this knowledge that allows some readers to produce true sentences about the referents in a text? We have little or no evidence, only the black boxes of folk psychology.

Despite its limitations, researchers held on to the computational hypothesis because they were more suspicious of black boxes than of weak theories. They adapted a slogan from Lyndon Johnson, "I'm the only President you've got,"[27] and stuck to their guns. Now, however, there is a potentially viable alternative, one that shows increasing promise. This new alternative, known as connectionism or, more technically, Parallel Distributed Processing (PDP), offers a model of mental activity that is in a very rough sense computational (in that it is implemented on computers) but is decidedly not computations on representations: "We wish to replace the 'computer metaphor' as a model of mind with the 'brain metaphor.' "[28] The details of the implementation of PDP systems are quite complex.[29] Instead of rules and data stored as propositions at particular addresses, a PDP system distributes its memory over many intricately connected processing units, each of which participates in representing many different specific items.[30] By distributing the roles of memory and processing among multiple units which play both roles, often simultaneously, PDP erases any meaningful distinction between memory (data, information, knowledge) and processing (operations, rules, skills). Also, because processing is distributed, PDP never "consults" rules or "looks up" information: it eliminates the need for a central controller, monitoring and guiding individual identifiable processes or storing and retrieving items from memory. If PDP or something like it proves a viable alternative to computations on representations, that very traditional conception of mind may have seen its day.

Although PDP's collapsing of memory and processing is attractive

in view of other evidence that skills and knowledge may not be easily distinguished, it too is at this stage far from an adequate model. The point is not that we must toss out any and all computational models, but that we are in no position to know just what kind of model will prove best, and so are in no position to create educational policies that rely so heavily on the truth of any one mental model. But if we have to put our money on one model, all the evidence runs against any simple information-processing model that sees understanding as operations performed on propositions.

Knowing or Understanding. In his 1982 exploration of the difficulties of modeling mental representations, Daniel Dennett aptly characterizes what is wrong with simple information-processing conceptions of mental activity (mentally consulting rules, looking up information, and so on): "It is the *worst sort* of classroom activity, the rote memorization, that supplies the best model for cognitive science, because it has the nice feature of decoupling memory from understanding."[31] Decoupling memory from understanding is a nice feature for cognitive science because it makes for simple, easily constructed models. Decoupling memory from understanding is a nice feature for the cultural literacy project because it makes for simple, easily implemented educational practices. Unfortunately for both, the recent research suggests that understanding knowledge is more important than mere remembering.

Two kinds of evidence from research since the late 70s suggest that the knowledge that readers bring to a text involves more than mere propositional knowledge, the sort that can be mentally looked up. One kind of evidence concerns the role of plans and goals in understanding texts, and it directly contradicts an important claim in the argument for cultural literacy.[32] Professor Hirsch uses a *TV Guide* article about baseball to illustrate his claim that reading requires only vague knowledge: "to understand this text, we don't have to know much about [beanballs], but we do require quite a lot of vague knowledge about baseball to give us a sense of the whole meaning" (*CL* 15). In a group of studies, James Voss and his colleagues found otherwise.[33] In the last of these studies, intended to gather some evidence of how knowledge influences understanding, subjects were asked to generate and recall half-inning accounts of a baseball game. Among other results, the group found that the more successful, "high-knowledge" readers were better able to understand the accounts *as episodes*—in terms of the goals of each player and team, in terms of major actions and changes, in terms of actions and goals grouped together. Not only did this enable the high-knowledge readers to recall more, but it helped them recall more details. The results, Voss

concludes, suggest that the low-knowledge subjects know only discrete (no doubt vague) facts about the game. On the other hand, "one thing the HK [high knowledge] person has learned from watching baseball games and/or listening to radio broadcasts"—not to mention *playing* the game—"is a set of *procedures* that are used to generate the actions and state changes of a baseball game."[34] The high-knowledge readers are able, as it were, to construct a scenario and "play along" as they read and recall the text.

Other studies also suggest that as we read we construct a scenario with which to understand the text. It appears that underlying every text, even densely analytical texts, is a story with actions, characters, settings, and so on, and that one component of understanding involves matching the text to its story. These scenarios are constructed along several lines—actions and objects that "go together," predictable sequences of actions, predictable roles for the participants, and so on. Readers have been shown to do better when they are able to construct coherent scenarios, less well when they cannot discover a scenario or when they find unexpected shifts in actions, objects, roles, and so on.[35] Other studies have shown that readers reconstruct temporal and other sequences in their "normal" order when they recall texts in which the episodes have been disrupted.[36] These findings are indirectly confirmed by the successful advice given to writers that the most readable prose foregrounds the elements of the scenario it asks the reader to project—definite agents, actions as verbs, predictable and clearly specified roles, and so on.[37] This research is further confirmed (and influenced) by AI research, whose frames and scripts are schematized scenarios.

Although the evidence of these studies is very indirect, the trend runs all in the same direction: when readers bring knowledge to bear on the task of understanding, the knowledge that counts most is not simply a list of facts—vague or precise—of the sort that can be looked up and memorized. The knowledge that counts most is richly organized and hierarchical—organized by plans and goals, organized into scenarios, organized by being understood and so connected to everything else we know. We do not know very much about *how* that organization is implemented and deployed, but all we do know indicates that it is not enough for readers to know the requisite facts: they must understand them.

A final line of research offers less direct but potentially more powerful evidence. With another group of colleagues, James Voss conducted a major study of "Problem-Solving Skill in the Social Sciences."[38] A problem in Soviet agriculture was given to experts in Soviet domestic affairs, to political scientists expert in other areas of

the world, to expert chemists, to graduate students in political science, and to novices taking a course in Soviet domestic policy. Subjects were asked to "talk through" their solutions, voicing each question, problem, idea as it came to them. These solution "protocols" were then analyzed both as solutions to the problem and as texts.

The results confirm the dominant trends we have come to expect in the role of knowledge: knowledge is a prerequisite to successful problem solving, and problem-solving skills do not transfer well from one area of expertise to another. There were three keys to the experts' performance: their expert knowledge allowed them (1) to see an abstract, general problem and to subordinate other issues to this problem, (2) to state a general solution that *also* solved many subordinate problems, and (3) to see a long chain of implications in their solution. Correspondingly, the novices (1) gravitated to particular rather than general statements of the problem, often taking a subordinate problem as the whole problem, (2) found correspondingly particular solutions, either ignoring other subordinate problems or treating them as wholly separate matters, and (3) saw few or no implications in their solutions.

The finding most pertinent here is what happened to the novices over the course of the the study. They were asked to solve the problem both before and after they took the class in Soviet domestic policy. These novices showed "relatively little difference in the form and content of the protocol" before and after the class.[39] In other words, the considerable factual information gained in the course did not make these novices any better at understanding and addressing the problem. Facts do not seem to be the kind of knowledge that matters most. And those who make educational policy cannot afford to behave as Voss's novices did, taking a partial, subordinate fact out of the larger context it needs to make the best sense and so forcing it into service as the solution to a larger, more general problem.

IV. Meaning: Bottom-Up vs. Top-Down

The mistakes in Professor Hirsch's account of the reading process are important so long as the List continues to influence educational policy. Were that all, it would be enough to point out the mistakes and caution against them. But the story Hirsch tells about reading encompasses more than the List. It shares much with other authoritative accounts, including well-established facts, many sound positions, and a central mistake about the nature of grammar and meaning. Since that mistake pervades so much in Hirsch's story, it will be necessary to

retell part of it, concentrating on fundamental questions of grammar and meaning. The story begins with a basic conception of the mind as a computing device, and with the theory of meaning that conception fosters.

Computational models of the mind have been closely associated with, and in part are a product of, simple compositional theories of meaning. In its classic form, the compositional hypothesis claims that the meaning of the whole is a function of the meaning of the components and of their interaction.[40] A contemporary version of simple Fregean compositionality can be found in the traditional semantics of Katz and Fodor.[41] In their view, the meaning of a sentence is the syntax-driven composition of the grammatical and semantic features of the words that comprise it, and the meaning of a text is no more than the meaning of its sentences. This process of understanding composes atomic, bottom-level primitives into larger and more complex structures.

So simple a compositional view of meaning and understanding survives in very few places. The evidence runs almost exclusively against it, and almost everyone claims to have surmounted the deficiencies of the compositional hypothesis.

