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The Acquisition of Reading Comprehension Skill

Charles A. Perfetti, Nicole Landi, and Jane Oakhill

How do people acquire skill at comprehending what they read? That is the simple question to which we shall try to make a tentative answer. To begin, we have to acknowledge some complexities about the concept of reading comprehension and what it means to develop it.

Introduction: Simple Ideas about Reading Comprehension

We can expect the comprehension of written language to approximate the comprehension of spoken language. When that happens, then reading comprehension has developed, for practical purposes, to its limiting or asymptotic level. (It is possible for reading comprehension skill to develop so as to exceed listening comprehension skill, but that is another matter.) All other limitations are imposed by linguistic abilities, relevant knowledge, and general intelligence. If we make things more complex than this, we push onto the concept of reading comprehension all these other important aspects of cognition, with the muddle that results from conceptual conflation.

This simple idea that the acquisition of reading comprehension is learning to understand writing as well as one understands spoken language has empirical justification. At the beginning of learning to read, the correlations between reading and spoken language comprehension are small (Curtis, 1980; Sticht & James, 1984). This is because at the beginning, children are learning to decode and identify words, so it is these word-reading processes that limit comprehension. However, as children move beyond the beginnings of learning to read, the correlations between reading comprehension and spoken language comprehension increase and then level out by high school (Sticht & James, 1984). As children learn to read words, the limiting factor in reading comprehension shifts from word recognition to spoken language comprehension. For adult college student samples,

the correlation between scores on reading comprehension and listening comprehension tests reaches $r = .90$ (Gernsbacher, 1990).

If this were the end of the story, then the study of reading comprehension would fold completely into the study of language comprehension. However, there is probably more to the story. First are some methodological considerations. Studies that compare reading comprehension with listening comprehension avoid the confounding of materials, making a clean comparison between the same or equivalent passages with only the "modality" (speech or writing) different. But for most people, what they usually hear is different in content and style from what they read. These differences extend through formal, semantic, and pragmatic dimensions of language. Thus, what is necessary for experimental control is problematic for authenticity. Second, one must make a decision about the speech rate in such comparisons. What is the proper rate for a comparison with reading? The listener's preference? The speaker's preference? A rate equal to the reading rate? Finally, we take note of a more interesting possibility; namely that literacy may alter the way people process spoken language (Olson, 1977). If so, this would boost the correlation of listening and reading comprehension in adulthood.

We accept, approximately and in an idealized form, the assumption that reading comprehension is the joint product of printed word identification and listening comprehension, an idea famously asserted by Gough and Tunmer (1986) as a simple view of reading. However, we also must assume that learning to read with comprehension brings enough additional complexities to justify a chapter on how that happens.

A Framework for Comprehension

Comprehension occurs as the reader builds a mental representation of a text message. (For a review of current ideas about reading comprehension in adults, see Kintsch & Rawson, current volume.) This situation model (Van Dijk & Kintsch, 1983) is a representation of what the text is about. The comprehension processes that bring about this representation occur at multiple levels across units of language: word level, (lexical processes), sentence level (syntactic processes), and text level. Across these levels, processes of word identification, parsing, referential mapping, and a variety of inference processes all contribute, interacting with the reader's conceptual knowledge, to produce a mental model of the text.

Questions of cognitive architecture emerge in any attempt to arrange these processes into a framework for comprehension. The various knowledge sources can interact freely, or with varying degrees of constraint. For example, computing simple syntactic representations (parsing) probably is more independent of nonlinguistic knowledge than is generating inferences. These issues of cognitive architecture are important, complex, and contentious; we will not discuss them further. Instead, we assume a general framework that exposes the processes of comprehension without making strong assumptions about constraints on their interactions. Figure 13.1 represents this framework schematically.

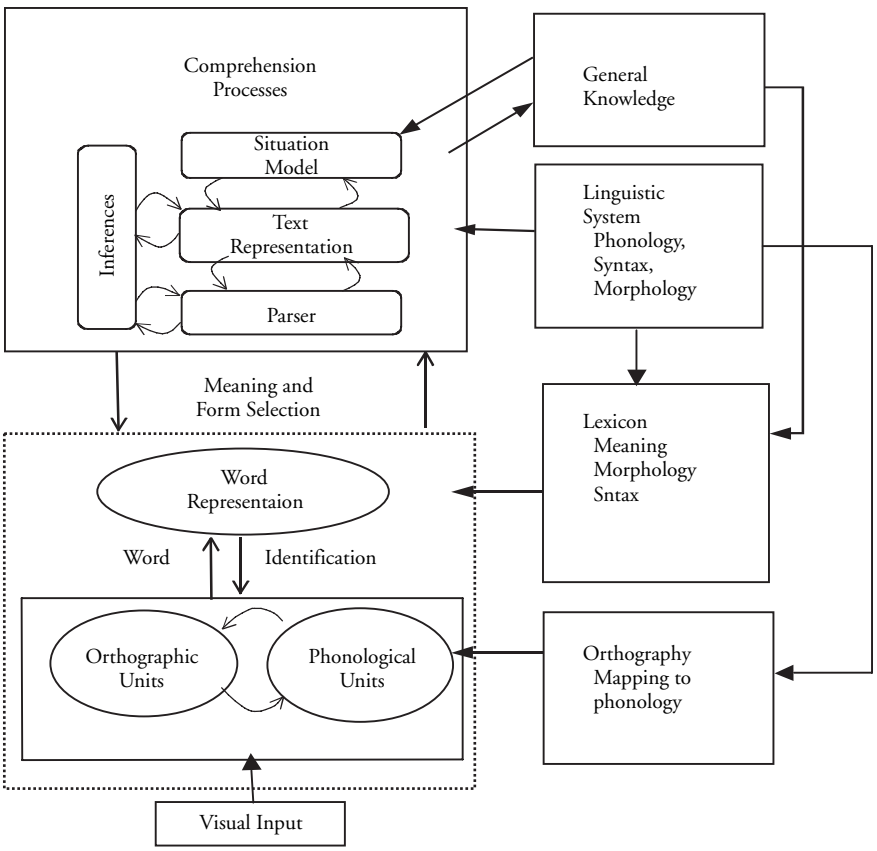

Figure 13.1 The components of reading comprehension from identifying words to comprehending texts. Adapted from Perfetti (1999).

Within Figure 13.1 are two major classes of processing events: (1) the identification of words, and (2) the engagement of language processing mechanisms that assemble these words into messages. These processes provide contextually appropriate word meanings, parse word strings into constituents, and provide inferential integration of sentence information into more complete representations of extended text. These representations are not the result of exclusively linguistic processes, but are critically enhanced by other knowledge sources.

