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Theory and Pedagogical Practices of Text Comprehension

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This article reports on the reading comprehension crisis of older students in the middle and high school grades in our nation. Its goal is to establish a common foundation for intervention by educators and clinicians alike, by providing a brief description of the state of the field in comprehension theory. In particular, the Kintsch construction–integration theory of comprehension is described in the context of its place in the history of memory and learning research. Finally, promising practical classroom applications that result from this model are presented. **Key words:** *comprehension theory*, *construction/integration model*, *latent semantic analysis*

THIS article discusses the disappointing current status of children's ability to comprehend what they read, the dominant theory behind text comprehension, current practices that are being used to teach reading comprehension in the K–12 classrooms in the United States, and why more than just the classroom teacher should be interested in understanding and solving this problem.

STATUS OF READING COMPREHENSION IN US CHILDREN

First, consider how high-stakes testing in schools as part of the No Child Left Behind Act (NCLB; Elementary and Secondary Education Act as amended by the "No Child Left Behind Act of 2001" P.L. 107–110) characterizes reading achievement. By the NCLB yardstick, reading comprehension abilities are characterized as below basic, basic, proficient, and advanced proficient. The question a society might ask is "What is good enough?" To read the comics in the newspaper, the basic level may be enough. To digest thoughtful essays from which responsible citizens must understand the issues to become informed voters, at least a proficient level would be required. To reach higher levels of academic achievement requiring such abilities as literary criticism and understanding of science and technology, levels of advanced proficiency must be reached.

The national report card (see National Center for Education Statistics, 2004), which is published by the National Assessment of Educational Progress (NAEP; a federally sponsored organization), shows that about half of the children in American schools have not attained more challenging forms of reading, above the level of basic proficiency. NAEP provides data on student academic achievement for grades K–12. Looking at reading scores for grade 8, we see that a flat trend appears from 1992, when students were first tested, through 2003. Over this time period, the annual composite score for eight graders

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ranged from 260 to 264 out of 500 possible points. Scores reported for 12th graders were not much better, ranging from 287 to 292 over the years. What is hidden in these scores are middle and high school readers who either cannot properly decode what they read, or cannot comprehend well in spite of successful decoding. This latter group is of particular concern as research shows that decoding skills become increasingly less relevant and/or less correlated with comprehension in older students (Underwood & Pearson, 2004). Estimates of the proportion of older students who fall into the category of poor comprehenders range from 4% to well above 60%. If researchers, educators, and clinicians are to come up with effective strategies for teaching deep comprehension, then clearly we need a model of comprehension that begins where decoding skills leave off.

As reported by Rayner, Foorman, Perfetti, Pesetsky, and Seidenberg (2001, 2002), a number of well-respected reading researchers who focus their work on decoding view reading comprehension in the context of a model that assumes that if the student becomes successful in the foundational decoding skills (e.g., phonemic awareness, phonics, vocabulary, and fluency), then comprehension follows, apparently on the assumption that the children have intact discourse processing skills. This perspective, however, does not give adequate credit to the complexity of the processes that underlie effective comprehension. These researchers argue that if a student is struggling with these basic skills, it essentially causes cognitive overload, presenting a processing bottleneck that impedes comprehension processes (Rayner et al., 2001, 2002).

It is well recognized that mastering foundational skills is a necessary first step to becoming successful readers (National Reading Panel, 2000). However, there is also evidence that as students enter middle school, more than a few fluent readers can be identified who have mastered the foundational skills involved in decoding, yet are still poor comprehenders (Duke, Pressley, & Hilden, 2004; Underwood & Pearson, 2004). It is these older students who are poor comprehenders that lead us to take a broader view of what it takes for successful reading comprehension. In addition to fluent decoding skills, successful comprehension depends on increasing vocabulary, world knowledge and active use of comprehension strategies that require the reader to actively interact with the content of the text. Such strategies include predicting, questioning, self-explanation, constructing images representing text meaning, relating text information to prior knowledge, monitoring understanding, summarizing, and seeking clarification.

Because reading comprehension is made up of a complex set of skills, Underwood and Pearson (2004) argued that educators and clinicians should take a proactive approach to reading comprehension instruction instead of the historical deficit approach that seeks to fix what is broken. Hence, educational policy is moving toward an approach of preventing reading comprehension difficulties rather than waiting to repair problems when they occur. This direction leads researchers and practitioners to look for an underlying theory of text comprehension to serve as a guide for building instructional applications and assessing their empirical outcomes.

A THEORY OF TEXT COMPREHENSION

One of the most complete and well-referenced theories of reading comprehension is that offered by Walter Kintsch (1998). Indeed, in the National Reading Panel (2000) discussion of comprehension, his was the dominant theory presented. Most of today's educational researchers interested in reading comprehension use this model as a starting point for their work. The goal of this article is to give the reader an overview of current thinking about what is entailed in reading comprehension. As the only comprehension model specifically named in the National Reading Panel (2000) report, providing some detail about the Kintsch model seems the best way to achieve this end.