> . . . new research has shown that reading doesn't follow an orderly pattern, as used to be thought. We don't first identify words, then word meanings, next combine word meanings to get the meanings of sentences, and finally combine sentence meanings to get the meaning of a whole text. This model isn't wrong in all respects, but we know that it is so oversimplified and incomplete that it presents a highly misleading picture of the way we understand texts.
>
> The new picture . . . brings to the fore the highly active mind of the reader, who is now discovered to be not only a decoder of what is written down but also a supplier of much essential information that is not written down. (*CL* 33–34)

A model does not, however, escape compositionality merely by acknowledging the role of knowledge. The essence of the compositional hypothesis is that meaning is lodged in or attached to words, and that understanding proceeds word by word, clause by clause. That readers are said to construct meaning by contributing their own knowledge does not change the essential bottom-up, compositional nature of such a model.[42] That more basic change comes only by shifting the ground of the grammar and the processing model it configures from the word and clause to the text.

That shift from word to text, however, must find in the text more than a composition of sentences. Now that the simplest compositional theories have been discredited, theorists have found several means to

move their models up from sentence toward text. After a series of efforts to make text structure an extension of sentence structure,[43] the ground was shifted to models that saw texts as an elaborate construction upward from a "propositional text base"—models which made text structure entirely a semantic structure.[44] These models begin with the propositional text base, an ordered but otherwise unorganized list of propositions which are assumed to be the product of the first pass of sentence-level processing. These propositions are then organized into elaborated *structures* of propositions, structures which are supposed to be constructed by readers sentence by sentence through real-time processing.

In one major model proposed by Bonnie Meyer,[45] the propositional text base is composed into a tree structure organized by the logical relationships that hold among propositions. Meyer constructs text-structure trees so that the highest levels contain the most general propositions in the text. She then proposes that the organizational importance of a proposition is measured by its height in the tree structure, so that organizational importance equals generality.[46] This equation of generality and importance seems, however, to contradict several key facts, ranging from the strong evidence that the "basic level" of our conceptual categories is not the most general,[47] to the evidence of the role of knowledge in sentence-level processing, to the plain evidence of our practice, in which controlling sentences are very often not the most general.[48]

In the most influential model, that proposed by Teun van Dijk,[49] the propositional text base is subject to "macrorules" which reduce the text base to a group of "macropropositions." Van Dijk's macrorules also privilege generality: one rule deletes irrelevant detail; one generalizes groups of propositions into one proposition; and one constructs a general proposition which can replace a group of more specific propositions. Unlike Meyer, van Dijk makes some allowance for the reader's constructive contribution to meaning. Each macrorule involves the reader's judgment, and each (especially the construction rule) employs the reader's knowledge. Nevertheless, van Dijk's macrostructure, like Meyer's content structure, operates only on the information available in the propositional text base. It knows before the analysis begins what information in the text base will be most important—the most general.[50] And like all models that rely on a propositional text base, macrostructure treats text structure as purely a content structure, the result of operations on the semantic output of sentence-level processing.

A second group of theorists has tried to escape compositionality largely by fiat. This group includes most of those who have investi-

gated the role of knowledge and have incorporated the reader's constructive activity in their processing models. They have rightly concluded that, by seeing meaning as the product of an interaction between semantic information and some aspect of the reader's knowledge, they have much surpassed simple compositional meaning. Whether that interaction is governed by the structure of the reader's knowledge or by the structure of the scenario the reader constructs from the text, its product is certainly something more, something "larger" than a word-by-word, clause-by-clause composite meaning. Either schemata or scenarios give an overarching structure to the process of understanding, a structure that, since it reflects the reader's knowledge, is larger than the clause-by-clause structure of any text.

So there is a sense in which knowledge-based models that add schemata matching to clause-level decoding are more than compositional, larger in scope than the simplest bottom-up models. One prominent theorist has gone so far as to claim that knowledge-based models are thereby top-down: " 'Top down' may be loosely equated with 'knowledge-based,' 'bottom up' with 'text-based.' "[51] For a model of reading, knowledge-based is better than text-based. But a knowledge-based model that pairs decoding and matching is not thereby noncompositional, does not escape being bottom-up.

The distinction between top-down and bottom-up models of understanding language is properly a matter of grammar. A bottom-up model is compositional. It relies on a grammar whose primary unit is not the whole unit in question (for example, a word, sentence, or text) but some smaller unit, usually a minimal unit (a semantic primitive, proposition, or sentence). A bottom-up model assumes that meaning resides in the smaller, primary unit, and it represents the unit in question by constructing increasingly complex combinations of the primary unit. A top-down grammar takes as its primary unit the largest, most encompassing structure in question; it assumes that meaning resides at the top-level structure; and it represents that structure and its meaning by a process of decomposition into constituents. Thus, a top-down model of understanding takes the text as the primary unit and subordinates lower levels of grammar (sentence meaning, word meaning) to the text grammar.[52] It would also, however, subordinate text grammar to a yet more general theory of meaning, one that encompasses the whole of the situation that makes a text meaningful.

Though they are knowledge-based, decoding-plus-matching models of the reading process are tied to the bottom-up grammars through which they model the decoding and matching. As a result,

these models must be as blind to text-level features as the grammars they employ. Even the best knowledge-based models do their schemata matching or scenario building clause by clause. They have no principled way to record such discourse-level structures as order, theme, topic, point, and so on. As a result, the research on those models shows a decided preference for very brief texts (often no more than a couple of sentences), whose discourse-level structures are elaborated barely, if at all.

Although the limitation is created by the underlying grammar, the consequences for the models of reading are great. Without a coherent discourse grammar, the models are overwhelmed by the well-established limitations on sentence-level processing. Since the working memory with which we do sentence-level processing is short-term, any clause-by-clause model must find a way to do all text processing before working memory deteriorates. This restriction is far too severe for the task of understanding, so bottom-up models of reading greatly enrich those aspects of the process that are not temporally constrained and that (not coincidentally) we do not understand very well. Thus they compensate by requiring readers' long-term memory to be unrealistically robust—with both rich, well-ordered, and ready-to-hand schemata and the capacity for almost instantaneous recognition and retrieval of relevant schemata.

A top-down grammar, on the other hand, offers a far more reasonable alternative: in text-level structures readers find information that directs the reading process quite apart from the limitations of working memory. Evidence of this aspect of the reading process has been scarce, however. There have been few linguistically informed studies of text grammar, and most of those have been bottom-up—and thus blind to structures above the sentence level. Some important studies have examined the grammar of texts that are structured by plots,[53] and these studies of "story grammar" have pointed up some of the limitations of the decoding-matching conception of reading. As important as they are, these studies are not yet organized by a single, overarching theory. Also, the texts that matter most to the cultural literacy project are not texts configured by plots, but (that other major species) texts that make points. Our understanding of those texts is even more limited, since most bottom-up models of text grammar are unable even to make the distinction between texts that have plots and texts that make points. I know of no formal studies that directly test the process of reading in terms of the features of discourse-level grammar of pointed texts.[54] Even so, we now know enough of text grammar to see clear signs of the top-down character of the reading process.

Top-down grammars require a constituent structure. The units of a story grammar are stories, whose constituent structures are episodes. While *story* and *episode* are terms derived from ordinary language, the language has few correspondingly familiar terms for the structure of pointed texts. The units of a pointed text are *discourse units* (or d-units).[55] A discourse unit has two major constituents or slots, the *issue* position and the *discussion* position. The top-level issue position does have a rough equivalent in common usage, *introduction,* but the issue-discussion structure extends to d-units too small to have an introduction, units as small as two sentences. This structure is recursive, so that the issue or discussion position of a text might itself be filled by a d-unit (which will, in turn, have an issue and a discussion). Each discourse unit makes a *point,* a single controlling (though complex) idea that provides the principle of selection for other aspects of the unit. The point is expressed in one or more contiguous point sentences, which must be located at the end of a constituent—either near the beginning of the unit, at the end of the issue, or at the end of the unit, at the end of the discussion.

For example, the second paragraph before this one forms a d-unit. Its issue position is filled by the first two sentences ("A top-down . . . quite limited"). It establishes the discourse topic of the paragraph as <our limited understanding of discourse-level grammar>. The discussion position is filled by sentences three through nine. It develops the topic of our limited understanding. The point is the last sentence, canonically located at the end of the discussion. That paragraph is also a constituent of a higher-level d-unit (the major subsection beginning with that paragraph and ending at the end of section IV). The paragraph fills the issue position of the larger unit, establishing as the discourse topics <what we know of top-down grammar> and <the top-down character of the reading process>. The point of the larger unit is expressed in its issue (that is, in that paragraph), and is the same as the point of the paragraph. At the paragraph level, the point is expressed at the end of the discussion; at the level of the larger d-unit, it is expressed at the end of the issue.