Within this framework, acquiring skill in reading comprehension may include developments in all these components. However, if we focus on reading, as opposed to language comprehension in general, then the unique development concerns printed words. All other processes apply to spoken as well as written language. Children must come to readily identify words and encode their relevant meaning into the mental representation that they are constructing. Although in a chapter on comprehension, we avoid dwelling on word identification, we cannot ignore it completely. Comprehension cannot be successful without the identification of words and the retrieval of their meanings. Both

children and adults with low levels of comprehension may also have problems with lexical representations, a point to which we shall return later. First we address the sentence and text-level processes that are the defining features of comprehension.

Propositions and mental models

The atoms of meaning are extracted from sentences, aggregated through the reading of other sentences of the text and supplemented by inferences necessary to make the text coherent. The bare bones of the text – its literal meaning or "text base" – consist of propositions (nouns and predicates or modifiers) derived from sentences. They are largely linguistic, based on the meanings of words and the relations between them (predicates and modifiers), as expressed in a clause. The reader's mental model can be considered an extended set of propositions that includes inferences as well as propositions extracted from actual text sentences. A mental model also may represent text information in an integrated nonpropositional format (Garnham, 1981; Johnson-Laird, 1983), preserving both stated and inferable spatial information in the form of spatial analogues (Glenberg, Kruley, & Langston, 1994; Haenggi, Kintsch, & Gernsbacher, 1995; Morrow, Greenspan, & Bower, 1987). More typical are texts that are organized, not around space, but about time (Zwaan & Radvansky, 1998). Research has clearly shown that readers are very sensitive to the temporal dimension of narratives (Zwaan, 1996).

With this framework of skilled comprehension, we can ask about the acquisition of comprehension skill and differences in comprehension skill. What accounts for comprehension failure? Are the difficulties in comprehension localized in the processes of inference that are needed for the situation model? Or in the processes of meaning extraction that are required to represent the propositions of the text? To address these questions, we examine studies that compare readers who differ in comprehension skill. In most research, the assessment of comprehension is a global one, based on readers' answers to questions following the reading (usually silent, sometimes oral) of very short texts. (For a rare example of an assessment based on the differentiation of comprehension components see Hannon and Daneman, 2001.)

We first consider those processes that go beyond understanding the literal meaning of clauses and sentences. We begin with processes commonly viewed as critical to producing higher-level comprehension.

Higher-Level Factors in Comprehension

Among the components of the comprehension framework are three that we highlight in this section: *sensitivity to story structure*, *inference making*, and *comprehension monitoring*. We begin with the last two, which have been proposed as important sources of comprehension development and comprehension problems.

Inferences

The language of any text, spoken or written, is not completely explicit. Deeper comprehension – building a situation model – requires that the reader make inferences that bridge elements in the text or otherwise support the coherence necessary for comprehension. Inferences come in a variety of forms, and various taxonomies have been proposed (e.g., Graesser, Singer, & Trabasso, 1994; Zwaan & Radvansky, 1998). Among those that appear most necessary for comprehension are inferences that are needed to make a text coherent. Additionally, skilled readers make causal inferences that make sense of otherwise unconnected actions in a story (Graesser & Kruez, 1993; Trabasso & Suh, 1993). However, readers do not routinely make predictive inferences and other elaborative inferences that are not compelled by a need for either textual or causal coherence (Graesser et al., 1994; McKoon & Ratcliff, 1992).

With the acquisition of reading skill, children come to approximate the adult model of inference making. Notice that this adult model is complex because readers make only some of the inferences that are plausible within a narrative. Two broad principles seem to be in play: (1) Inference generation is costly to processing resources. (2) The reader strives to develop some degree of coherence in the mental model. This means that inferences that can be made without much cost to resources (e.g., mapping a pronoun onto an antecedent) are more likely than inferences that are resource demanding (e.g., inferring that an action described abstractly in the text was performed in a certain way – "going to school" elaborated as taking a bus to school). And it means that inferences that support coherence are more likely to be made than inferences that merely elaborate.

What about development of inference skills? Studies suggest that young children are able to make the same inferences as older ones, but are less likely to do so spontaneously. They may only do so when prompted or questioned (Casteel & Simpson, 1991). Because knowledge also develops with age, the availability of knowledge could be a key factor in the development of inference-making ability. However, a study by Barnes, Dennis, and Haefele-Kalvaitis (1996) suggests there may be more to the development of inference making than knowledge availability. Barnes et al. taught children (6–15 years old) a novel knowledge base to criterion, and then had the children read a multi-episode story and answer inference questions that depended on the knowledge base. Controlling for knowledge availability (by conditionalizing inferencing on the knowledge recalled), Barnes et al. found age-related differences in inference making. They also found that even the youngest children, 6–7-year-olds, were sensitive to inferences needed to maintain coherence. Furthermore, less-skilled comprehenders fail to make appropriate inferences when they read. Oakhill and colleagues (Oakhill, 1993; Oakhill & Garnham, 1988; Oakhill & Yuill, 1986; Yuill & Oakhill, 1988, 1991) have found that more skilled comprehenders make anaphoric inferences and integrate information across stories better than do less-skilled comprehenders. Skilled readers are also reported to make more causal inferences than less-skilled readers (Long, Oppy, & Seely, 1997).

What explains the variability in children's tendencies to make inferences? Satisfactory explanations for observed differences in inference making are difficult because of the dependence of inferences on lower-level comprehension processes and knowledge

(Perfetti, Marron, & Foltz, 1996). Yuill and Oakhill (1991) proposed three possibilities to explain inference-making differences between skilled and less-skilled comprehenders: (1) General knowledge deficits restrict less-skilled comprehenders' inference making. (2) Less-skilled comprehenders do not know when it is appropriate to draw inferences. (3) Less-skilled comprehenders have processing limitations, which hamper their ability to make inferences and integrate text information with prior knowledge.

A methodological digression. In sorting through various causal possibilities, there is a pervasive experimental design issue to consider: how to define comparison groups in relation to relative skill and age. One can sample within an age or grade level and compare the more skilled with the less skilled on measures that tap processes hypothesized to produce the differences in comprehension. But any differences in inference making, for example, between a 10-year-old highly skilled comprehender and a 10-year-old less-skilled comprehender could have arisen because of their differences in comprehension skill or amount of reading. An alternative is to match the children not on chronological age but on "comprehension age"; that is, on their assessed level of comprehension. The comparisons then are between a group of younger children who have attained the same level of comprehension as a group of older children. The older group will be low in comprehension skill relative to their age, whereas the younger group will be average in comprehension relative to their age. These comprehension age matched (CAM) designs allow some of the causal possibilities to be ruled out. If the younger children are better at inferences than the older children, this cannot be attributed to a superior comprehension of the younger group, because the groups have the same absolute level of comprehension skill. Thus, by elimination, a causal link between inference making and comprehension skill becomes more likely. However, all comparisons, whether age- or comprehension-matched, rest on the association of differences, and thus they inherit the limitations of correlational designs for making direct causal conclusions.