Representation of meaning

To articulate a theory of comprehension, one must first settle on some notion of how language users can practically represent meaning in memory. Such a representation must fill multiple functions that take into account text representation, memory structures such as general knowledge, concepts and word meaning (semantic memory), and experience (episodic memory). In Kintsch's (1998) theory of comprehension, knowledge and experience both play a part in creating mental representations of texts, so a representational format must be able to handle both.

Examples of meaning representations

Some formats for representing meaning that have considerable support in the literature include systems that use features. A classic example of how meaning is assigned in a feature system is the example that Katz and Foder (1963) used for the word *bachelor. Bachelor* = HUMAN + MALE, and + HAS-NEVER-MARRIED. As one can see, this list of features is not all that might be meant by the word *bachelor.* Nevertheless, almost all psychological models of categorization and episodic memory, and even connectionist models of comprehension, use features in some manner (e.g., Estes, 1986; Gillund & Hintzman, 1988; Murdock, 1982; Rumelhart & McClellan, 1986; Shiffrin, 1984; Smith & Medin, 1981).

Another strategy for representing meaning involves associative networks, which rely on temporal and causal contiguity. Associative networks are as old as Aristotle. They characterize concepts as nodes, and the relationships between nodes are represented by unlabeled links. The strength of these links is typically determined by the degree to which the concepts co-occur in context or by causal connections. Contemporary versions of associative networks use data from free-association studies to estimate the strength of links (e.g., Meyer & Schvaneveldt, 1971). There is strong empirical support that these nets describe lexical access, but the notion is limited in that not all knowledge can be captured by just nodes and links.

Semantic networks are another representation format. In this format, concepts are nodes and links, which are labeled to indicate relationships such as being a member of some class, for example *is a; part of.* These relationships allow for a well-ordered hierarchy among the nodes. So *a rose is a flower*; *petals are part of flowers*. Items further away in the hierarchy are assumed to be less related, although research shows there are other factors such as typicality and frequency that also play a role in the strength of the relationship. This format allows economy of storage and is widely used in artificial intelligence work (e.g., Barr & Feigenbaum, 1982). Scripts, frames, and schemas are another popular form of representation (e.g., Minsky, 1975; Schank & Ableson, 1977).

These constructs can all be characterized as structures that organize the concepts that make up an event or super-concept. A famous example is the restaurant scenario, which was dubbed a *script* by Schank and Ableson (1977). Most restaurant experiences can fit into a description that includes making a reservation or giving your name and number of guests to the host as you arrive, being seated, being given menus, reading the menus, and ordering food from a waiter or waitress who comes to the table, who writes down the order on a pad, and so forth. Research shows that when a script/schema/frame is instantiated in readers' minds, it will cause them to infer things that were missing from a related text they just read. They may even believe that the inferred information was actually in the text. (e.g., Schank & Ableson, 1977).

The notion of scripts, frames, and schemas has persisted over the past few decades as an important construct in cognitive theory, but newer versions have become more viable. Scripts and schemas have changed from early static versions that suggested they could be plucked from memory on demand to more recent and more flexible versions that are more consistent with actual human experience.

Newer versions of schemas are viewed more as prescriptions for generating organizational structures in a given task context, thus ensuring that the structure that is generated fits the particular context in use at that time (e.g., Kintsch, 1998; Mannes & Kintsch, 1987; Schank, 1982; Whitney, Budd, Bramuci, & Crane, 1995). More flexible version of scripts and schemas do play a role in the construction–integration (CI) model, as we shall discuss later in this article, but first, we offer a formalism to represent the basic unit of memory as a means of observing, measuring, and describing the impact of factors that affect memory.

Propositions as meaning units

Kintsch (1998) based his theory of comprehension on a predicate–argument schema that yields networks of propositions, which is more robust than the strategies described above for the purpose of defining the basic units that feed the comprehension processes defined in the model. Earlier work by Kintsch (1974) demonstrated that ease of reading comprehension was directly tied to the number of propositions in the text, as opposed to other popular metrics such as number of words and sentence length. Hence, Kintsch has consistently viewed the proposition as the basic element of meaning. A basic proposition is defined by a relational term, that is, the predicate, and one or more arguments, written as PREDICATE (ARGUMENT, ARGUMENT, etc.) The arguments indicate semantic roles like agent, object, and goal. For example, the sentence "John gave to Susan a red rose" would be represented as the following propositions:

GAVE (JOHN, ROSE, SUSAN)
(RED, ROSE)

The goal of this analysis is not to represent all the surface features of language, but rather the semantic relations that are key to how people understand, remember, and think with language. Thus, each proposition is a unit of meaning.

These units can represent text not only at an abstract level, but can also be used to represent meaning at other levels including the perceptual, action, linguistic, and symbolic levels (van Dijk & Kintsch, 1983). In this manner, this approach to representation subsumes all the worthy aspects of other representational strategies mentioned previously. It should be noted that this theoretical construct is viewed as only a rough approximation of the true meaning in text, but it is sufficiently accurate to get the job done in terms of modeling text comprehension processes. Indeed, considerable empirical data exist to support the notion that these propositional units do map onto basic meaning units (e.g., Barshi, 1997; Goetz, Anderson, & Schallert, 1981; Kintsch, 1974; Kintsch & Keenan, 1973; van Dijk & Kintsch 1983).