Of the two discourse constituents, the issue position normally has the greatest impact on understanding. Like the topic position in the sentence, the issue has effects that are a consequence of its initial position. Among the functions of the issue position is to allow the reader to generate the expectations that will guide further reading—in the computational terms others use, to call up semantic networks, schemata, and other aspects of memory that will provide the knowledge and structure needed for processing. One aspect of this function concerns lexical cohesion. Coherent pointed texts will mention, at or

near the end of the issue position, key words that establish the small[56] group of lexical sets that signal both the connections among the information in the text and the major nodes of those connections.

The effects of the issue's announcing function can even override aspects of sentence-level processing. Using cues provided by the issue segment, readers will under certain conditions associate all or most of the information in the corresponding discussion with schemata "called up" by the issue's announcements. They will even do so when the concepts announced in the issue do not provide a very good fit with the information in the discussion. This effect is all the more significant when the issue also includes the point of its d-unit, so that the announcing function is combined with its point-making function, both occurring at the end of the issue.

Other discourse structures described by a top-down grammar can also influence processing. For example, one of the simplest discourse structures is the lexical string. Lexical strings are series of repeated or related words that track the lexical sets that serve as connecting threads in the text. In this text, for example, some recent lexical strings have centered on TOP-DOWN, BOTTOM-UP, DISCOURSE/TEXT LEVEL, UNDERSTANDING/PROCESSING. If lexical strings are extended (as those are) over several low- and middle-level d-units and if their items occur frequently, they are marked as key nodes in the text's structure of information. This effect is all the more significant when a lexical string is also marked by the issue's announcement of a discourse topic.

Yet another discourse-level effect is associated with the special kind of lexical string called a topic string. A topic string is a lexical string that is thematized because many of its items are sentence topics.[57] Thus the topic string combines the memorability of the lexical string and the additional focus of repeated sentence topics. Because of this additional focus, topic strings do more than generate central nodes to which other textual information is associated. They also generate the effects commonly grouped under the term *point of view*. Topic strings can establish main characters in scenarios, so that, for example, shifts in the topic string can make readers change their judgments about the relative responsibility of different characters. Topic strings can also shape readers' judgments about discourse topic and other kinds of "angles" or "perspectives" on textual information.

A final example of the discourse-level effects of topic strings is their ability to determine how much prior knowledge readers need in order to understand. Though it is clear that readers use world knowledge to understand texts, it is also clear that texts can, under the proper circumstances, help readers to understand significant amounts of en-

tirely new information. One key seems to be how the discourse structure leads readers through the web of new information. Readers have the most trouble with new, unrecognizable information when it is located in the topic position at the beginning of sentences. If, however, all information not yet known to readers is located at the end of sentences whose topic positions contain information that is familiar and that gives readers an "angle" on the unfamiliar information to come, then readers are able to accept and understand much more information for which they do not have ready-made schemata. It may be that certain kinds of discourse structures can mitigate the effects that make background knowledge look so important for reading.

What we now know of the discourse-level grammar of texts makes it clear not only that discourse structure contributes significantly to meaning and understanding, but also that those discourse structures govern the generation and understanding of sentence-level structures. (Three informal tests of these phenomena are reported at the end of this article.) It is no longer possible to think of our investigations of sentence-level processing as a basic or fundamental first step that can be conducted independently of the structure of discourse. A key task for empirical research is to explore the scope and character of discourse-level effects; another is to investigate the interrelations of processing at different levels; a task for grammatical research is to explain how the social situations within which pointed texts function are encoded as generic constraints on discourse grammar. It is from these kinds of additional information that a top-down grammar and model of reading gain their superior explanatory power.

In order to see some of the differences in explanatory power between a top-down and a bottom-up analysis, consider one of Professor Hirsch's examples which is entirely typical of bottom-up, knowledge-based accounts. Hirsch speaks of his businessman father's use of Shakespearean allusion in "business letters":

> These allusions were effective for conveying complex messages to his associates, because, in his day, business people could make such allusions with every expectation of being understood. For instance, in my father's commodity business, the timing of sales and purchases was all-important, and he would sometimes write or say to his colleagues, "There is a tide," without further elaboration. . . . To say, "There is a tide," is better than saying "Buy (or sell) now and you'll cover expenses for the whole year, but if you fail to act right away, you may regret it for the rest of your life." That would be twenty-seven words instead of four, and while the bare message of the longer statement would be conveyed, the persuasive force wouldn't. Think of the demands of such a business communication. To persuade somebody that your recommendation is wise and well-founded, you have to give lots of reasons and cite

known examples and authorities. My father accomplished that and more in four words, which made quoting Shakespeare as effective as any efficiency consultant could wish. (*CL* 9)

The lesson Hirsch draws from this example is the lesson of cultural literacy: "The fact that middle-level executives no longer share literate background knowledge is a chief cause of their inability to communicate effectively" (*CL* 9–10). One can reach the conclusion that Shakespearean allusions are more efficient than plain talk and that it matters how full are a young executive's Shakespeare schemata, only by adopting some of the least plausible assumptions of a bottom-up analysis. It is characteristic of bottom-up analyses that they give inordinate importance to such local phenomena as allusion. A top-down analysis produces a very different—and, I think, far more intuitive—conclusion about the role of Shakespearean allusions in the conduct of business affairs.

Before we can proceed, however, we will have to determine certain facts that Hirsch's example fails to provide. Since bottom-up analyses have no use for top-level grammatical information, they tend to omit information essential to a coherent account. For example, it will be essential to know where in the text structure "There is a tide . . ." occurs. If it is a high-level point, or if it occurs in the key position at the end of the top-level issue, then its role in the text grammar and so in the reader's understanding will be far greater than if it occurs low in the text structure of a minor paragraph. It will also be essential to know something more about the genre of these "business letters"—an ad hoc category that gives too little information about text grammar. Business correspondence falls into many different genres, each of which allows only certain of the many possible configurations of text grammar.[58]

Some of the necessary information about these business letters we can fairly infer from Hirsch's example. But much of it I simply have to assume. I take it that I can fairly do so, since Professor Hirsch's analysis claims that "There is a tide . . ." will be processed in the same way, no matter where it occurs and no matter what the genre—his analysis is even indifferent to whether the allusion is written or spoken. So I will supply the information that Hirsch ignores, sticking always to the simplest and most typical structures so that the analysis focuses on a common and well-defined genre. I will assume that "There is a tide. . ." is used in internal correspondence, within a given business unit (either within a major department or in a business small enough not to have major departments). This assumption avoids the complexity that attends when writer and reader do not substantially

share common goals, understandings, knowledge, and so on. It also helps to fix the social dynamic between reader and writer. Nowadays, such internal correspondence is almost always called a memo. I will also assume that "There is a tide . . ." occurs relatively low in the text structure. It would be extremely unusual for a business writer, no matter how pretentious, to use an allusion as a major point or other high-level structure. Finally, given what Hirsch says of his father, I think we can fairly assume that this correspondence more often goes from a superior to a subordinate.

With that information in hand, our analysis can proceed. Most kinds of business letters belong to that species of texts that make points. Thus the text as a whole must make a global point; each constituent of the text will itself be a discourse unit that makes a point; and these subunits will in turn be composed of other units that make points. In most memos, this nesting of discourse units continues down to the level of the paragraph, each of which will therefore make its own point. In the face of all of these points, "There is a tide . . ." would have to have a powerful effect indeed in order measurably to increase the communicative efficiency of the text.

Business correspondence, especially the internal memo, has a strong generic preference (though it is not an absolute requirement) for locating the global point near the beginning, at the end of the "introduction" or top-level issue. There is also the grammatical requirement that the issue establish the discourse topic by mentioning at the end key words that announce the lexical sets that will form the basis for the text's lexical cohesion. Thus, in this genre the key words and the global point almost always occur together. Combine these facts with the strong generic preference for brevity, and it is evident that a very great deal of the top-level grammatical information will be available to the reader very soon in his encounter with the text. Here too, it is hard to imagine how "There is a tide . . ." can improve communicative efficiency more than marginally.