Inferences as causal in comprehension skill

In trying to determine the causal status of inference ability in comprehension development, Cain and Oakhill (1999) used the comprehension-match design described above. They compared two groups, one younger and one older, matched on comprehension (CAM) and one group of age-matched skilled comprehenders, as measured by the comprehension score of the Neale Analysis of Reading Ability (Neale, 1997). Thus, less-skilled comprehenders of age 7–8 were compared with both more skilled comprehenders of the same age and with a younger comprehension matched (CAM) group of age 6. The older two groups were matched on word reading ability according to the Neale accuracy score, whereas the younger CAM group had reading accuracy commensurate with their chronological age, about one year lower than that of the older skilled and less-skilled comprehenders.

The three groups read passages and were asked questions that required one of two types of inferences, text connecting or gap-filling. In a text-connecting inference, the reader needed to make a referential link between noun phrases in successive sentences;

for example *Michael took the drink out of his bag. The orange juice was very refreshing.* Inferring that Michael took orange juice out of his bag is a text-connecting inference. The gap-filling inferences had a more global scope; for example, they required an inference about the setting of a story. One text referred to two children playing in the sand and swimming. Inferring that the children were at the beach would be a gap-filling inference. Cain and Oakhill found that skilled readers and CAM readers were better than less-skilled readers at making text-connecting inferences. On the logic of age-match and comprehension-match comparisons, their conclusion was that comprehension skill is not a cause (it could be a consequence) of text-integration skill (as measured by the ability to make text-connecting inferences). Because skilled comprehenders were better than both the age-matched less-skilled and CAM groups at making such inferences, the causal connection between gap-filling inferences and comprehension was not clarified by the study.

If the problems in inference making arise from a poor representation of the text itself, rather than some deficit in the ability to make an inference, then attending to the text could help. When Cain and Oakhill (1999) told children exactly where to look in the text for the relevant information, their performance on the text-connecting inference questions improved, but their performance on the gap-filling inference questions remained poor. The authors concluded that less-skilled readers may have different goals when reading text, perhaps focusing on reading individual words rather than striving for coherence. This suggests that the causal relation between inference making and comprehension could be partly mediated by the reader's *standard for coherence*.

As a working hypothesis, a standard for coherence broadly determines the extent to which a reader will read for understanding, make inferences, and monitor his or her comprehension. A corollary of this hypothesis is that a low standard for text coherence is a general characteristic of low skill comprehenders. Consistent with this possibility, Cain and Oakhill (1996) found that when children were prompted to tell a story, less-skilled comprehenders told stories that had local coherence, but which lacked any overall main point.

Cain and Oakhill (1999) proposed that the less-skilled and CAM readers performed more poorly on the gap-filling questions because they failed to know when to use relevant knowledge during reading. They ruled out the availability of the knowledge because a posttest showed equivalent relevant knowledge across the groups. Cain, Oakhill, Barnes, and Bryant (2001) further examined this knowledge question by creating the relevant knowledge. Children were taught an entirely new knowledge base about an imaginary planet ("Gan"), including such facts as "The bears on Gan have blue fur" and "The ponds on Gan are filled with orange juice." Once the knowledge base had been learned to criterion (perfect recall), the children heard a multi-episode story situated on the imaginary planet, and were asked both literal and inferential questions about the story. Correct responses required children to integrate information from the knowledge base with premises from the story. Even when knowledge was controlled in this way, the skilled comprehenders were still able to correctly answer more inference questions than were the less-skilled comprehenders.

Not ruled out in either of the above studies are differences in the processing resources (i.e., working memory) that are required to juggle the demands of reading. The retrieval of relevant knowledge, the retention of text information needed for the inference, and

the building of the inference itself all compete with each other and with other processes (word identification and meaning retrieval). Verbal working memory tasks in fact correlate with both inference tasks and general comprehension measures (Oakhill, Cain, & Bryant, 2003a; Oakhill & Yuill, 1986). However, when we look beyond the correlations, working memory is not the critical factor in comprehension, or at least not the only one. Oakhill et al. (2003a) showed at each of two time points in the study (when the children were age 7–8 and 8–9) that inference and text integration skills were predictive of comprehension skill over and above the contribution of working memory, verbal IQ, vocabulary, and word reading accuracy. So, although working memory is likely to contribute to comprehension-related skills like inference making, it is unlikely to be the whole story.

Finally, the Cain and Oakhill (1999) study addresses a vexing problem for conclusions about the causal status of inference making. Perfetti et al. (1996) argued that before one can conclude that inference making is a cause of poor comprehension, assurance is needed that the poor comprehender has an effective representation of the basic text meaning (i.e., its literal meaning.) An impoverished representation of the word and clause meanings will make inferences difficult. Cain and Oakhill (1999) addressed this problem by measuring responses to questions about literal content (e.g., asking for the names of the characters which were explicitly given), and found no significant differences (less-skilled readers did show nonsignificantly lower scores).

On theoretical grounds, we think the complete separation of inferences from the literal meaning of a text is difficult. In the Construction-Integration processing model of comprehension (Kintsch, 1988), the production of inferences can feed back to literal propositions and strengthen their memory representation. We ought to be surprised to find no differences at all between the literal memory of children who are making inferences and those who are not. Indeed, Cain and Oakhill (1999) showed that literal memory does predict global comprehension; however, they further found that performance on both text-connecting and gap filling inferences predicted comprehension ability even when the ability to answer literal questions (and vocabulary and word reading ability) were controlled. Notice that these results clarify the unique role of inferences in global assessments of comprehension that follow reading. However, they do not verify the assumption that literal text elements are available to the reader when the inference is to be made. As far as we know, although studies have assessed answers to literal questions *after* reading, the more direct link from a given inference to the text supporting that inference has not been established.

Comprehension monitoring

Readers who strive for coherence in their representation of a text must be able to monitor their comprehension. Monitoring allows the reader to verify his or her understanding and to make repairs where this understanding is not sensible. Skilled readers can use the detection of a comprehension breakdown (e.g., an apparent inconsistency) as a signal for rereading and repair. Less-skilled readers may not engage this monitoring process (Baker, 1984; Garner, 1980). Again the question is why not?