Propositions that are directly derived from the text form something called the *textbase*. However, in order for comprehenders to understand a text, they also bring their world knowledge and experience to the effort. This information from long-term memory (LTM) is also represented in propositional format and integrated with the textbase propositions to form what is called the *situation model*. The situation model is what readers form to integrate the textbase with their relevant prior knowledge, experience, goals, and motivations. This will be discussed further in the context of the comprehension model.

When talking about propositions, another important construct is the notion of microstructure and macrostructure. The microstructure is a network of propositions representing meaning at the sentence level of a text; it includes both text-based propositions and those propositions generated from LTM to create a local understanding at the sentence level. The macrostructure of a text, on the other hand, is a hierarchical set of propositions that represents the global structure of the text. A good summary of a text would comprise the text macrostructure.

In an ideal world, readers ascertain the microstructure and macrostructure of a text in a manner that the author intended. However, the situation model developed by any individual reader is not necessarily the same as that intended by the author. As we shall explain with regard to this comprehension model, there is opportunity for a reader to form a different interpretation of the text, or even to fail to fully grasp the meaning of a text. This is because readers form their personal situation models made up of the textbase and the integration of the unique contribution from their LTM composed of their world knowledge and experience.

Creating the textbase in memory occurs with little awareness and is essentially effortless in skilled readers. This is the content of student responses when they are asked to recall a text in typical psychological experiments. Recall of the textbase represents a shallow processing of the text. Comprehension at a deeper level occurs when students also construct a situation model of the text meaning. This is an effortful, almost problem-solving process that readers engage in as they link the textbase with their world knowledge and experiences. Typical texts are not completely coherent, that is, with all the semantic relationships spelled out. Therefore, readers must engage inferential processes to bridge these gaps, such as relating pronouns to the proper referent or establishing the relationship of a particular example at the microstructure level with a superordinate topic at the macrostructure level. Some of these processes occur automatically during reading by skilled readers, but many are subject to active, effortful processing, which leads to an adequate situation model and deeper level comprehension (Franzke, Kintsch, Caccamise, & Johnson, 2004).

The reader's mental representation of the meaning of a text is composed of the textbase and situation model the reader creates as a function of the comprehension process. Normally, the reader's mental representation of a text contains a mixture of these two components, but it is possible for either the textbase or the situation model to dominate (Bransford, Barclay, & Franks, 1972; Moravcsik & Kintsch, 1993). So when readers process a text, they create a textbase that contains the meaning of the actual words plus constructions such as inferences. In addition, readers create a situation model in which their prior knowledge interacts with the text.

Construction of concepts

The network of propositions that comprises the meaning of a text is called a *knowledge net.* The nodes of the net are propositions, schemas, frames, scripts, production rules—all of which can be represented by the predicate–argument schema, represented by propositions described above. The links to the nodes are not labeled and vary in strength, based on encounters with the information in that node and its connection or co-occurrence with other nodes. In this manner a *knowledge net* is a type of associative net. Nodes get their meaning by their position in the net. Defining meaning by *knowledge nets* is an abstract, linguistic approach. On a psychological level, only those nodes that are activated in working memory contribute to the meaning of a linked node. Although working memory is very limited, available networks of nodes can be readily accessed if they have stable links (retrieval structures) to the initial nodes in working memory. In this manner, very complex meaning can be generated automatically with only a few nodes in working memory at any one time (Kintsch, 1998).

Concepts do not have a fixed meaning. They evolve as a function of each activation, which brings its own net of related nodes, based on the context of that occasion. For instance, the word *mint* could mean candy or a building, depending upon the context in which the word/concept is encountered. Which nodes get activated in a particular instance is influenced by many things, including the reader's knowledge, experience, emotional state, goals, cultural influences, and so forth. The structure that a concept derives from its *knowledge net* is relatively stable—although learning continually modifies this structure. However, meaning derives from what portion of the *knowledge net* is activated in any given instance and, in that sense, meaning is flexible and changeable depending on specific instances.

In a *knowledge net* framework, word meanings are not looked up, they are constructed. Meaning is built by activating nodes in the neighborhood of a word. This process is probabilistic and relates to the strengths of the connections among the nodes. Knowledge nets also serve as retrieval structures (Ericsson & Kintsch, 1995). If any element of a knowledge net is in working memory, it can lead to the spreading activation of other related nodes. The context under which these nodes are activated provides the necessary inhibition to activating the whole net, as one accesses instances that are irrelevant to the particular situation. Empirical findings do support this view that concepts are temporary constructions in working memory, generated in response to specific task demands and constrained by the knowledge base and situational context (e.g., Barclay, Bransford, Franks, McCarrell, & Nitsch, 1974; Barsalou, 1993; Kintsch & Welsch, 1991). Studies by Barsalou (e.g., 1993) demonstrate the temporariness of concepts cogently. He asked subjects to write down features that define common categories (e.g., dog, cat, fruit, vegetable). Using these feature lists to define concepts, subjects agreed with other subjects only 44% of the time and with themselves on two successive sessions only 66% of the time.