The rhetorical action of the internal memo is never appropriately *persuasion,* as students of literature understand the term. Since these texts go mostly up and down the business hierarchy, the social structure of that hierarchy determines the rhetorical actions available in the genre. Texts that go up the hierarchy are, when they are geared toward action rather than simply informing, recommendations. While these recommendations may be persuasive, the persuasion has to be very careful to leave the decision (and the responsibility for it) in the hands of the superior party. And the powerful, widely enforced preference for brevity precludes "giv[ing] lots of reasons and cit[ing] known examples and authorities." On the other hand, texts that go

down the hierarchy are, when geared toward action, orders. A good manager will sometimes adopt a few—but only a few—gestures of persuasion, but all involved understand that instructions from the boss are orders. One can only wonder how much Shakespeare really improves the persuasive efficiency of the boss.

Given these few features of the grammar of the internal memo, how might the allusion function? We have seen that the reader will encounter the allusion after processing a great deal of the top-level grammatical structure of the text. Among other considerations, the reader will have processed the main point of the memo and some number of the subpoints and lower-level points. The reader will have called up and begun to fill the dominant schemata that control the information-structure of the text—all this before the allusion can have its effect.

Now, with all this grammar in place, the reader encounters the allusion to Shakespeare. Suppose the reader recognizes the allusion and knows the relevant Shakespeare. Then, if the allusion seems consistent with the top-level structure, it might serve as a marginal reinforcement; if it seems inconsistent and so beside the point, then it can only interfere (though only slightly) with the communicative efficiency of the text. Suppose the reader recognizes that the phrase is an allusion but does not know the relevant Shakespeare. Then the allusion is at best a minor distraction. Suppose the reader does not recognize the allusion at all. Then there's no telling what the effect will be, although it is likely to be negligible: readers are very good at naturalizing sentence-level structures that are inconsistent with their developing discourse-level understanding.

This hardly seems ground for an argument that middle-level executives need to know Shakespeare in order to communicate efficiently. In fact, there is an argument to be made that such allusions in such circumstances are always communicatively inefficient. My father, too, wrote a great deal of business correspondence, as district controller for a major corporation. A graduate of night school, my father never to my knowledge intentionally used a Shakespearean allusion. Moreover, he saw to it that his employees did not use such devices, not only because he would not have recognized the allusions or even because he thought them an affectation, but because those devices seemed to him beside, and so a distraction from, the point. Like most business writers, he held a strong preference for sticking to the top-level discourse structures—that is, for sticking to the point.

My point is not that relatively low-level features such as incidental allusions to Shakespeare are never effective or even crucial to the understanding of a text. We can certainly imagine a situation in which

low-level processing might be decisive to the communicative effectiveness of a text. But we have to *imagine a situation*: in order to make these allusions more than incidental, we have to envision a special story with special circumstances—a sure sign of what linguists called a marked situation, one beyond the norm. Normally, sentence-level structures are understood *in light of* discourse-level structures, so that those low-level structures are assimilated into mental structures dictated less by schemata matching than by discourse grammar. We cannot begin to explain how sentence-level structures are understood without taking discourse structure into account. In fact, only by understanding the discourse grammar and how that grammar encodes the social situation that produced the text can we predict those situations in which low-level structures such as allusions are likely to have major effects.

V. The Process of Understanding

In the last section, I spoke freely about how discourse grammar might translate into a processing model. However, drawing conclusions about processing is the most delicate and dangerous of tasks. What little evidence we can gather is really very indirect. When we use human subjects, it is impossibly hard both to limit the test to a single aspect of mental activity and to control against all intervening effects. Even with very brief passages, the record for controlling against them is not very good. Moreover, the information we gather from research on human subjects has so far been largely semantic. When we use this semantic information to draw conclusions about the mechanism of the processes that generate that information, it is little more than guesswork. Using machines, we can achieve the kind of controls we need, with full accounts of the syntax of the process, but then we face the problem of drawing conclusions about organic-based mental activity from the evidence of silicon-based mental activity—a translation that is notoriously hard to make. And in any case, the machine models do not work nearly as well as the human original equipment.

Given these limits on the evidence, we face the problem of knowing how to combine each new result with other results. Since the results themselves are so narrow, they can be combined into many different pictures. Even when the individual results do seem to add up to a somewhat larger picture, that picture can be made to support a wide variety of processing models. For example, the cultural literacy proposal puts together some classic results to make the following picture of reading: "According to the picture sketched by recent research, the reader is confined to a rather narrow window of attention that is

limited by short-term memory. Through this window, the reader constantly connects a few words into clauses that have meaning and the clauses to appropriate schemata based on past experience. Thus, the reader is not just passively receiving meaning but is actively selecting the most appropriate schemata for making sense of the incoming words" (*CL* 53). These classic results will also support many other processing models. Add a few other, equally narrow results, and Hirsch's picture perfectly supports the following account, one that is consonant with a top-down theory of meaning. (Note, this is no more than an alternate picture, since it too involves too many assumptions for which the evidence is extremely skimpy.)

> The reader is confined to a narrow window for processing sentence-level grammatical information, a window that is limited by the time constraints of short-term memory. In this working memory, the largest (though not the only operative) level of syntactic processing is the clause, and the semantic output of processing clauses is (either during or after the syntactic processing) matched to schemata or scenarios that the reader knows/creates.
>
> However, the limitations imposed by short-term memory are significantly mitigated by the information derived from discourse-level grammar. Readers come to each clause with elaborate expectations derived from the discourse grammar of the text, from the situation within which they are reading the text, and from their own goals and purposes in reading. These expectations cause readers already to have called up and prepared the schemata, goals, plans, and other mental structures by and through which most of the processing will occur. Because of the discourse-level information available in the text, readers need to process clause-level grammatical information only lightly—basically using that grammatical information as a check to see how well their continually developing expectations are being met.
>
> Sentence-level grammatical processing can become the primary level of processing, but only in special circumstances. One such circumstance is when there is too much dissonance between the expectations generated by text-level processing and the information of clause-level structures. If, in that situation, a brief period of clause-level grammatical processing (often processing clauses previously read) does not yield a revised set of text-level expectations, then clause-level processing becomes the dominant level of processing. Another such circumstance is when texts contain too much unfamiliar information for the reader to assimilate. Then processing remains at, or even below, the clause-level, and the reading process slows or stops entirely.

Although I think this the most plausible current story of how we read, I do not believe that we know enough to stand firmly by *any* story of the specific process of reading. In order to have a viable processing model, we need to know a great deal more than we do. We need a more complete grammar of discourse structures above the sentence. We need to know the relative contribution of understanding of each level of grammar. For reasons of grammatical theory and for reasons derived from snippets of empirical evidence, I believe that there is a top-level bias in processing, but I cannot produce a wealth of significant, systematic empirical evidence for that belief. We need to know how information derived from different levels of discourse structure affects processing at the other levels. We need to know what prompts readers to give prominence—if they ever do—to one level of processing over another. We need to know whether there is such a thing as the "sampling" of lower-level structures of the sort that I propose, and if there is, what kind of information that sampling produces. We need to know how processing of lower-level structures leads us to revise our understanding of top-level structures.

There is still a great deal we need to know about language and how it is understood. As researchers, we can and must continue to spin out stories of how reading works, stories we need to shape our understanding of the evidence we have and to shape our further investigations. But as honest researchers, we have to be very careful not to let the easy plausibility of the stories we spin out stand as firm truth for those who do not understand just how preliminary and provisional those stories really are. And as educational theorists and policy makers, we are obliged to be extraordinarily careful not to make policy as though those stories were as simple as they seem and as true as they feel. It is disastrous to assume that a policy grounded in one of those stories must succeed—and so should be implemented willy-nilly—because the story is compelling and happens to fit into a larger story, motivated by economic and political considerations, about a golden age.

Appendix: Lexical Strings, Topic Strings, and Textual Focus

The series of repeated or related words called lexical strings are the lowest level of text structure above the sentence. What counts as a lexical set is a direct function of the reader's knowledge: the relatedness of words depends on their relatedness in the reader's memory. Three features of lexical strings locate them as discourse-level struc-

tures. First, they are independent of sentence syntax. Second, lexical strings are specifically marked by the discourse-level structure, issue. It is a grammatical requirement that the major lexical strings begin in the issue and appear at or near the end of the issue.[59] Third, lexical strings outlive sentence-level structures. While the grammatical information of sentence-level syntax is quickly lost, the lexical sets tracked by lexical strings survive in readers' memory for text.