This question has not been answered conclusively, but some hints are provided by the many studies on monitoring. For example, a study by Hacker (1997) examined compre-

hension monitoring in seventh-grade, ninth-grade, and eleventh-grade students (mean ages 12 to 16 respectively), with three levels of reading ability within each grade-level. Texts contained three types of detectable problems: contradictory sentences (semantic), various formal writing errors classified as "syntactic" errors (capitalization, verb agreement), and spelling errors. The developmental pattern was increased detection of all categories of text errors with age and, within age, with reading skill. More interesting were the results of an attention manipulation, with students asked to focus on meaning or on form (spelling and grammar). Directing attention to meaning was effective for improved monitoring of meaning errors (with no reduction in detecting form errors) but only for above-average readers. For low-skilled readers, instructional focus appeared not to matter. Thus, for a skilled reader, drawing attention to meaning improves comprehension monitoring.

Low reading comprehension appears to be associated with low monitoring performance at all age levels. In the study by Hacker (1997), eleventh-grade low-skill readers were no better than ninth-grade low-skill readers and not as good as seventh-grade skilled readers. The cause of this monitoring problem evades easy explanation. When students were given an additional chance to find the errors with an examiner pointing to the line containing an error, performance improved. However, the least skilled group of readers failed to improve as much as the more skilled groups. This certainly suggests that relevant knowledge is not always used in monitoring and that there are knowledge and basic processing differences that limit monitoring among some low-skilled readers. Thus, not all the problems can be due to a "monitoring deficit." Again, reading with a certain coherence standard is necessary for monitoring to be engaged.

It is important to note that observed differences in monitoring comprehension are not independent of the reader's ability to construct an accurate representation of the sentences in the text (Otero & Kintsch, 1992; Vosniadou, Pearson, & Rogers, 1988). Vosniadou et al. (1988) studied first-, third-, and fifth-grade readers' detection of text inconsistencies compared with their detection of false sentences that contradict facts that the child could know from memory. The familiarity of the critical information proved to be important for whether the child could detect an inconsistency, based either on memory or the text. This result, while not surprising, reinforces the important point that retrieving relevant knowledge during reading is essential for monitoring. However, when they controlled the familiarity of the critical information, Vosniadou et al. (1988) found that children were as good at detecting inconsistencies based on two contradictory text sentences as they were at detecting the contradiction of a single sentence with a familiar fact. This finding suggests that at least some problems in monitoring can be characterized as a failure to encode the meaning of a sentence in a way that promotes its comparison with other information, either in the text or in memory.

A simple explanation is difficult because comprehension monitoring, like inference making, both contributes to and results from the reader's text representation. This makes it difficult to attribute comprehension problems uniquely to a general failure to monitor comprehension. Any observed problem can result from an incomplete representation of sentence meaning, a failure to activate relevant knowledge at the critical moment, a failure to monitor the coherence of the text with respect either to its internal consistency or the readers' knowledge of the world. Finally, as in the case of inference making, the standard-

of-coherence hypothesis may be relevant: Comprehension monitoring failures may result from a low standard for coherence.

Sensitivity to story structure

The genre of texts (narrative, descriptive, etc.), their linguistic styles, and the various layouts of texts all can present novel problems that are solved only by experience in reading. Among the many text genre possibilities, the simple story of the sort encountered by children in schools has attracted the most attention, and we focus here on this specific text type.

The developmental research on this topic has focused on the understanding of story structure (e.g., Smiley, Oakley, Worthen, Campione, & Brown, 1977; Stein & Glenn, 1979). What is interesting about this development is its earliness. Stein and Albro (1997) argue that story understanding depends on knowledge about the intentions that motivate human action, and conclude that this knowledge is typically acquired by age 3. If so, although the application of narrative understanding to written texts can undergo further development with reading experience, we would not expect that story structure "deficits" would limit comprehension skill. Beyond the conceptual bases for narrative, however, is the understanding that the text itself honors the narrative structure through coherence devices. Differences in this sensitivity to text coherence could lead to differences in comprehension. Indeed, a study by Yuill and Oakhill (1991) demonstrated that, when they were required to narrate a story from a picture sequence, the less-skilled comprehenders produced fewer causal connectives and made more ambiguous use of referential ties than did skilled comprehenders. The less-skilled comprehenders also had difficulties in using linguistic elements to make their stories well structured and integrated.

Less-skilled comprehenders have been found to have weakness in other aspects of text structure understanding. Cain and Oakhill (1996) required groups of skilled and less-skilled comprehenders, together with a comprehension-age match group, to tell stories prompted by a title, such as "Pirates." The less-skilled comprehenders produced more poorly structured stories than either of the other two groups. Their poorer performance relative to the comprehension-age match group indicates that the ability to produce well-structured stories is not simply a by-product of having a certain level of comprehension skill. (Again, on the logic of comprehension match, this is because the poor comprehenders and the younger, comprehension-age match group had the same absolute level of comprehension skill.) Rather, an ability to produce a well-structured story is more likely to be associated with the causes of comprehension development. A sensitivity to story structure is one possibility for a cause of this development. A standard for coherence that extends to both production and comprehension is another possibility.

Reading comprehension skill is also related to children's knowledge about particular story features: notably titles, beginnings and endings. In one study, more than 80% of skilled comprehenders could give examples of the information contained in a story title, such as "it tells you what it's about and who's in it"; whereas, only about 25% of a same-age group of less-skilled comprehenders were able to do so (Cain, 1996). Some of the

less-skilled readers claimed that the title of a story provides no useful information at all. Less-skilled comprehenders were also less aware that the beginnings of stories might provide useful information about the story setting and characters. Thus, less-skilled comprehenders appear to have less explicit awareness of the features of stories that might help scaffold their mental representation of the text. However, although less-skilled comprehenders are poor at explaining the function of a variety of text features, they must have at least some implicit awareness of the use of such features, because they benefit from integrated and goal-directed titles in both comprehension and production tasks (Cain & Oakhill, 1996; Yuill & Joscelyne, 1988).

The Linguistic-Conceptual Machinery for Comprehension

Below the higher-level aspects of comprehension are the processes that convert sentences into basic semantic content, their propositional meaning. The derivation of propositional meaning requires knowledge about syntactic forms and the meanings of words.

Syntactic processing

Since the defining arguments by Chomsky (1965) and early research on the development of language (e.g., McNeill, 1970), the implicit assumption seems to have been that syntax should not be an issue for the development of reading. Competence in the grammar of one's native language is acquired naturally, emerging from biological dispositions through the filters of a local linguistic environment well before entry to school. Reading would naturally use this same grammatical knowledge. However, once differences in syntax between typical spoken forms and typical written forms are acknowledged (O'Donnell, 1974), the simple story is compromised. The question becomes empirical: Are the child's syntactic abilities, cultivated in a natural social environment, enough to meet the challenges of the more formal and more complex syntax that is present in written texts? We should expect that language skill differences lead to individual differences in comprehension, and, in fact, younger less-skilled readers show a wide range of problems with syntax and morphology (Fletcher, Satz, & Scholes, 1981; Stein, Cairns, & Zurif, 1984). The question is whether such problems arise from a syntactic knowledge deficit or from some other source that affects performance on syntactic tasks (such as working memory, lack of practice, or lexical processing limitations). Research with children (Crain & Shankweiler, 1988) and adults (Carpenter, Miyake, & Just, 1994) suggests that syntactic parsing problems can arise from processing limitations rather than a lack of syntactic knowledge. Comprehension difficulties may be localized at points of high processing demands, whether from syntax or other sources.