In this section, we have introduced the definitions for the formalistic components of the CI model, that is, its meaning units, concept formation, and so forth. In the next section, we put it all together to describe the CI model of comprehension.

CI model of comprehension

Most language comprehension studies conducted over the centuries by philosophers, linguists, logicians, and others have focused on analyzing language as an object. The breakthrough toward process inquiry has come relatively recently with efforts in artificial intelligence systems that model natural language, as well as from techniques for the simulation of higher order cognitive processes, leading to psychological process models of comprehension. The goal has been to create a model that captures the flexible, fluid nature of human meaning construction, taking into account all of the variables that impact meaning construction. These variables generally play a role in the process each time, but do so uniquely with each situation. Comprehension is greater than the sum of its perceptual and conceptual parts. It is viewed as a process, or series of processes, that transform oral or written language into a meaning representation in the reader or listener's mind. To this end, there is really only one unitary mental representation of a text, but there are levels of comprehension from surface structure of the text to deeper level comprehension.

Rigid explanations of comprehension as a top-down process driven by fixed schemata/scripts (e.g., Shank & Ableson, 1977) do not capture the fluid, flexible nature demonstrated in empirical studies, where meaning is highly context dependent. Kintsch (1988, 1998) offered an alternative with the bottom-up, highly flexible, and context-sensitive model he called the CI model. The CI model views the comprehension process as having two phases: a construction phase, where a rough but somewhat inaccurate model of the meaning is constructed locally from the textbase and the reader's background knowledge and goals; in the second phase, an integration process engages in constraint satisfaction that deactivates any local constructions that do not fit with the global, coherent context of the text being read.

An example given by Kintsch (1998) illustrates the difference. When a language user encounters the sentence, *the earthquake destroyed all the buildings in town except the mint,* a traditional schema theory, which is always "smart" (i.e., always does the right thing), picks only correct meanings for the word, *mint*. That is, schema theory would activate only one meaning for *mint,* and *chocolate* would never be activated as an associate of the word *mint* in this schema. In contrast, with the CI model, *chocolate* would be activated, but extinguished via the integration process before a solution (*mint* as a building) comes to consciousness. In this manner, the CI process is dumb, activating all possibilities in the construction phase, but then deactivating contextually inappropriate options in the integration phase.

The question of whether the original versions of schema theory or the CI model is a better fit to human processing has been tested empirically. Schema theory and the CI model both lead to the same outcome at the time of a conscious response. The schema model would predict a priming effect[1] for the correct response, given the sentence; whereas the CI model would predict a priming effect for both options, indicating that a construction phase occurs prior to the integration phase. Empirical studies that have looked for priming effects have shown that indeed, all word-meaning options, including thematically correct but contextually incorrect options, had equal priming effects during the early construction phase at less than 350 ms, but only the correct option had a priming effect at 500 ms (word meanings are identified in approximately 350 ms), supporting the CI model (Till, Mross, & Kintsch, 1988). Long, Oppy, and Seely (1994) reported similar priming effects as early as 300 ms. The work by Till et al. also involved inference targets, so that, taken together, the estimated fixation time in skilled readers for word meaning is 300–350 ms, and for inferences, 500–750 ms. The researchers concluded from these studies that meaning construction takes time and involves a dynamic interaction with the discourse context, with local and global constructions determining the outcome from the very beginning.

Rules for construction

What are these imperfect, bottom-up, irrepressible construction processes? The first, we already briefly reviewed in our discussion of a formalism that can be used to represent meaning when we described the predicate–argument schema that yields propositions at the microstructure and macrostructure level of the discourse. Van Dijk and Kintsch (1983) and Kintsch (1998) provide a more detailed discussion of this aspect of meaning construction. Three forms of construction rules are described in the sections that follow.

Construction rules to interconnect propositions in a network. Three levels of connection exist among propositions. They may be directly related, indirectly related, or subordinated to another proposition. Propositions may also be negatively related, or inferred from another. An ambiguous statement may generate two competing propositions that would typically be disambiguated by the context. Failing enough contextual cues, one proposition may then be favored over another in an ambiguous case depending on differing strength of their links (e.g., most popular/likely answer or based on the unique world knowledge the reader brings to the task).

Construction rules to activate knowledge. In an associative fashion, items in working memory activate neighboring nodes in the knowledge net. This is done in accordance with probabilities proportional to the strengths of each of the links in the net (Mannes & Kintsch, 1987).