A few formal studies have suggested the longevity of lexical strings, but these tests are too indirect to be entirely reliable.[60] Memory for lexical strings is easy enough to test, however, and it has been tested hundreds of times as a demonstration in the program of writing instruction known as the Little Red Schoolhouse.[61] Subjects read a coherent text of some length (500–1000 words), which has five or fewer dominant lexical strings which are (1) pertinent to the point of the passage and (2) mentioned at or near the end of the issue segment. When asked later to list words that capture what the text is about, the words they most remember, almost all subjects list one item from the dominant lexical strings, most list most of the items, and a significant minority list all of them. When, however, the items in the lexical strings are either removed or replaced with distant synonyms, subjects' lists are far more varied.

Closely related and more significant are the focusing effects of topic strings. In a series of tests conducted at the National Judicial College by Joseph Williams and myself, groups of state and federal judges and administrative law judges were given a one-page report of a personnel problem. There were two sets of reports, one set involving a sexual harassment complaint and the other involving a promise made to a new employee. Each incident involved two major characters, and each was tested in two different versions. In one version, character A dominated the topic string: whenever possible, character A was the first or second noun phrase in the topic position of each sentence. In the other version, character B dominated the topic string as the first or second noun phrase in each sentence. Otherwise, the two versions were the same, with identical propositional text bases.

When asked a question designed to elicit an evaluation of the relative responsibility of the two characters, judges consistently assigned greater responsibility to the character who dominated the topic string.[62] In a related test, judges were asked to listen to and take notes on the two sexual harassment reports. When asked two hours later to consult their notes and list three or four reasons for deciding what action a personnel manager should take, the judges showed an even greater tendency to skew responsibility in favor of the character dominating the topic string.

Topic Strings and Understanding the Unfamiliar

In a series of tests, Joseph Williams and I evaluated readers' ability to accept information for which they had no prior knowledge. A 147-word account of a biochemical mechanism was given to different groups of readers. The passage begins as follows: "An appreciation of the effects of calcium blockers can best be attained by an understanding of the activation of muscle groups. The proteins actin, myosin, tropomyosin, and troponin make up the sarcomere, the fundamental unit of muscle contraction. The thick filament is composed of myosin, which is an ATPase or energy producing protein. . . ." The significant discourse feature here is the topic string, which consistently thematizes technical information unknown to most readers who are not schooled in biochemistry.

This passage has been read by several hundred lawyers in writing classes or in-house training programs, mostly in groups of twenty to fifty. Few lawyers can understand or remember the passage, and almost all (for most groups, more than 75 percent) try to stop reading long before they reach the end of the passage. When they are encouraged to keep reading, the lawyers report that they are very quickly unable to process sentence syntax, and so are reduced to reading individual words and phrases.[63] The same passage has been read by several groups of more than a hundred orthopaedic surgeons and their guests. While most of the guests and some of the surgeons react as the lawyers do, most of the surgeons find the passage relatively easy to understand and remember. Very few of the surgeons report that they cannot process the sentence syntax.

In contrast, parallel groups of lawyers and surgeons have been asked to read a version of the calcium-blockers passage that begins as follows:

> Our muscles work by contracting, and the contraction of muscle depends on calcium. If we can understand how calcium activates muscle groups to make them contract, then we can appreciate how those muscle groups are affected by the new drugs called calcium blockers.
>
> The fundamental unit of muscle contraction is the sarcomere. The sarcomere has two filaments, one thick and one thin. These filaments are composed of substances called proteins that either prevent contraction or cause contraction. The thick filament contains the protein myosin, which is an energy producing or ATPase protein. . . .

Here, the topic string thematizes familiar information, so that readers encounter the technical information only toward the end of sentences. Both lawyers and surgeons understood and remembered this

passage better. Almost every lawyer was able to finish the passage, and none reported that he or she was unable to process the sentences. Asked to rate the passage they read on a ten-point "reader-friendliness" scale, both lawyers and surgeons significantly preferred the version that does not thematize technical information—although both groups also recognized that the version that thematizes non-technical information might, in many situations, seem inappropriately unprofessional.[64]

This result suggests that certain discourse structures can mitigate the difficulties of reading without the appropriate background knowledge. Writers who thematize information unfamiliar to readers cut those readers off from the information path they need in order to assimilate the information. If, on the other hand, a text consistently thematizes recognizable information and gives *in the text* a path connecting that recognizable information to less recognizable technical information, readers are able to understand and remember. It may be that researchers have overemphasized the difficulty of texts that contain information readers do not recognize. An equally important consideration may be whether the text makes a connection to the reader's knowledge by thematizing familiar, recognizable information.

The Issue Position and Readers' Expectations

A final example will show how readers use constituent structure to direct their understanding. In this test, a marginally coherent, naturally occurring text was altered so that its constituent structure worked against rather than with other aspects of discourse structure. Specifically, this test was designed to gauge how the announcements in the issue position play a role in constructing a coherent understanding of a text.

The text sample was derived from the global discussion segment of a memorandum from a lawyer to a drug-company executive. This discussion segment was itself a coherent d-unit, d_a, composed of sixteen paragraphs. The first paragraph comprised the overall issue, with the rest disposed into three subunits, d_b, d_c, and d_d. The constituent structure was as follows (d-units are marked with curly brackets, constituents with square brackets; the subunits d_{b-d} are not expanded into constituents):

$$\{[\P_1]_{\text{Issue}_a}\ [d_b\ d_c\ d_d]_{\text{Discussion}_a}\}_{d_a}$$

The overall issue, Issue_a, announced a very general topic ("the standard of care in malpractice cases"), which governed all three units in

the overall discussion but which was not closely related to the specific discourse topic of any of the three subunits, d_{b-d}. For this test, the second and third subunits, $d_{c,d}$, were removed, so that the test sample had the following structure (with d_b expanded into constituents):

$$\{[\P_1]_{\text{Issue}_a}\ [\{[\P_2]_{\text{Issue}_b}\ [\P_3\ \P_4\ \P_5\ \P_6]_{\text{Discussion}_b}\}_{d_b}]_{\text{Discussion}_a}\}_{d_a}$$

As a result of this alteration, the subunit d_b is much more directly dominated by the overall issue, Issue_a, than was the case in the original—dominated more than the coherence of d_b can stand. The hypothesis was as follows: after the alteration, the strong announcement of a discourse topic at the end of Issue_a would dominate the discourse topic of the subunit d_b; thus, what was originally the topic of the larger unit d_a (<standard of care>) would interfere with the specific discourse topic of the subunit d_b (which was concerned with the admissibility of evidence of a reference work published by the AMA). As a result, readers would inappropriately try to use <standard of care> as the chief ground of lexical cohesion in d_b. If the issue segment has the effects the grammar predicts, then subjects would have greater difficulty because they brought to d_b inappropriate expectations. Since the lexical strings in d_b were extremely varied, using only loosely related words and phrases and almost no repeated words, readers would find relatively few signals in d_b that might lead them to reject their original expectations. A second, control passage was composed only of subunit d_b, without the misleading opening paragraph about standards of care.

The targeted passage was read by dozens of groups of fifteen to twenty lawyers and by two groups of approximately seventy-five undergraduates, graduates, and faculty at a technical university. After reading the passage, subjects were asked to list key words or main ideas without referring back to the text. Agreement among subjects was almost nonexistent. The total number of items recorded by at least one person in a group was never fewer than twelve and was once double that. The one item remembered most often by all groups was the general topic <standard of care> which was announced at the end of $\P_1$ but occurred only once in d_b. As for the key lexical sets in d_b, no item was remembered by as many as half of the subjects in any group. Only two or three items were remembered and recorded by as many as a quarter of the respondents, and most were remembered by 10 percent or fewer. Groups of lawyers generally reached higher agreement than the two mixed groups, probably because they knew the subject and were better able to recognize related items as belonging to a common lexical set. But the agreement was never good

enough to say that any group had reached anything like a common understanding of the test passage.

In a control test, one group of thirty-five judges (who are, of course, also lawyers) and one group of thirty undergraduates at a technical university were given the control passage without $\P_1$ and its announcement of a misleading topic. For both groups, the total number of items recorded by at least one person in a group was significantly fewer than for the target passage, seven for the judges and nine for the undergraduates. Among the judges, agreement in the lists was very high, with five of the seven items remembered by eighteen judges and two remembered by twenty-six. It seems, then, that in at least some circumstances, the expectation-generating function of the issue segment has decisive effects on what readers understand and remember, and presumably on how readers process subsequent text.

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NOTES

1 E. D. Hirsch, Jr., *Cultural Literacy: What Every American Needs to Know* (Boston, 1987); hereafter cited in text as *CL*.

