

CHAPTER 7

SYNTACTIC COMPLEXITY AND READING ACQUISITION.

Stephen Crain  
Donald Shankweiler

# LINGUISTIC COMPLEXITY AND TEXT COMPREHENSION: *Readability Issues Reconsidered*

**Edited by**

**ALICE DAVISON**  
*University of Wisconsin*

**GEORGIA M. GREEN**  
*University of Illinois*



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## Syntactic Complexity and Reading Acquisition

Stephen Crain  
Donald Shankweiler  
*University of Connecticut and Haskins Laboratories*

### INTRODUCTION

Learning to read is difficult for most people and complete mastery usually requires years of practice. In this paper we explore how the difficulties are related to linguistic structure. We focus primarily on one component of the language apparatus, the syntactic component, and consider the role of syntactic complexity in the problems of reading. These problems are most transparent at the early stages of learning, and therefore, it should prove most revealing to compare beginning readers who are progressing at the expected rate with those who are failing to make normal progress.

The approach we take assumes that the language faculty is composed of several autonomous subsystems, or modules. The modules are autonomous in the sense that they develop and function according to operating principles that are specific to them, i.e., not shared by other subsystems of language or other cognitive systems. Although these subsystems are intertwined in normal language use, experiments can be devised to disentangle them. The importance of this step has not always been recognized, however. We argue that failure to take account of the modular organization of language has led to many apparently conflicting findings concerning the syntactic competence of young children. We will show, moreover, that the concept of language as a modular system has important implications for understanding how reading is acquired and for interpreting the difficulties that so often arise.

A modular view of the language apparatus raises the possibility that a single component may be the source of reading difficulty. We assume that levels of language processing are organized in a hierarchical fashion and that the flow of



information is unidirectional and vertical ("bottom up") such that lower levels serve as input to higher levels and not the reverse. This means that if a lower-level component is implicated in reading difficulty, manifestations may appear at higher levels. A lower-level deficit may, therefore, masquerade as a complex of lower-level and higher-level deficits. We argue that this is what often happens in cases of childhood reading disability: the verbal short-term memory system, hereafter called working memory, which briefly retains a phonological record of the input, is largely responsible for difficulties in processing complex syntactic structures. In developing a modular approach to reading difficulties, we were influenced by the work of M. L. Kean (1977) on the analysis of language deficits in aphasia. By seeking a unified account of language problems associated with reading difficulties we may be able to move toward an explanation of what would otherwise look like an aggregate of individual differences between good and poor readers.

There are many unanswered questions about how reading exploits the language apparatus. In order to identify the questions and examine them it is important to say what we mean by the term "language apparatus." We use it to cover both linguistic structures and the processing systems that access and manipulate these structures. The structures include the language user's stored knowledge of rules of phonology, morphology, syntax, semantics, and pragmatics. The processing systems that invoke these structures include the verbal working memory system, the syntactic parsing mechanism, and the semantic and pragmatic processors.

Since our concern is not exclusively with the reading process but more generally with the question of what makes a sentence complex, we have found it appropriate, indeed necessary, to consider the problems associated with reading from the standpoint of language acquisition. For the most part these two aspects of cognitive development have been studied independently, but we have found compelling reasons to bring them together.

Broadly speaking, there are two ways to view the relationship between children's acquisition of language and the subsequent development of reading abilities. Each view of the relationship offers an explanation of the important facts about reading; namely, why it is hard to learn to read, and why reading, unlike speech, is not universal. The differences between the views are fundamental. Each conceives of syntactic complexity in a different way and each has a different conception of language acquisition. One view is that reading demands more syntactic competence than beginning readers have at their disposal. This view assumes that some aspects of syntax that are necessary for reading are not yet in place in the beginning reader. Since reading problems are seen as a result of missing structures, we call this position the Structural Deficit Hypothesis (SDH).

The second view locates the problem elsewhere. It supposes that most syntactic structures are mastered well before the child begins to learn to read, and therefore that the source of reading difficulty lies in the subsidiary mechanisms

that are used in language processing, mechanisms that may require modification in order to accommodate print. This position is called the Processing Deficit Hypothesis (PDH).

These hypotheses are somewhat idealized, but they provide a framework from which to direct the search for causes of the difficulties encountered in mastery of reading, and each offers a distinctive perspective on the nature of syntactic complexity. In the later sections we consider how each hypothesis squares with research on language acquisition (section 3.A), with emphasis on one syntactic construction, the restrictive relative clause (3.B). We then focus on the plight of the poor reader; Section 3.C gives an account of an experiment designed to determine which hypothesis can best explain failures to comprehend sentences containing relative clauses. Section 3.D explores the implications of empirical findings showing that poor readers have problems with lower-level language operations. We raise there the possibility that these difficulties may, in turn, have ramifications for processing language structures at higher levels. We argue, moreover, that written language places special demands on the subsidiary language processors such that reading comprehension is often more limited than comprehension of spoken sentences.