Rules for constructing inferences. Defining all the types of inferences readers might make when reading a text is greatly influenced by an interaction of their background knowledge, goals, and motivation. Basic inference types that bridge information in a text to render it more coherent are common to all reading situations (e.g., referent for a pronoun used in a later sentence). In addition, readers generate inferences when attempting to construct the macrostructure and situational model of the text. For instance, readers could imagine in detail the actions someone takes from the time of leaving the house in the morning until opening the door of the business that represents the person's employment. Or they could infer from these details that the person "went to work," the macrostructure or gist

[1]Priming effects result from a facilitation of a response due to memory processes and structures, yielding a faster response time than an unprimed response.

of the details. Propositions that get activated via inferences follow the spreading activation pattern through the knowledge net, and are constrained by the particular context—hence inference making is limited to reflect the situational model being developed. The spreading activation process is continued for as many cycles as are necessary for the activations to stabilize. Details that lead to stabilization are not specifically known at this time but are characterized as a constraint satisfaction process.

Psychological experiments have shown that most readers make a minimal effort at making inferences. Specifically, McKoon and Ratcliff (1992, 1995) noted the phenomenon and formulated a minimalist hypothesis to explain it, whereby readers only make the most obvious bridging inferences to establish local coherence and knowledge elaboration with strong associations. Other researchers such as Graesser, Singer, and Trabasso (1994) argued that initial processing extends beyond the bare minimum, in that readers are prone to construct inferences necessary for global coherence (superordinate goal inferences, thematic inferences, and character motivations/emotions) as they read. Conclusions are limited by the fact that much of this research is based on (short) stories. Expository text is the stuff of information conveyance, and it is a very different genre.

Only in recent years have researchers increasingly turned to expository text when studying comprehension. In drawing conclusions about inference making based on experimental environments, one has to take into account the motivation of particular readers, their goals or lack thereof, and other arbitrary and unfavorable conditions that may be called into play in that context—as compared to (for instance) how they might read and process the same experimental texts if these texts were required reading in one of their classes where they would be tested and receive a grade.

Kintsch's CI model (1993, 1998) also handles inferences in text comprehension. Inferences can occur during the retrieval or the generation process, and the processes can be automatic or controlled. The most typical inferences during reading are the type that are automatic and involve retrieval processes. These are bridging inferences that close coherence gaps in the text and associative elaborations that enrich the information in a text. The simplest example is the pronoun–referent instance. In the sentences "John gave Mary a ring. He intended to marry her," readers must infer that *He* refers to *John.* This example also provides us with an instance that might require a more effortful inference to gain coherence, depending upon prior knowledge. For readers to really understand the connection between *ring* and *marry*, they must understand that in some cultures, a man gives a woman a ring when he proposes marriage. When the reader makes that inference in this case, it makes the text more coherent. Failure to bridge a coherence gap (e.g., not recognizing that two terms refer to the same entity) can initiate a conscious effort to close the gap, such as by performing a deliberate memory search through the previously read text. Such inferences are effortful and more akin to problem solving.

The inference types and processes briefly described above apply to both the construction of a coherent textbase and a situation model. Many researchers have concerned themselves with defining the construction of situation models, but the point is that there is no one type of situation model or way to construct it. Situation models are a form of inference and are therefore subject to all the varieties of inference type and processes that construct them, along with the background knowledge, goals, biases, and so forth, that each reader contributes to the task. Readers construct a situation model by forming a memory representation that includes links between text elements and related information in their own knowledge base. In this manner, readers understand the information of a text in the context of what they already know.

Memory and CI processes. Historically, working memory was viewed as being part of short-term memory.[2] That conclusion, however, is now seen as an artifact of the types of activities in which subjects engaged (e.g., list learning) during these earlier memory experiments. Instead, Ericsson and Kintsch (1995) provided empirical support for a theory of Long Term Working Memory (LT-WM) that is compatible with processes descibed by the CI model and repeated in findings of other researchers (e.g., Fischer & Glanzer, 1986; Glanzer, Fischer, & Dorfman, 1984). LT-WM is fast, reliable, and flexible because it is linked to the rich networks of various LTM regions.

LT-WM is key to CI processing. LT-WM is important to the CI model because text comprehension in this model is viewed as a sequentially iterative process. It is not possible to comprehend a whole text in one process. Rather, the reader comprehends sentence by sentence, adding to the situation model with each iteration based on textual/linguistic cues, background knowledge and experience, and other factors such as goals and motivation. To bring these factors to bear, as each sentence is read, the reader must retrieve information from his or her LTM to compare/add to the forming episodic memory in LT-WM of the text being read. This process can be automatic or controlled, based on the preexisting coherence of the text and degree of resources needed and available from LTM to create a coherent textbase and situational model.

It should be noted that the model assumes an ideal reader who engages in comprehension processes leading to correct outcomes. Faulty world knowledge on the part of the reader would cause him or her to create a faulty mental representation based on misconceptions. This may be less a failure of the model and more an accurate representation of when a reader and text are mismatched in terms of the reader's current level of knowledge on that subject.