2 Patrick Scott, "A Few Words More about E. D. Hirsch and *Cultural Literacy*," *College English*, 50 (1988), 333–38, notes that the examples in *Cultural Literacy* tend to favor communicative transactions that support the "language is a container of meaning" theory that has dominated Hirsch's work since *Validity of Interpretation* (New Haven, 1967). The view that "language is a container" is prevalent not only in theoretical discussions, but also as a root metaphor in much of our talk about language (see e.g., Michael J. Reddy, "The Conduit Metaphor," in *Metaphor and Thought*, ed. Andrew Ortony [Cambridge, 1979], pp. 284–324).

3 The largest reaction to the cultural literacy proposal has been to the list of "What Literate Americans Know," and therefore "What Every American Needs to Know" and every school should teach. This list is supposed to contain the "background information" that readers need in order to participate as fully enfranchised citizens. Professor Hirsch has recently published a dictionary, refining the List and giving definitions for each item. See E. D. Hirsch et al., *The Dictionary of Cultural Literacy: What Every American Needs to Know* (New York, 1988). He had already established the Cultural Literacy Foundation for propagating the List.

4 The centerpiece of that program, a group of advanced courses for upper-class undergraduates and graduate students known as The Little Red Schoolhouse, is designed to address and engage both students' "skills" and their "knowledge." Other aspects of Chicago's Writing Programs are equally knowledge-based.

5 In a forthcoming critique of *Cultural Literacy*, Andrew and James Sledd, "Hirsch's Use of His Sources in *Cultural Literacy*: A Critique," *Profession '88*, try to make a case that Hirsch misuses his sources. Although they raise disturbing questions, especially about the use of sources concerning national languages and other sociolinguistic issues, I do not here argue that Hirsch misuses his sources, only that he misunderstands their significance.

6 John and Evelyn Dewey, *Schools of To-morrow* (New York, 1915), p. 13.

7 Professor Hirsch has long thought that the bottom-up view is best: "Practical experience tells us that the main uncertainties of bad writing are small-scale, local uncertainties, persisting from word to word and sentence to sentence." See E. D. Hirsch Jr., *The Philosophy of Composition* (Chicago, 1977), p. 105.

8 See Robert M. Krauss and Sam Glucksberg, "Social and Nonsocial Speech," *Scientific American,* Feb. 1977, pp. 100–5.

9 See Frederic Charles Bartlett, *Remembering: A Study in Experimental and Social Psychology* (1931; rpt. Cambridge, 1977).

10 The constructive nature of understanding was also recognized by some students of literature. Roman Ingarden, *The Literary Work of Art: An Investigation on the Borderlines of Ontology, Logic, and Theory of Literature* (1931), tr. George G. Grabowicz (Evanston, Ill., 1973), offered a study of the constructive nature of understanding that was perhaps the most detailed of all before the 1970s. For a more recent development of the Ingarden position, see Wolfgang Iser, *The Act of Reading: A Theory of Aesthetic Response* (Baltimore, 1978). A noted scholar who early recognized the constructive nature of understanding was I. A. Richards; see C. K. Ogden and I. A. Richards, *The Meaning of Meaning: a study of the influence of language upon thought and of the science of symbolism* (New York, 1923).

11 Hirsch gives a good account of this part of the story in his second chapter, "The Discovery of the Schema" (*CL* 33–69). See the notes to that discussion for a relatively complete list of the specific sources of these findings.

12 See *The Handbook of Artificial Intelligence,* ed. Avron Barr and Edward A. Feigenbaum, 2 vols. (Stanford, 1981–82).

13 For example, a system developed at Yale by a group led by Roger Schank uses the linguistic information it processed to set up expectations about what it will encounter next, creating gaps in the machine's conceptual structure that it then sought to fill. Thus, the computer's constructive processing—filling gaps—drives the processing. See R. Davis and G. de Jong, "Prediction and Substantiation: Two Processes that Comprise Understanding," *Proceedings of the IJCAI* (1979), pp. 217–22.

The Yale group was by no means alone in its efforts. There were early failed attempts to build purely syntactic NLP parsers and early NLP semantic models that failed. Others succeeded through uninteresting forms of trickery. Many later efforts competed with or complemented the Yale group. For a complete history, see Barr and Feigenbaum.

14 The classic work on frames is Marvin L. Minsky, "A Framework for Representing Knowledge," in *The Psychology of Computer Vision,* ed. Patrick H. Winston (New York, 1975), pp. 211–77. For a survey of the early use of frames, see *Frame Conceptions and Text Understanding,* ed. Dieter Metzing (Berlin, 1980). See also R. P. Abelson, "Concepts for Representing Mundane Reality in Plans," in *Representation and Understanding: Studies in Cognitive Science,* ed. Daniel G. Bobrow and Allan M. Collins (New York, 1975); Daniel G. Bobrow and Terry Winograd, "An Overview of KRL: A Knowledge Representation Language," *Cognitive Science,* 1 (1977), 3–46; Eugene Charniak, "On the Use of Framed Knowledge in Language Comprehension," *Artificial Intelligence,* 11 (1978), 225–66, and "The Case-Slot Identity Theory," *Cognitive Science,* 5 (1981), 285–92.

15 See R. E. Cullingford, "SAM," in *Inside Computer Understanding: Five Programs Plus Miniatures,* ed. Roger C. Schank and Christopher K. Riesbeck (Hillsdale, N.J., 1981).

16 See J. Mehan, "Tale-Spin," in *Inside Computer Understanding,* pp. 197–226; and N. Dehn, "Story generation after TALE-SPIN," *Proceedings of the IJCAI,* pp. 16–18.

17 P. N. Johnson-Laird, *The Computer and the Mind: An Introduction to Cognitive Science* (Cambridge, Mass., 1988), p. 51.

18 Rand J. Spiro, "Constructive Processes in Prose Comprehension and Recall," in *Theoretical Issues in Reading Comprehension,* ed. Rand J. Spiro, Bertram C. Bruce, and William F. Brewer (Hillsdale, N.J., 1980), p. 245. A year later, the writing specialist George Dillon, *Constructive Texts* (Bloomington, Ind., 1981), p. xi, told the same story: "The meaning of the text is not on the page to be extracted by readers; rather . . . the written marks on the page more resemble a musical score than a code requiring deciphering." Seven years later, Professor Hirsch's summary account exactly mirrors the earlier examples: "The new picture . . . brings to the fore the highly active mind of the reader, who is now discovered to be not only a decoder of what is written down. . . . The explicit meanings of a piece of writing are the tip of an iceberg of meaning; the larger part lies below the surface of a text and is composed of the reader's own relevant knowledge" (*CL* 33–34). For an up-to-date account, see *Reading Comprehension: From Research to Practice,* ed. Judith Orasanu (Hillsdale, N.J., 1986).

19 Throughout *Cultural Literacy,* the "background knowledge" that readers bring to bear on a text is referred to indifferently as "knowledge" and "information," the two terms clearly synonymous. In the Preface, knowledge is referred to as "knowledge" exactly once, as "information" fifteen times. In the first eight pages of ch. 1, which set forth the broad outlines of the project, "knowledge" is used ten times, "information" thirteen.

20 The main line of psycholinguistic studies of text understanding explicitly assumes that texts are understood *and stored* as propositions. See Walter Kintsch, *The Representation of Meaning in Memory* (Hillsdale, N.J., 1974); Joseph E. Grimes, *The Thread of Discourse* (The Hague, 1975); and Bonnie J. F. Meyer, "Identification of the Structure of Prose and its Implications for the Study of Reading and Memory," *Journal of Reading Behavior,* 7 (1975), 7–47, and *The Organization of Prose and its Effects on Memory* (Amsterdam, 1975). Researchers interested in smaller-scale texts clearly presume calculations on propositions, assuming that their tests of reading time measure such matters as the speed of "retrieval" operations, the "depth" of items on a tree of mental addresses, the length of a "search path," etc. See Allan M. Collins and M. Ross Quillian, "Retrieval Time from Semantic Memory," *Journal of Verbal Learning and Verbal Behavior,* 8 (1969), 240–48, and "Experiments on Semantic Memory and Language Comprehension," in *Cognition in Learning and Memory,* ed. Lee W. Gregg (New York, 1972), pp. 117–37; Brian H. Ross and Gordon H. Bower, "Comparisons of Models of Associative Recall," *Memory and Cognition,* 9 (1981), 1–22; Herbert H. Clark, "Bridging," in *Theoretical Issues in Natural Language Processing,* ed. Roger Schank and B. Nash-Webber (Cambridge, Mass., 1975); Simon Garrod and Anthony J. Sanford, "Interpreting Anaphoric Relations: The Integration of Semantic Information While Reading," *Journal of Verbal Learning and Verbal Behavior,* 16 (1977), 77–90, and "Bridging Inferences and the Extended Domain of Reference," 9th International Attention and Performance Conference (Cambridge, Mass., 1980); and Anthony J. Sanford and Simon Garrod, *Understanding Written Language: Explorations of Comprehension Beyond the Sentence* (Chichester, 1981).