Crain and Shankweiler (1988) concluded that even less-skilled readers have the necessary syntactic abilities to comprehend the relatively complex sentences they used in their studies. For example, children as young as three years can understand restrictive relative clauses such as "A cat is holding hands with a man that is holding hands with a woman."

Thus, difficulties with syntax, when they are observed, may be in masquerade, with the real problem lying elsewhere. The "elsewhere" has been assigned to verbal working memory ability (Crain & Shankweiler, 1988; Perfetti, 1985) or difficulty processing phonological material (Bar-Shalom, Crain, & Shankweiler, 1993).

Nevertheless, there have been few thorough studies of the broader question of the syntactic abilities of less-skilled comprehenders. Accordingly, the conclusion that all syntactic difficulties originate as working memory limitations is too strong. Differences in syntactic processing can be observed in the absence of obvious phonological problems (Stothard & Hulme, 1992).

In a study of 7–9-year-olds, Oakhill et al. (2003a) found significant relations between global comprehension skill and a measure of syntactic ability (the TROG, a picture-sentence matching test, also used by Stothard and Hulme, 1992). (Relations were also found for text integration, comprehension monitoring, and working memory.) However, with verbal ability and vocabulary controlled, syntactic ability was significant at only the second of two test points. Although a more precise role for syntactic abilities, free of other factors, remains to be worked out, its role may be genuine, reflecting variability in the development of functional language skills.

Finally, gaining experience with syntactic structures that are less common in spoken than written language, e.g., the use of nominalizations, clausal noun phrases, and other more complex structures, is something that benefits from successful reading. Experience with a variety of syntactic structures should increase functional expertise in syntax and reduce the demands of complex structures on working memory.

Working memory systems

Understanding a sentence involves remembering words within the sentence, retrieving information from preceding text, parsing the sentence, and other processes that require resources. Working memory – one or more systems of limited capacity that both store and manipulate information – is a bottleneck for these processes. The hypothesis that working memory factors are correlated with individual differences in comprehension has received wide support (Baddeley, Logie, & Nimmo-Smith, 1985; Crain & Shankweiler, 1988; Just & Carpenter, 1992; Perfetti & Lesgold, 1977). In addition, the evidence shows it is an active working memory system rather than a passive short-term memory store that is important in reading comprehension skill (Daneman & Carpenter, 1980; Perfetti & Goldman, 1976; Seigneuric, Ehrlich, Oakhill, & Yuill, 2000).

Different subsystems of working memory have been postulated, including one that is specialized for holding and manipulating phonological information (Baddeley, 1979). Phonological working memory has a direct link to reading through the need to keep active the contents of a sentence until the end of a clause or sentence, when integrative processes complete their work and make a verbatim memory less important. A phonological memory system directly affects the comprehension of spoken language. In fact, children who are less skilled in reading comprehension show poorer memory for words they recently heard from spoken discourse (Perfetti & Goldman, 1976). This interdependence of spoken and written language comprehension is important in the analysis of reading

comprehension problems. Whether phonological memory is the critical cause of differences in both spoken and written language comprehension is another matter. As we suggest below, the basic language processing mechanisms, which include more than phonological representations, may affect performance in working memory tasks.

Phonological memory processes may affect reading comprehension by an additional pathway through the development of word identification. Dufva, Niemi, and Voeten (2001), in a longitudinal study from preschool through second grade, used assessments of phonological awareness, phonological memory, word identification, and spoken and written comprehension. Structural equation modeling showed an indirect causal link from preschool phonological memory to word recognition development between first and second grade, which was mediated by phonological awareness. Phonological memory showed a similar indirect causal link to reading comprehension, mediated by listening comprehension. The results suggest that the ability to hold and manipulate phonemes in memory may explain the relation between phonemic awareness and reading. Moreover, they suggest that phonological memory supports listening comprehension and thus, indirectly, reading comprehension.

Because word identification and listening comprehension are primary determinants of reading comprehension, phonological knowledge prior to literacy could play a role in the development of reading comprehension by either or both of two pathways. A causal path from early phonological knowledge through word identification to later reading comprehension is one possibility. Another possibility is a pathway from phonological processing to listening comprehension to reading comprehension. Of course, both causal pathways could be involved. On either description, working memory capacity is not at the heart of comprehension problems, but rather its correlations with comprehension reflect limitations in phonological processing. Indeed, Crain and Shankweiler (1988) argued that differences in working memory capacity arise from difficulties in phonological processing.

In the absence of specifically phonological problems, working memory differences are still observed and can be traced to other language processing weaknesses (Nation, Adams, Bowyer-Crane, & Snowling, 1999; Stothard & Hulme, 1992). The general conclusion appears to be that working memory differences related to reading skill are fairly specific to language processing. Indeed, the even more general conclusion is that language processing weaknesses are at the core of reading comprehension problems. These weaknesses will often be manifest specifically in phonology but they can also be reflected in other aspects of language processing.

The assumption of a limited capacity working memory system has been central in theories of cognition generally. An additional implicit assumption is that this system is more or less fixed biologically. However, alternative perspectives on working memory suppose that its limitations are not completely fixed but at least partly influenced by knowledge and experience (Chi, 1978; Ericsson & Delaney, 1999; Ericsson & Kintsch, 1995). If we see working memory as partly fixed and partly "expandable," we move toward a perspective that views the role of effective experience as critical in the development of comprehension skill. Effective experiences in a domain strengthen the functionality of memory resources in that domain. In the case of reading, the effective experience is reading itself (with a high standard for coherence) so as to support the fluent processing that effectively stretches working memory.

Building conceptual understanding from words

Vocabulary has been a slightly neglected partner in accounts of reading comprehension. This neglect arises not from any assumption that vocabulary is unimportant, but from theoretical interests in other aspects of the comprehension problem. The research strategies have either assumed or verified that relevant vocabulary knowledge is equal between a group of skilled and less-skilled comprehenders, so that experimental designs could focus on inferences, monitoring, working memory, or whatever component of comprehension was the target of interest. Of course, everyone accepts that knowledge of word meanings and comprehension skill are related.

The possible causal relations underlying their relationship include several plausible possibilities (Anderson & Freebody, 1981; Beck, McKeown, & Omanson, 1987; Curtis, 1987). Word meanings are instrumental in comprehension on logical as well as theoretical grounds. Nevertheless, the more one reads, the more comprehension brings along increases in the knowledge of word meanings. Sorting out causality is again difficult, and we might expect research designs to follow the lead of the comprehension-match design, making matches based on vocabulary levels.