Learning from text

Learning can mean many things, but for the purposes of this discussion, we define learning as deliberate action on the part of a student to comprehend and extract meaning from a text. Classic learning and comprehension models viewed learning from a text as a passive activity by which the reader extracts facts to add to LTM, which typically were out of context. These models also did not define attempts to connect text content with existing knowledge. The current constructivist theories, of which CI is one, view learning as a process of meaning construction, whereby readers interact with text content by using their intelligence, world knowledge and situated goals to interpret and evaluate the text in a manner that constructs new meaning. This meaning is very much linked to readers' preexisting world knowledge and experience in a manner that enables them to use and extend this new knowledge to novel situations.

Factors within learners that contribute to reading comprehension

A good reader by our definition is one who reads with deep understanding, as demonstrated by such things as the ability to abstract, apply, or generalize the information in the text. Three of the main skills that make for a good reader are decoding skills, language skills, and domain knowledge. As mentioned previously, decoding skills have been researched in depth for more than 30 years. The conclusions of the National Reading Panel (2000) provided a rich and concrete blueprint for the development of successful instruction for these foundational skills. Such skills are a necessary component and first stage on the road to being a good reader, and some percentage of middle and high school poor readers can be attributed to an inadequate mastery of decoding skills.

A significant number of these poor readers, however, are struggling because of other

[2]Experiments show the size of short-term memory (STM) to be 7 ± 2 items—a very small capacity (Miller, 1956).

factors that interest current reading researchers because they are less explored and hold the prospect of reducing the number of poor readers with further study and resulting practical applications. One of these factors is language skills. In terms of the CI model, these skills are critical for constructing the mental representations in the model, supporting such elemental processes as figuring out the propositions that make up the meaning of the text and organizing them into a coherent structure, including a macrostructure.

Lexical factors are also significant. Work by Gernsbacher and Faust (1991) suggested important differences between good and poor readers in the way they construct meaning for words. Their research demonstrated that both good and poor readers are equally sensitive to context-appropriate *versus* context-inappropriate associates that are retrieved during the construction phase. For good readers, interference from context-inappropriate associates extinguishes as good readers reach the integration stage of assigning a meaning to a word in a given context. Poor readers, however, continue to show interference long after the normal period for word-meaning assignment (approximately 350 ms), taking more than 850 ms to reject the context-inappropriate associate.

Other aspects observed in poor readers regarding language skills include such things as overreliance on a top-down process that uses causal inferences with a high frequency to compensate for other weak processes and a seeming lack of an automatic retrieval structure for bridging inferences. For example, Gernbacher and Faust (1991) found poor readers to rely on controlled, effortful retrieval processes to create the necessary bridging inferences. Further research is needed to explore these differences between good and poor readers and point to better, more focused instructional interventions to help with these process deficits.

A final internal factor contributing to reading ability is domain knowledge. Readers with high domain knowledge comprehend more and remember more about a text than do readers with low domain knowledge. High domain knowledge, in fact, may compensate for other weaker components. A study by Schneider, Korkel, and Weinert (1989) showed that high domain knowledge could even compensate for low IQ or low verbal ability. Furthermore, as will be discussed later, some threshold of domain knowledge is required if a reader is going to be able to form a situation model. Without sufficient domain knowledge, even good readers are limited to creating a textbase that only helps insofar as reproducing the literal text—the situation model must be constructed so as to construct meaning that transcends the facts of the text, and this requires domain knowledge.

Sources of reading disabilities for students labeled as poor readers include deficits in decoding and fluency of reading, vocabulary, world knowledge, and poor oral language skills. These factors are exacerbated among second-language learners, or when readers assume a passive approach to reading or when they demonstrate a lack of comprehension strategies for making predictions, asking questions, constructing images that represent text content, summarization, and seeking clarifications. Regardless of source of difficulty, many poor readers seem to benefit from similar instructional strategies (Brown, Bransford, Ferrara, & Campione, 1983; Pressley & Hilden, 2004).

A factor not quite internal to the reader, but perhaps within the family and school, is prior exposure to high-quality reading instruction and other experience. Practice in reading improves comprehension because it helps to build vocabulary, as reading is the primary manner in which vocabulary is learned during the school-age years (Sternberg, 1987). World knowledge also is developed through experiences in home and school. Funds of both vocabulary and world knowledge are critical components that allow readers to bring meaning to text. It is not surprising then that study after study shows that reading and the availability of print media in the home are highly predictive of higher reading comprehension scores on standardized tests.

Factors within texts that contribute to reading comprehension

Studies show that increasing the coherence of a text (i.e., making text connections more explicit, cueing macrostructure, etc.) helps readers form a more coherent textbase. In addition, degree of prior knowledge has been shown to improve a reader's comprehension of a text and that these effects were cumulative (Britton & Gulgoz, 1991; McNamara, Kintsch, Songer, & Kintsch, 1996). However, the advantage of increased text coherence best fits readers with an inadequate background knowledge base for the given text.