On the empirical side, our conclusions are tentative; much research remains to be done. On the theoretical side, we offer a new perspective on reading and its problems—one that ties reading research more securely to current linguistic and psycholinguistic research.

## 2. TWO HYPOTHESES ABOUT READING ACQUISITION

In this section we fully sketch the two hypotheses that were briefly introduced earlier. First we examine their different conceptions of the sources of syntactic complexity. From these conceptions are derived different explanations about what makes reading hard to learn. Ultimately our concern is with the different empirical predictions of the two hypotheses, since, in our view, one of the principal tasks of the psycholinguistics of reading is to discover which hypothesis comes closer to the truth.

### A. The Structural Deficit Hypothesis

The first proposal is based on the premise that some syntactic structures are inherently more complex than others. The supposition that linguistic materials are ordered in complexity invites an inference about the course of language acquisition; namely, that language acquisition proceeds in a stepwise fashion, beginning with the simplest structures and culminating only when the most complex structures have been mastered. This view of the course of language

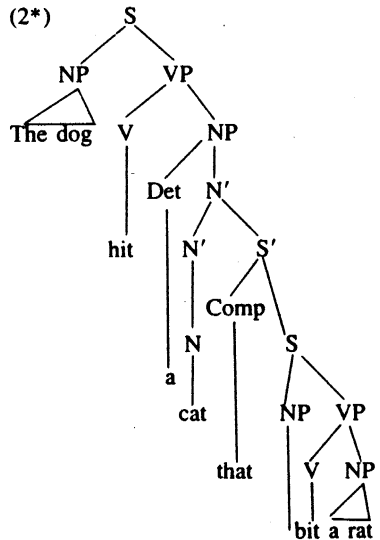
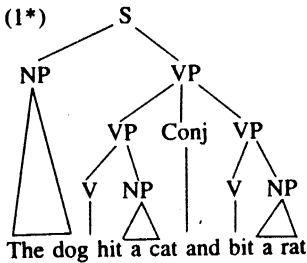
acquisition provides a foundation for hypotheses about learning to read and about the factors that distinguish good and poor readers. In this way, the SDH is intimately linked with a particular viewpoint on language development.

The SDH maintains that, at the time reading instruction begins, children are only partway through the course of language acquisition. If true, this hypothesis of gradually unfolding competence could explain why reading is delayed in most children until they are 5- to 7-years-of-age. Moreover, the difference between successful and unsuccessful readers could be attributed to further lags in primary language abilities in some children or to deficient instruction and/or experience with written language. This view may also contain implications for the role of experience. Although the early development of language requires only immersion in a speaking environment, the later development of language, as well as the early stages of reading, may require both graded inputs and extensive experience.

To develop this hypothesis further, we consider first the claim that syntactic structures differ in inherent complexity. As a case in point, it has been claimed that a sentence containing both a main clause and a subordinate clause, such as (2), is more complex than a coordinate structure, as in (1) (see section 3.B).

- (1) The dog hit a cat *and* bit a rat.
- (2) The dog hit a cat *that* bit a rat.

Syntactic differences between (1) and (2) can be gleaned from a cursory examination of the following, hypothetical tree-diagrams:



One difference is in the number of syntactic constituents in (1\*) and (2\*). Notice that there is a higher ratio of phrasal categories to words in (2\*). Another difference is that (2\*) but not (1\*) contains a "missing" noun phrase, indicating that a constituent has been "moved" by transformational rule.

It is an empirical question whether or not these structural differences contribute to difficulties in processing either in speech or in reading (see Fodor & Garrett, 1967; Kimball, 1973). This possibility could be tested by measuring reaction-time latencies to sentences like (1) and (2) on some reading task that is sensitive to ease of processing. But in the research discussed here the indicator of the relative complexity of syntactic structures is the following: one structure is simpler than another if children can speak and comprehend it first. Returning to our examples, if sentences like (2) take longer to master than sentences like (1), this would be attributable to the relative complexity of (2\*) as compared to (1\*).

As we noted, the SDH makes an explicit prediction about reading acquisition: The structures that beginning readers and poor older readers find most difficult are just those that appear last in the course of language acquisition. Advocates of the SDH, then, would point to data on the late acquisition of specific structures in poor readers, particularly those structures underlying complex sentences (e.g., Byrne, 1981; Fletcher, Satz, & Scholes, 1981; Vogel, 1975). The SDH regards learning to speak and learning to read as continuous processes that tap the same cognitive abilities, but it is argued that reading is difficult largely because many of the primary linguistic abilities that support it are acquired late.