21 Jerry A. Fodor, *The Language of Thought* (Scranton, Pa., 1975).

22 For an account of how psycholinguists presumed on the intelligence of their subjects and of themselves, see Gregory G. Colomb and Joseph M. Williams, *Discourse Structure,* Technical Report of the Writing Programs of the University of Chicago (Chicago, 1987), esp. ch. 7.

23 Daniel C. Dennett, "Intentional Systems," *Journal of Philosophy,* 8 (1971), 87–106; rpt. in his *Brainstorms: Philosophical Essays on Mind and Psychology* (Cambridge, Mass., 1978), pp. 3–22. There are also important discussions of this and related issues in Daniel C. Dennett, *The Intentional Stance* (Cambridge, Mass., 1987).

24 Hans von Foerster, A. Inselberg, and P. Weston, "Memory and Inductive Inference," in *Cybernetic Problems in Bionics,* ed. H. L. Oestreicher and D. R. Moore (New York, 1968).

25 A memory or processing model is proposition-based whenever it relies on specific items of information (whether words, word concepts, or semantic primitives) located at specific memory addresses. Any such system will treat items as *information* that must be read and interpreted by some internal mechanism.

26 Jerry A. Fodor, *The Modularity of Mind* (Cambridge, Mass., 1983), p. 129.

27 Fodor, *The Language of Thought,* p. 27.

28 David E. Rumelhart, Geoffrey E. Hinton, and James L. McClelland, "A General Framework for Parallel Distributed Processing," in *Explorations in the Microstructure of Cognition,* Vol. 1 of *Parallel Distributed Processing,* ed. David E. Rumelhart and James L. McClelland (Cambridge, Mass., 1986), p. 75.

29 For a good general account see Johnson-Laird, *The Computer and the Mind,* pp. 174–94.

30 Each processing unit is located in a network that gives it potential connections to a great many other units. Also, each unit is assigned a "weight" or value which can activate one of the connections between that unit and adjacent units. Whether a given unit is activated depends on whether, and how, surrounding units have been activated. Thus, each "item" in memory is represented by one or more activation "paths" through the network. See David E. Rumelhart et al., "Schemata and Sequential Thought Processes in PDP Models," in *Parallel Distributed Processing,* ed. David E. Rumelhart and James L. McClelland, II, 7–57. "There is no representational object which is a schema. . . . Schemata are not explicit entities, but rather are implicit in our knowledge and are created by the very environment that they are trying to interpret—as it is interpreting them."

31 Daniel C. Dennett, "Styles of Mental Representation," *Proceedings of the Aristotelian Society,* 83 (1982–83), 220; rpt. in his *The Intentional Stance.* This conclusion is also reached by one of Hirsch's major sources; see J. Larkin et al., "Expert and Novice Performance in Solving Physics Problems," *Science,* 208 (1980), 1341: "effective learning involves more than (and differs from) memorizing materials presented in texts and lectures."

32 See John B. Black and Gordon H. Bower, "Episodes as Chunks in Narrative Memory," *Journal of Verbal Learning and Verbal Behavior,* 18 (1979), 309–18; Gordon H. Bower, John B. Black, and Terrence J. Turner, "Scripts in Memory for Text," *Cognitive Psychology,* 11 (1979), 177–220; Teresa Nezworski, Nancy L. Stein, and Tom Trabasso, "Story versus Content Effects on Children's Recall of Stories," *Journal of Verbal Learning and Verbal Behavior,* 21 (1982), 196–206; Nancy L. Stein and Christine G. Glenn, "An Analysis of Story Comprehension in Elementary School Children," in *Advances in Discourse Processing,* Vol. II of *New Directions in Discourse Processing,* ed. Roy O. Freedle (Norwood, N.J., 1979); Gordon H. Bowers, "Plans and Goals in Understanding Episodes," in *Discourse Processing,* ed. August Flammer and Walter Kintsch (Amsterdam, 1982), pp. 2–15; Richard C. Omanson, "The Relationship between Centrality and Story Category Variation," *Journal of Verbal Learning and Verbal Behavior,* 21 (1982), 326–37; Richard C. Omanson, W. H. Warren, and Tom Trabasso, "Goals, Inferential Comprehension, and Recall of Stories by Children," *Discourse Processing,* 1 (1978), 337–54; Linda Flower and John R. Hayes, "Images, Plans, and Prose: The Representation of Meaning in Writing," *Written Communication,* 1 (1984), 120–60; and Nancy L. Stein and Gregory G. Colomb, "Knowledge, Learning, and Development," *The National Center for the Study of Writing: A Proposal* (Chicago, 1985).

33 See George J. Spilich et al., "Text Processing of Domain-Related Information for

Individuals with High and Low Domain Knowledge," *Journal of Verbal Learning and Verbal Behavior,* 18 (1979), 275–90; Harry L. Chiesi, George J. Spilich, and James F. Voss, "Acquisition of Domain-Related Information in Relation to High and Low Domain Knowledge," *Journal of Verbal Learning and Verbal Behavior,* 18 (1979), 257–74; James F. Voss, Gregg T. Vesonder, and George J. Spilich, "Text Generation and Recall by High-Knowledge and Low-Knowledge Individuals," *Journal of Verbal Learning and Verbal Behavior,* 19 (1980), 651–67.

34 Voss, Vesonder, and Spilich, "Text Generation and Recall," p. 664; emphasis added.

35 See Perry W. Thorndyke, "Cognitive Structures in Comprehension and Memory of Narrative Discourse," *Cognitive Psychology,* 9 (1977), 77–110; Garrod and Sanford, "Interpreting Anaphoric Relations"; Sanford and Garrod, *Understanding Written Language*; Alan Garnham, Jane Oakhill, and P. N. Johnson-Laird, "Referential Continuity and the Coherence of Discourse," *Cognition,* 11 (1982), 29–46; and Alison Black, Paul Freeman, and P. N. Johnson-Laird, "Plausibility and the Coherence of Discourse," *British Journal of Psychology,* 77 (1986), 51–62.

36 See Nancy L. Stein and Tom Trabasso, "What's in a Story: An Approach to Comprehension and Instruction," in *Advances in Instructional Psychology II,* ed. R. Glaser (Hillsdale, N.J., 1981), pp. 213–67; and William F. Brewer and E. H. Lichtenstein, "Event Schemas, Story Schemas, and Story Grammars," in *Attention and Performance IX,* ed. J. Long and A. D. Braddeley (Hillsdale, N.J., 1981), pp. 363–79.

37 See Hirsch, *The Philosophy of Composition*; Linda Flower, "Writer-Based Prose: A Cognitive Basis for Problems in Writing," *College English,* 41 (1979), 19–37; Joseph M. Williams, "Defining Complexity," *College English,* 40 (1978), 595–609, and *Style: Ten Lessons in Clarity and Grace* (Glenview, Ill., 1981); and Colomb and Williams, "Perceiving Structure in Professional Prose," in *Writing in Nonacademic Settings,* ed. Lee Odell and Dixie Goswami (New York, 1986).

38 James F. Voss et al., "Problem-Solving Skill in the Social Sciences," *The Psychology of Learning and Motivation,* 17 (1983), 165–213. It is not obvious that results from research in problem solving can be directly applied to reading and writing. Voss thinks it can, and argues as much in his 1980 study. Linda Flower and John R. Hayes, "Problem-Solving Strategies and the Writing Process," *College English,* 39 (1977), 449–61, have made a similar case for the study of writing.

39 James F. Voss et al., "Problem-Solving Skill in the Social Sciences," p. 195.

40 See Gottlob Frege, "On Sense and Reference," in *Translations from the Philosophical Writings of Gottlob Frege,* ed. Peter Geach and Max Black (Oxford, 1981).

41 See Jerrold J. Katz and Jerry A. Fodor, "The Structure of a Semantic Theory," *Language,* 39 (1963), 170–210.

42 My key terms here, *bottom-up* and *top-down,* are used in several different senses in the various disciplines I here bring together. I do not use the terms in the sense common in AI research. A bottom-up grammar is compositional; a top-down grammar is not. How we should characterize bottom-up and top-down models of reading is a matter of some debate, which I address below.