McNamara et al. (1996) found that if readers possess adequate knowledge, a fully explicit text might not be optimal for them. The study included participants with high knowledge or low knowledge of the topic, who read texts that were either completely coherent (all connections coherent, macrostructure cued) or texts with low coherence, in which bridging inferences were required and the macrostructure needed to be inferred. Subjects were tested with 4 types of questions: text-based questions, elaboration questions that required relating text information to the reader's background knowledge, bridging inference questions that required connecting two or more separate text segments, and problem-solving questions that required applying text information in a novel situation. As predicted, low-knowledge subjects performed better after reading the high-coherence texts. High-knowledge subjects, however, did better on problem-solving tasks and a sorting task after reading the low-coherence text. This well-replicated result suggests that making a text too easy (i.e., too coherent) for high-knowledge students may make the text boring to the point of inducing them to process the text in a shallow fashion. Less coherent texts apparently challenge high-knowledge students to engage their available background knowledge and comprehension skills more actively, thus causing them to process the information more deeply.

Aside from deliberately reducing text cohesion for more advanced students, other more appropriate pedagogical interventions may be aimed at getting readers to process the material more actively. Indeed, when subjects in a subsequent experiment read the same high-coherence texts but were asked to comment on their understanding as they read each sentence, the interaction between high-knowledge and low-knowledge readers disappeared, and the high-coherence text had the advantage over the low-coherence text for both groups (Kintsch & Kintsch, 1995). Pedagogical approaches described in the next section represent empirically tested methods that achieve these results in the classroom.

COMPREHENSION MODELS AND INSTRUCTIONAL APPLICATIONS

Underwood and Pearson (2004) described a framework in which to view existing research in reading comprehension. In *their* view, there are three levels that embrace not just text and reader, but also author and context, including social/cultural influences. Levels 1 and 2 describe cognitive psychology models of comprehension that deal with readers' prior knowledge, memory processes, and propositional content of texts. Level 3 builds on levels 1 and 2 by adding author and cultural context. Underwood and Pearson (2004) placed Kintsch's theory of comprehension in levels 1 and 2 along with other psychological models of comprehension. However, we would argue that Kintsch's formulation does allow for level 3 activities as well because it accounts for author and cultural context as defined in Underwood and Pearson's notion of Level 3. Kintsch's theory, however, does not address specific pedagogical strategies.

This, then, is the crux of the disconnect between Kintsch and Underwood and Pearson's notions of comprehension models. When Underwood and Pearson (2004) described the framework for Level 3 (i.e., builds on levels 1 & 2 to add author and cultural context), they defined it in terms of instructional strategies instead of a cognitive theory of comprehension. Although in our view, this omission is critical, we also value the Underwood and Pearson description of level 3 for its integration of various bodies of research, which leads to pedagogy that is collaborative between teachers and students, as they metacognitively construct the meaning from text.

Transactional instructional practices

Using collaborative approaches, instructors gradually scaffold students into the ability to metacognitively guide their own independent reading to comprehend the content at a deep enough level to both extract literal and inferential meaning, as well as possible/viable ramifications of that content. The early formulations of this work were described as reciprocal teaching (RT; Palincsar & Brown, 1984) and have more recently evolved into what has been called transactional strategies instruction (TSI; Pressley & Hilden, 2004). In particular, RT and TSI approaches provide a classroom method for teaching students how to construct situation models from what they read. The progression of increased independence of students as they grasp the constructivist comprehension strategies scaffolds them into developing automatic construction processes that experts use.

Transactional strategies instruction (Pressley & Hilden, 2004) and reciprocal teaching (Palincsar & Brown, 1984) follow a Vygotskian (Vygotsky, 1978) approach to the internalization of cognitive processes by scaffolding students to build on what they know through active cognitive processing. Students learn active comprehension strategies, including predicting, questioning, self-explanation, constructing images representing text meaning, relating to prior knowledge, monitoring understanding, summarizing, and seeking clarification. The instructional process involves first having the strategies explained and modeled by the teacher (expert), then gradually scaffolding students to demonstrate the strategies themselves, as they participate and even lead small reading groups where meanings are discussed. In this manner, the cognitive strategies for comprehension become internalized and self-regulated. (Pressley & Hilden, 2004).

The difference between TSI and RT is that TSI evolved from RT, providing a more flexible implementation of the various strategies. Recognizing individual differences in readers, order of strategy instruction was no longer as important, and new strategies were embraced, such as "text analysis," which looks at how information is structured in expository texts. Transactional strategies can dramatically impact struggling readers with comprehension disabilities (Deshler, Ellis, & Lenz, 1996; Pressley & Hilden, 2004).

Instructional practices based on the CI model

To pursue classroom research, researchers have recently developed a system for measuring the relatedness among meaning units in instructional texts so as to automatically assess text meaning. Although this method is less detailed than the propositional analysis method used in laboratory research described above, it is a methodology that scales to enable classroom applications. The analysis method, called Latent Semantic Analysis (LSA; see Landauer & Dumais, 1997), is automatic and computer generated. This process uses an algorithm that is similar to proposition nets hypothesized to underlie human processing according to Kintsch's (1998) CI theory. That is, it has nodes with links between them that represent the strength of their association. Briefly, in LSA, a concept or proposition is defined as a vector of numbers, each number indicating the strength of the linkage with other concepts or propositions. LSA provides the text meaning analysis for a computer-driven tutor called Summary Street®, which enables students in grades 5 to 12 to practice writing summaries, with feedback about irrelevant and redundant sentences that lead writers to form an appropriate macrostructure of the text they are asked to summarize.