## B. The Processing Deficit Hypothesis

We now introduce an alternative account of the fundamental facts of reading acquisition. Based on a different conception of linguistic complexity, this hypothesis supposes children have already acquired a great deal if not all of the primary linguistic apparatus by the time they begin to learn to read. But in addition to this, reading demands a number of secondary processing mechanisms to interface spoken language and an orthographic system of representation. These subsidiary mechanisms include verbal working memory, routines for identification of printed words, and the syntactic, semantic, and pragmatic processors.

Because many of the same structures are used in reading and speech, it is easy to overlook the possibility that reading may make special demands on the language processing systems beyond those required for speech. In speech processing, word identification, syntactic parsing, and semantic composition of word meanings are all highly automatic from the earliest stages of language acquisition. In reading, these processes must be reshaped to interface with a new input source. At the lowest level, a system for gaining access to the mental lexicon from print must be mastered to the point that it is both rapid and accurate. Until

this is accomplished, higher-level processes such as syntactic parsing and semantic composition may be inhibited, reduced to a level far below the level at which they function in speech.

To make this discussion more concrete, suppose that working memory resources are exhausted by the task of identifying words from their orthographic representations. In that case, higher-level syntactic and semantic processing may be preempted. Much evidence exists that word recognition difficulties persist for a long time in early readers and that good and poor readers are sharply distinguished in orthographic ("decoding") skills (Gough & Hillinger, 1980; Perfetti & Hogaboam, 1975; Shankweiler & Liberman, 1972). If it could be shown further that when the pressures on working memory were reduced, beginning readers could comprehend structures that were otherwise problematic, this would provide confirmation for the PDH.

To develop this account, and to explain that the PDH offers a different view of syntactic complexity, we must consider further the implications of the early acquisition of syntax, a tenet we take to be central to this hypothesis. To this end, we draw upon the modularity hypothesis introduced earlier, which can be contrasted with the view that knowledge of language is a composite of more general cognitive faculties (for a recent statement, see J. A. Fodor, 1983). One tenet of the modularity thesis is the innate specification of language structures. Neurological evidence for the innateness of the language faculty is extensive. Among the facts that should be mentioned are the existence of special brain mechanisms present from birth, and evidence of dissociation between patterns of sparing and loss in language and other cognitive abilities in cases of brain damage (Dennis, 1980; Milner, 1974; Whitaker, 1976).

It is difficult to find psycholinguistic evidence that a *particular* linguistic structure, such as syntax, constitutes a submodule of the language component. Even the apparent innateness of some ability does not guarantee modular organization. An ability might, in principle, be innate and also multifactorial in composition. There are, however, some general guidelines for detecting modular organization, and tests for innateness are certainly among them. In the best case, an innate system could be expected to unfold rapidly, with much latitude regarding input from the environment, and with minimal interaction with concurrently developing systems (in Fodor's terms, "informationally encapsulated").

The acquisition of syntax adheres closely to these guidelines for innateness and, by extension, seems to conform to the modularity hypothesis. If the recent findings of early mastery of complex structures can be generalized (see section 3A), this would constitute strong empirical support for one tenet of linguistic theory, namely the hypothesis that there is an innately specified "Universal Grammar." The theory of Universal Grammar maintains that the language module develops into a rich and intricate system of rules much more rapidly than many other cognitive structures because of its innately specified content. Children seem to know too much too soon and they take too few wrong turns for the

acquisition of language to be explained without supposing that it is both guided and constrained by innate principles (for further discussion, see Chomsky, 1971, 1975, 1981; Hamburger & Crain, 1984; and Lasnik & Crain, 1985).

Our specific concern here is with syntactic structure. If syntactic structure is largely built into the blueprint for development, then it makes little sense to ask if some syntactic constructions are harder to learn. Each construction simply develops in its own time, according to a predetermined schedule, regardless of its specific properties. In this way, the PDH calls into question the notion of linguistic complexity advanced by the SDH.

One possible advantage of modular organization, then, is that extreme structural complexity (by pretheoretic standards) can come "prewired." And what is not prewired may nonetheless be rapidly acquired, since the modular character of the linguistic system may endow it with heavy internal constraints on the types of hypotheses that a child can entertain. One way that children's grammar formation is believed to be constrained is in the structure-dependent nature of rules. A structure-dependent rule is one that is based on an abstract schema that partitions sequences of words into constituent structure. By contrast, a structure-independent rule, such as a simple counting rule, is applied directly to sequences of words themselves, without partitioning them into abstract functional units.

The theory of Universal Grammar maintains that children invariantly adopt structure-dependent rules in the course of grammar formation, eschewing structure-independent rules even when much of the available data is consistent with hypotheses of either type (Chomsky, 1971, 1975). Moreover, children are predicted to opt for structure-dependent rules even if structure-independent rules are computationally *less complex*. In the next section we present evidence of children's acquisition of an apparently complex rule at a time when a simpler rule would suffice.