For some purposes, it does not matter whether the causal history is from vocabulary-to-comprehension or comprehension-to-vocabulary. Indeed, the causal relationship is likely to be reciprocal. To the extent that word meanings are inferred from context, then vocabulary growth results from comprehension skill, including inference making. But at the moment a reader encounters a text, his or her ability to access the meaning of the word, as it applies in the context of this particular text, is critical.

Not knowing the meanings of words in a text is a bottleneck in comprehension. Because readers do not know the meanings of all words they encounter, they need to infer the meanings of unknown words from texts. This process, of course, requires comprehension and like other aspects of comprehension, it is correlated with working memory (Daneman & Green, 1986). This correlation might reflect working memory's role in learning the meanings of words from context (Daneman, 1988). Note also that inferring the meanings of unknown words from the text is possible only if most words are understood and if some approximation to text meaning is achieved. One estimate is that a reader must know at least 90% of the words in a text in order to comprehend it (Nagy & Scott, 2000). We know very little about the kind of text representation that results when words are not understood. The nature of this representation would depend on all sorts of other factors, from the role of an unknown word in the structure of the text message to the reader's tolerance for gaps in comprehension.

Somehow, children's knowledge of word meanings grows dramatically. Nagy and Herman (1987), based on several earlier estimates of vocabulary growth, computed the per-year growth of vocabulary at 3,000 words over grades 1–12. The gap between the number of words known by the high-knowledge and low-knowledge children is correspondingly large. According to one estimate, a first-grade reader with high vocabulary knowledge knows twice as many words as a first-grade reader with low knowledge, and this difference may actually double by the twelfth grade (Smith, 1941).

Differences in word knowledge emerge well before schooling. Large social class differences in the vocabulary heard by children at home produce corresponding differences

in the vocabularies of children as they enter school (Hart & Risley, 1995a). These differences are not about only the conventional meanings of words, but the background knowledge needed to interpret messages that contain these words. Consider this example (from Hart & Risley, 1995a): *My wife and I wanted to go to Mexico, but her only vacation time was in July.* Interpreting the "but" clause, which needs to be understood as causal for an unstated action (they probably did not go to Mexico), is easier if the reader knows that Mexico is very hot in July and that some people might not want to have a vacation in high heat. Knowledge of this sort is critical in its consequences for understanding even simple texts.

Beyond the general importance of word knowledge (and associated conceptual knowledge) are specific demonstrations that children less skilled in comprehension have problems with word knowledge and semantic processing. Nation and Snowling (1998a) compared children with specific comprehension difficulties with a group of skilled comprehenders matched for decoding ability, age and nonverbal ability on semantic and phonological tasks. They found that less-skilled comprehenders scored lower on a synonym judgment task (Do BOAT and SHIP mean the same thing?), although not on a rhyme judgment task (Do ROSE and NOSE rhyme?). Less-skilled comprehenders were also slower to generate semantic category members (but not rhymes) than skilled comprehenders. This suggests that comprehension problems for some children are associated with reduced semantic knowledge (or less effective semantic processing) in the absence of obvious phonological problems. (See also Nation, this volume.)

More interesting, however, is that these same less-skilled comprehenders showed a problem in reading low-frequency and exception words. In effect, Nation and Snowling observed a link between skill in specific word identification (not decoding) and comprehension that could be mediated by knowledge of word meanings. Theoretically, such a link can reflect the role of word meanings in the identification of words that cannot be identified by reliable grapheme–phoneme correspondence rules. Children with weak decoding skills may develop a dependency on more semantically based procedures (Snowling, Hulme, & Goulandris, 1994).

Thus, knowledge of word meanings may play a role in both the identification of words (at least in an orthography that is not transparent) and in comprehension. This dual role of word meanings places lexical semantics in a pivotal position between word identification and comprehension. (Notice that figure 13.1 reflects its pivotal position.) This conclusion also accords with an observation on adult comprehenders reported in Perfetti and Hart (2002), who reported a factor analysis based on various reading component assessments. For skilled comprehenders word identification contributed to both a word form factor (phonology and spelling) and a comprehension factor, whereas for less-skilled comprehenders, word identification was associated with a phonological decoding factor but not with spelling or comprehension. This dual role of word meanings in skilled reading also may account for previous observations that less-skilled comprehenders are slower in accessing words in semantic search tasks (Perfetti, 1985).

If less-skilled readers have a weak lexical semantic system, then one might expect semantic variables that reflect the functioning of this system to make a difference. For example, concrete meanings are more readily activated than more abstract meanings.

Nation, et al. (1999) found that an advantage for concrete words was more pronounced for less-skilled readers than skilled readers who were matched for nonword reading (decoding). In a priming study, Nation and Snowling (1999) found that less-skilled comprehenders are more sensitive to associative strength among related words and less sensitive to abstract semantic relations, compared with skilled comprehenders. Research at this more specific semantic level could help clarify the nature of the semantic obstacles to comprehension.

Word Identification, Decoding, and Phonological Awareness

If word meanings are central to comprehension and important for identification of at least some words, then we have come to an interesting conclusion: Despite trying to ignore word level processing in comprehension, we cannot. In examining the role of working memory, we were forced to conclude that a link to comprehension could go from phonological processing through word identification to comprehension. Even phonological awareness, ordinarily considered only important for decoding, has been found to predict young readers' comprehension independently of working memory (Leather & Henry, 1994).

The general association between word identification and reading comprehension skill has been well established for some time (Perfetti & Hogaboam, 1975). This association reflects the fact that word identification skill and comprehension skill develop in mutual support. The child's development of high-quality word representations is one of the main ingredients of fluent reading (Perfetti, 1985, 1991). Such representations must be acquired in large part through reading itself.

Instrumental in acquiring these word representations is a process identified by Share (Share, 1995, 1999) as self-teaching. This process allows children to move from a reading process entirely dependent on phonological coding of printed word forms to a process that accesses words quickly based on their orthography. What drives this development of orthographic access is the child's decoding attempts, which provide phonological feedback in the presence of a printed word, establishing the orthography of the word as an accessible representation. Models that simulate learning to read words can be said to implement this kind of mechanism (Plaut, McClelland, Seidenberg, & Patterson, 1996).

As children develop word-reading skills, comprehension becomes less limited by word identification and more influenced by other factors. However, even for adult skilled readers, the association between reading comprehension and word identification persists, reflecting either a lingering limitation of word identification on comprehension or a history of reading experience that has strengthened both skills. The word-level skill can be conceived as reflecting lexical quality (Perfetti & Hart, 2001), knowledge of word forms and meanings, which has its consequences in effective and efficient processing. Word level processing is never the whole story in comprehension. However, it is a baseline against which to assess the role of higher-level processes such as comprehension monitoring and inference making (Perfetti et al. 1996).