This is one example of a way to require students to engage actively with the text they are reading, without adding more time commitment from teachers. Imagine one classroom of 30 students asked to summarize a text and revising until it is done well. No teacher could devote the individual attention to this activity for each student. Summary Street®, is a computer-driven tutor that automatically provides this mentoring, based on a representation of meaning in memory and reading activities (e.g., summarization) drawn from the constructivist CI model. Such a tool offers another means of assisting students to create a situation model that leads to deeper comprehension and greater learning. (See Kintsch article in this edition.)

A detailed description and demonstration of Summary Street® is available at the Web site at *www.colit.org*. Although outcome data are currently being collected, the preliminary results are encouraging. For example, Franzke, Kintsch, Caccamise, and Johnson (2004) studied seventh-grade students using Summary Street® in language arts classes over a period of 6 weeks in practice writing sessions. They compared the performance of students who were using the software with that of control students who used MS Word to write summaries. The Summary Street® group, scored significantly higher than the control students on an independent comprehension measure for test items that tapped gist (macrostructure)-level comprehension. Summaries written by participants in the Summary Street® group were also judged in blind scoring to be significantly better on several measures of writing quality. The results also suggest that students with reading achievement scores in the low to moderate range on standardized tests benefited most from using the tool.

THE COLLISION OF POLICY WITH THEORETICALLY GUIDED BEST PRACTICES

Oral language processing capabilities are implicated as one element that is important to successful reading comprehension (Catts & Kamhi, 1999; Gillam & Gorman, 2004). Interestingly enough, some schools today are set up such that speech-language pathologists and classroom teachers occupy the same building and see the same subset of students, but seldom interact at a professional level beyond the mandated Individualized Education Plan (IEP) meetings.

As Pressley and Hilden (2004) reported in their otherwise successful implementation of TSI, they were at a loss as to how to incorporate the efforts of the school speech–language pathologists with those of the classroom teacher. Silliman, Wilkinson, and Brea-Spahn (2004) defined the disconnect more explicitly, and pointed to wide variations across states in their disability criteria and policy changes for such categories as specific learning disabilities and speech–language impairment. They argued that these variations lead to rigid professional boundaries and fragmented services. Federal and state laws and regulations, including Title 1, view regular education as a separate system from special education, and this is mirrored in actual practices in schools. The NCLB Act, requiring results in the form of mandated annually administered state achievement tests, may be the impetus for regular and special education teachers to increase their collaboration. This act requires that by the school year 2013–2014, 100% of students, students in both regular education and those with disabilities, will meet state standards for proficiency in reading and math. The consequences of not meeting this standard are dire, including school closures and loss of jobs for educators in chronically below-proficiency schools.

The NCLB act also requires proof of "highly qualified" teachers. Although this has been directed at classroom teachers, the constructs for quantifying this aspect of the educational environment across the country are currently quite variable and highly politicized. To achieve the NCLB goals and standards, collaboration among the teaching staff will become more urgent so that students may transfer the skills they learn in specialized instructional settings to activities in the general classroom. In doing so, it seems inevitable that special education teachers will be folded into the "highly qualified" requirement and speech–language pathologists will need to ensure that their professional preparation includes a conceptual knowledge base that links language and literacy learning so that they can implement the evidence-based strategies for improving literacy in their students. (See Silliman et al., 2004, for an in-depth discussion of these policies and issues.)

Speech–language pathologists understand how deficits in phonological, morphosyntatic, semantic, and contextual processing affect spoken language development; all processes shown to have an important impact on the acquisition of foundational reading skills and subsequent reading comprehension (Gillam & Gorman, 2004). Already a few studies demonstrate promising results when speech–language pathologists collaborate with elementary general education classroom teachers, providing some of the classroom instruction to include this expertise, with results indicating significant improvements in reading decoding skills for experimental classrooms as compared to control classrooms where the collaboration did not take place (e.g., Farber & Klein, 1999; Hadley, Simmerman, Long, & Luna, 2000).

CONCLUSIONS

More than a decade of reading achievement assessments on a national scale show that a significant portion of America's older children is barely proficient at comprehending what they read. This deficit has led to sweeping new national policy and high-stakes testing. Recognizing that current policy and law are likely to foster increased collaboration among the team of educators and clinicians at schools, this article was intended to inform those who are not currently familiar with leading edge comprehension theories and instructional strategies with a summary of the state of the field. It is hoped that readers will integrate these concepts with their existing expertise to enhance their contributions in school settings in a manner that is in keeping with emerging literacy theory and instructional practices.

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