43 See János S. Petöfi, "On the Syntactico-Semantic Organization of Text-Structures," *Poetics,* 3 (1972), 56–99, "Textlinguistic Aspects in the Grammatical Theory of Sentence," *Actes du Xle Congrès International Linguistes des Bologna* (1972), and "Towards an Empirically Motivated Grammatical Theory of Verbal Texts," in *Studies in Text Grammar,* ed. János S. Petöfi and Hannes Reiser (Dordrecht, 1973); Werner Kummer, *Grundlagen der Texttheorie: zur handlungstheoret* (Reinbeck [bei Hamburg], 1975); Hannes Reiser, "Sentence Grammar, Text Grammar, and the Evaluation Problem," in

Studies in Text Grammar; and Teun A. van Dijk et al., "Two Text Grammatical Models: A Contribution to Formal Linguistics and the Theory of Narrative," *Foundations of Language,* 8 (1972), 499–545. The closest that such extended sentence grammars come to discourse structure is in their accounts of cohesion. Petöfi, "Towards an Empirically Motivated Grammatical Theory of Verbal Texts," includes, for example, a brief sketch of textuality (in his "fixed linearity grammar") which is as informative as Ruqaiya Hasan, *Grammatical Cohesion in Spoken and Written English: Part I* (London, 1968). But when Petöfi tries to go further (in his "not fixed linearity grammar"), all he can do is fall back on especially elaborate propositional analysis.

44 These purely semantic models followed the prevailing view, most authoritatively articulated by M. A. K. Halliday and Ruqaiya Hasan, *Cohesion in English* (London, 1976), that a text "is not a structural unit. . . . There are certain specifically text-forming relations which cannot be accounted for in terms of constituent structure. . . . They are, as we have suggested, semantic relations, and the text is a semantic unit" (7).

45 See Meyer, "Identification of the Structure of Prose and its Implications for the Study of Reading and Memory," and *The Organization of Prose and its Effects on Memory*; see also Grimes, *The Thread of Discourse.*

46 Meyer purports to have evidence that importance does equal generality, in that subjects in her tests recalled "top-level" propositions more often than lower-level ones. There are, however, serious difficulties with the design of those tests. See Colomb and Williams, *Discourse Structures* (Chicago, 1987).

47 See Eleanor Rosch, "Principles of Categorization," in *Cognition and Categorization,* ed. Barbara B. Lloyd (Hillsdale, N.J., 1978), and "Categorization of Natural Objects," *Annual Review of Psychology,* 32 (1981), 89–115.

48 In Meyer's system, the controlling sentence of this paragraph would be the first, topic-announcing sentence rather than the last, point-making sentence.

49 See Teun A. van Dijk, *Macrostructures* (Hillsdale, N.J., 1980).

50 See van Dijk, *Macrostructures,* p. 85: "Macrostructures are not only the explicit representation of the global meaning of the text but also give at least a partial explanation of such notions as *importance, relevance,* or *prominence.*"

51 Spiro, "Constructive Processes in Prose Comprehension and Recall," p. 262.

52 To insist on top-down grammars is not to deny the relevance or the relative independence of lower-level grammars. A complete grammar will build into lower-level grammars an account of possible relations to higher levels and will have a general account of subordination of lower levels to higher levels (including an account of how usually subordinate, lower-level considerations can themselves become dominant).

53 See J. M. Mandler, "Recent Research on Story Grammars," in *Language and Comprehension,* ed. Walter Kintsch (Amsterdam, 1982), and *Stories, Scripts and Scenes: Aspects of Schema Theory* (Hillsdale, N.J., 1985); Stein and Trabasso, "What's in a Story"; Tom Trabasso, Tom Secco, and Paul van den Broek, "Casual Cohesion and Story Coherence," in *Learning and Comprehension of Text,* ed. Heine Mandl, Nancy L. Stein, and Tom Trabasso (Hillsdale, N.J., 1984), pp. 83–111; and Nancy L. Stein and Margaret Policastro, "The Concept of Story: A Comparison between Children's and Teacher's Viewpoints," in *Learning and Comprehension of Text,* pp. 113–155.

54 Some studies testing bottom-up theories have touched on the discourse-level grammar of pointed texts. For example, David Kieras, "Good and Bad Structure in Single Paragraphs," *Journal of Verbal Learning and Verbal Behavior,* 18 (1978), 13–29, and "Initial Mention as a Signal to Thematic Content in Technical Passages," *Memory and Cognition,* 8 (1980), 345–53, tested for topic and topic sentences' effects. However, topic sentences are not themselves pure grammatical features (they collapse two different

features of text grammar), and so it is impossible to draw consistent conclusions from that data.

55 For a fuller account of the grammar of pointed texts, see Joseph M. Williams, "Nuclear Structures in Discourse," in *Selected Papers from the 1981 Texas Writing Research Conference,* ed. Maxine C. Hairston and Cynthia L. Selfe (Austin, 1981); and Colomb and Williams, "Perceiving Structure in Professional Prose" and *Discourse Structures.* For early attempts at top-down models, see John Hinds, "Organizational Patterns in Discourse," *Syntax and Semantics,* 12 (1979), 135–57; and H. Sopher, "Discourse Analysis: The Hierarchic Structure of Meaning-Content," *Journal of Literary Semantics,* 8 (1979), 100–8.

56 There appears to be a fuzzy limit on the number of major lexical sets a reader can keep track of. Experience suggests that many readers are stressed by as many as five major lexical sets (though this will vary with the reader's knowledge and comfort with the subject matter). However, I know of no formal tests of this question.

57 Sentences have two marked information slots: a position fixed at the beginning of the sentence, called the Topic or Theme, which marks information as topical or thematic; and a position fixed at the end of the sentence, called the Comment or Rheme. The Topic position creates focus; the Comment position creates stress. See F. Danes, "Functional Sentence Perspective and the Organization of the Text," in *Papers on Functional Sentence Perspective,* ed. F. Danes (The Hague, 1974); William Vande Kopple, "Functional Sentence Perspective, Composition, and Reading," *College Composition and Communication,* 30 (1982), 50–75; Julia Penelope, "Topicalization: The Rhetorical Strategies It Serves and the Interpretive Strategies It Imposes," *Linguistics,* 20 (1982), 683–95; and Joseph M. Williams, *Style: Ten Lessons in Clarity and Grace,* 3rd ed. (Glenview, Ill., 1988).

58 I do not mean to suggest that these genres are very well understood by analysts. The state of our ethnographic understanding of the kinds of writing that happen in the workplace is very poor. Business practitioners have very many different names for the genres they employ, often ad hoc names, and like all language users, they describe their genres poorly because their understanding of them is largely intuitive, not a matter of consulting rules.

59 Discourse-level grammatical requirements are often registered in more diffuse judgments—generally, judgments about the text as a whole—than are features of sentence-level grammar. There are several reasons. First, discourse grammar is not explicitly taught in schools and so is not socially marked as is sentence grammar. Second, we experience many more sentences than monologic discourses. Third, it is impossible to hold a discourse in memory all at once.

60 For example, Walter Kintsch et al., "Comprehension and Recall of Text as a Function of Content Variables," *Journal of Verbal Learning and Verbal Behavior,* 14 (1975) 196–214, found that subjects remembered passages with fewer key words, often repeated, better than passages with many different words, seldom repeated. But the passages they tested were quite short (mostly two and three sentences), and the passages were not controlled for other aspects of discourse-level structure.

61 The Little Red Schoolhouse, a program of instruction in advanced professional and academic writing, forms the basis of all writing instruction at the University of Chicago, Georgia Institute of Technology, Duke University, the Law Center of the University of Southern California, the National Judicial College, and others. Its program is grounded in a top-down conception of both grammar and pedagogy.

62 For two groups of 74 and 22 judges who read the sexual harassment reports, the ratings on a six-stage scale (1 = not serious; 6 = serious) were as follows: when

character A dominated the topic string, an average of 2.42 and mean of 2; when character B dominated, an average of 3.69 and a mean of 3.

63 This may well explain why the passage is so poorly remembered. George A. Miller, "The Magical Number Seven, Plus or Minus Two," *Psychological Review,* 63 (1956), 81–97, established long ago that memory for lists of individual words is much impoverished compared to memory for the "chunked" information in sentences.

64 For three recent groups of 15, 17, and 35 lawyers and judges, the "technical" version scored an average of 2.29, with a mean of 2; the "nontechnical" version scored an average of 6.125, with a mean of 6.