Which components bring about growth in comprehension skill?

To this point, we have examined the acquisition of reading skill largely through studies comparing skilled and less-skilled readers, whether matched on relevant skills or age. Longitudinal studies that track the course of changes in comprehension skill can provide additional information about the causal relations among the components of comprehension, and thus about the course of development. A few such studies have begun to appear. Muter, Hulme, Snowling, and Stevenson (2004) studied young children for two years from their entry into school, assessing a number of abilities, including phonological, grammatical, vocabulary knowledge. Word identification skills, grammatical knowledge, and vocabulary assessed at age 5–6 each predicted unique variance in reading comprehension at the end of the second year of schooling. This pattern confirms the contributions to comprehension of three factors we have reviewed in previous sections.

In a longitudinal study of children in school years 3 to 6, Oakhill, Cain, and Bryant (2003b) extended the study of Oakhill et al. (2003a) by the addition of a third cohort of children and providing a longitudinal analysis of data from ages 7–8 (Year 3), 8–9 (Year 4), and 10–11 (Year 6). In each age group, there were measures of reading comprehension and reading accuracy, verbal and performance IQ (Time 1 only), working memory (both verbal and numerical span measures), phonemic awareness (phoneme deletion), vocabulary (BPVS), syntax (TROG), and measures of three comprehension related skills: inference making, comprehension monitoring and story-structure understanding (story anagram task). The results of multiple regression were applied to a causal path diagram to show the pattern and strength of relations among the various skills across time. The final causal path diagram, with only significant paths included, is shown in figure 13.2.

Initial comprehension skill was a strong predictor of later comprehension, and verbal ability (vocabulary and verbal IQ) also made significant contributions to the prediction of comprehension ability across time. Nevertheless, three distinct predictors of comprehension skill emerged, either through direct or indirect links: answering inferential questions, monitoring comprehension (by detecting inconsistencies in text), and understanding story structure (assessed by the ability to reconstruct a story from a set of jumbled sentences). These factors predicted comprehension at a later time even after the autoregressive effect of comprehension (the prediction of comprehension at later times from comprehension at earlier times) was controlled. With reading accuracy as the dependent variable, the pattern was quite different. The significant predictors were previous measures of reading accuracy and a phoneme deletion measure taken at Time 1.

From these analyses a picture of skill development emerges in which certain components of comprehension are predictive of general comprehension skill. Early abilities in inference skill, story structure understanding, and comprehension monitoring all predict a later global assessment of comprehension skill independently of the contribution of earlier comprehension skill.

Finally, to assess growth in skill, Oakhill et al. (2003b) calculated estimates of growth in reading comprehension and reading accuracy, and used these estimates as dependent variables in two further sets of regression analyses. (Verbal and performance IQ and vocabulary were entered at the first step, followed by all of the reading-related and language variables and working memory measures entered simultaneously.) Although vocabulary

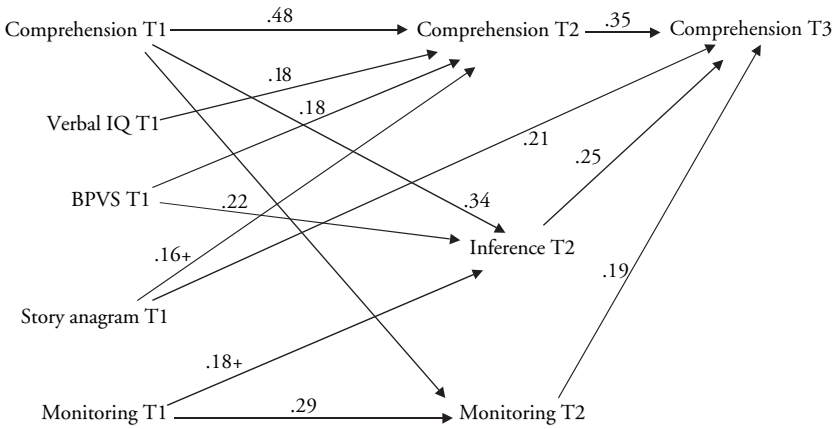

Figure 13.2 Path analysis based on data from longitudinal study by Oakhill, Cain, and Bryant (2003b). Variables measured at Time 1 (age 7–8) predict variables at Time 2 (age 9–10) and Time 3 (age 11–12). Variables shown were significant predictors after the effects of all other variables were removed: a global comprehension measure (COMP), a picture vocabulary test (BPVS), verbal IQ (VIQ), detection of text contradictions (MONITOR), a sensitivity to story structure (Story Anagram), and integrative inferences (INFER). Paths that linked Time 1 and Time 2 variables but not Time 3 comprehension have been excluded for clarity. Because the original data were standardized, the coefficients shown are directly comparable.

and verbal IQ predicted growth in comprehension and reading accuracy, other variables made independent predictions. Story structure understanding was the sole predictor of growth in reading comprehension. Phonemic awareness was the sole predictor of growth in reading accuracy skill.

The study confirms that a set of higher-level comprehension components, which, on theoretical grounds, ought to be instrumental in the growth of reading comprehension skill, may indeed be instrumental. Muter et al. (2004) report a slightly different pattern for their younger children. Word identification (Hatcher, Early Word Recognition Test, Hatcher, Hulme, & Ellis, 1994) was important in predicting comprehension, as one might expect for younger children, as were knowledge of word meanings and grammatical knowledge. Because Muter et al. had a comprehension assessment only at the final test point in their study, their study is not directly comparable with the study by Oakhill et al. (2003b). It is possible that all the factors identified in these two studies influence comprehension development, with the strength of their contribution depending upon the level of the child's skill. However, studies that carry out comparable assessments, including tests of comprehension at more than one time point, are needed to test this possibility.

Comprehension Instruction

A failure to develop a high level of comprehensions skill creates a severe obstacle to educational attainment. Accordingly, there is widespread concern about how to improve chil-

dren's reading comprehension. Although we cannot review the research on instruction in comprehension here, we briefly note the wide extent of such research, drawing on a comprehensive review of research on reading (National Institute of Child Health and Human Development [NICHD], 2000). The summary NICHD report refers to 453 studies between 1980 and the time of the review, augmented by a few earlier studies from the 1970s. The 205 studies that met the methodological criteria led the report to identify seven categories of comprehension instruction that appeared to have solid evidence for their effectiveness.

These seven include procedures that we characterize as drawing the reader into a deeper engagement with the text – in a phrase, active processing. They include comprehension monitoring, question answering (teacher directed questions) and question generation (student self-questioning), the use of semantic organizers (students making graphic representations of text), and student summarization of texts. Instruction in story structures was also judged to be effective. The NICHD Report concludes that these procedures are effective in isolation in improving their specific target skills (sensitivity to story structures, quality of summarization, etc.) but that improvement of scores on standardized comprehension tests may require training multiple strategies in combination.

The procedures that the NICHD Report suggests are effective are consistent with the comprehensions skills we have reviewed in this chapter. Active engagement with the meaning of text helps the reader to represent the text content in a way that fosters both learning (as opposed to superficial and incomplete understanding) and an attraction to reading. However, the NICHD report adds some cautions to its conclusions on behalf of the instruction strategies it recommends. To those, we add our own reservations. Instructional interventions may produce only short-term gains. Two years after the intervention, is the child comprehending better? Answers to this kind of question appear to be lacking. We think the complex interaction among the comprehension components and the role of motivation for reading make real gains difficult to achieve. Internalizing externally delivered procedures so that they become a habit – a basic attitude toward texts and learning – may be a long-term process. It requires both wanting to read and gaining skill in reading, which go hand in hand.

Conclusion: A More General View of Comprehension Development

We conclude by taking a step back from the details of how skill in comprehension is acquired. With more research, the kind of developmental picture we described in the preceding sections may be confirmed or alternative pictures will emerge, based on different experimental tasks and resulting in a different arrangement of causal relations. Because a detailed model of skill acquisition seems premature, we turn to a more general, speculative account of acquisition. This general model framework, which is illustrated as a highly schematic representation in figure 3.3, can be realized by a number of specific models.

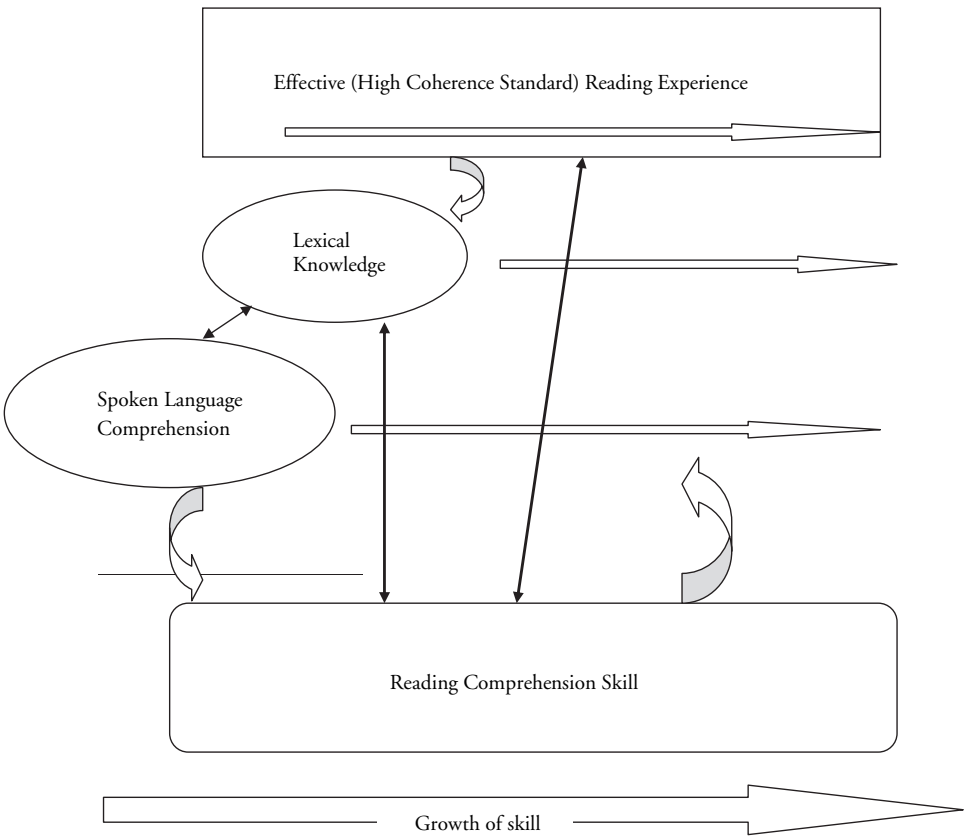

Figure 13.3 A schematic representation of the major components in the acquisition of reading comprehension skill. The left–right arrows represent increases in skill across with experience and gains in knowledge. Reading comprehension depends on spoken language comprehension throughout development. Early in reading, written word identification (not shown) is a limiting factor for reading comprehension. Reading comprehension has reciprocal relationships with both spoken language comprehension and lexical knowledge. Not represented: general knowledge (which, of course, also increases) and the specific processes of comprehension (e.g., syntactic processing and inference making).

We assume the following:

1. General skill in reading comprehension and its related components increase with reading experience, and, with some component skills, with spoken language experience.
2. Reading comprehension and listening comprehension are related throughout development. Their relation is reciprocal, with experience in each potentially affecting skill acquisition in the other. However, this does not mean that the two are "equal," and substantial asymmetries can develop.

3. Word identification skill sets a limit on how closely reading comprehension skill can approach listening comprehension skill. It specifically limits comprehension early in reading development.
4. Knowledge of word meanings is central to comprehension. This knowledge derives from multiple sources, including written and spoken comprehension, and grows indefinitely.
5. Higher levels of comprehension require the reader to apply a high standard of coherence to his or her understanding of the text.

The first four assumptions comprise a basic analysis of what is necessary for comprehension. Our review of research on higher-level comprehension processes emphasizes the need for this basic analysis to be taken into account – that is, "controlled for" – in the search for higher-level comprehension factors that are strategic; for example, monitoring comprehension, making inferences. However, we conclude also that the basic analysis provides the necessary, but not sufficient, causal story.

For comprehension to develop to higher levels, the reader must adopt a high standard of coherence – to care whether the text makes sense. When coherence is a goal, inferences are made to keep things coherent. When coherence is a goal, inconsistencies between text elements or between text elements and the reader's knowledge are resolved rather than ignored or not noticed. All readers find themselves relaxing their standards for coherence occasionally. Unwanted reading and countless nontext distractions can promote this laxity. The goal, however, is adopting the high-standard criterion as the "default." We think skilled readers do this. This brings reciprocal supports into play. Adopting a high coherence standard supports interest in reading, which encourages a high standard of coherence. The result of these influences is more reading and, especially, more effective reading. This surely aids reading comprehension.[1]

Note

1. The authors are grateful to Kate Cain for providing comments on a draft of this chapter, which was prepared while the first author was a visiting research fellow at the University of Sussex. The first author's work on the chapter was supported by a Leverhulme Visiting Professorship and a comprehension research award from Institute for Educational Sciences (US Department of Education).