To summarize, the two views we have presented make different predictions because they locate the source of reading difficulties in different components of the language apparatus. In essence, the views turn on the distinction between structure and process. On the first view there is a structural deficit, i.e., a deficit in stored knowledge. On the second view the problem is one of process, i.e., access and use of this stored knowledge. What is common to these hypotheses is that each attempts to locate the *causes* of reading difficulties. In this way they go beyond description and move towards explanation.

Each hypothesis attempts to account for the same basic facts about reading, but ultimately they diverge. Both predict that beginning readers will have difficulty reading some linguistic material, but on the SDH they should have trouble understanding complex linguistic structures even when these are presented in the speech mode. This hypothesis maintains that the late emergence of some structures places an upper bound on both the reading skills and the spoken language skills of the young reader. On the PDH, beginning readers will have achieved a high level of mastery of the grammatical operations that are required for speaking

and understanding spoken sentences. The strongest version of the PDH would hold that all of the primary language apparatus is in place before formal instruction in reading begins. But even in this strong version, reading and writing will be acquired gradually, with some difficulty and with uncertain results, precisely because they tap abilities that may appear to be peripheral to the language module, though closely associated with it (Lieberman, Shankweiler, Fischer, & Carter, 1974; Mattingly, 1972; 1984; Rozin & Gleitman, 1977; Shankweiler & Lieberman, 1976). The PDH predicts that most beginning readers may be competent to deal with complex linguistic constructions in spoken language, whatever the attained level of reading skill, within the constraints imposed by their limitations in processing capacity.

It is important to point out, in this connection, that we are discussing performance here, and not competence. Poor readers' performance on complex sentences may often be faulty. But, according to the PDH, the failures in comprehension should be ascribed to secondary processing limitations, such as limitations on working memory, and not to lack of syntactic competence per se. Beginning readers and those with persisting difficulties may not be able to make use of their underlying grammatical competence because lower-level processing may preempt higher-level processing. Only by experimental means can we assess underlying competence when performance is faulty: the prediction of the PDH is that syntactic competence should be revealed in contexts that reduce the processing demands on the secondary language apparatus. In the next section we discuss how primary and secondary linguistic abilities may be successfully teased apart in studies of language acquisition.

### 3. IMPLICATIONS OF LANGUAGE ACQUISITION FOR READING

This section reviews aspects of language acquisition that are relevant to the two hypotheses about the sources of reading difficulty. The SDH distinctively predicts, as we noted, that relatively more complex linguistic structures emerge only at the later stages of language development. By contrast, the PDH predicts rapid acquisition of complex syntactic structures. As a test of this difference, the following experiment addresses the claim of Universal Grammar that children adopt only structure-dependent rules even if there exist viable alternative rules that appear to be considerably simpler. Following this, we shift our attention to the acquisition of another syntactic construction, the restrictive relative clause. We consider first its course of acquisition in normal development; then we present a study of the comprehension of this construction by good and poor readers.

### A. Structure-Dependence in Language Acquisition

It is Chomsky's hypothesis that children unerringly adopt structure-dependent rules. To test this hypothesis Crain and Nakayama (in press) developed an experimental task, in the form of a game, to elicit yes/no questions that are amenable in principle either to structure-independent or structure-dependent analyses. For yes/no questions, the structure-independent strategy might be as follows:

Move the *first* "is" (or "can," "will" etc.) to the front of the sentence.

Notice that this principle gives the correct question forms for many simple sentences, as in (3).

- |     |                          |                          |
|-----|--------------------------|--------------------------|
| (3) | John is tall.            | Is John tall?            |
|     | Mary can sing very well. | Can Mary sing very well? |

Since the structure-independent strategy produces the correct forms in simple cases, and since it appears to be computationally simpler than the structure-dependent operation, we might expect some children to adopt it were it not precluded by Universal Grammar. However, the structure-independent rule produces incorrect question forms for more complex cases, as examples (4) and (5) illustrate.

- (4) The man who is running is bald.  
 (5) \*Is the man who — running is bald?  
 (6) Is the man who is running — bald?

Applying the structure-independent strategy to sentence (4) results in the ungrammatical question (5). The correct form (6) comes from the application of a rule that treats "the man who is running" as a constituent. It is the auxiliary verb following this constituent, the entire subject noun phrase, that must be fronted.

To discover whether children could be induced to give structure-independent responses such as (5), sentences like (7) were used.

- (7) Ask Jabba if the man who is running is bald.

Sentences like (7) evoked corresponding yes/no questions from thirty 3- to 5-year-old children. These children were enjoined by one experimenter to pose questions about a set of pictures to Jabba the Hutt, a figure from "Star Wars," that was concurrently manipulated by a second experimenter. Following each question, Jabba would be made to look at the picture and give an appropriate response. This game was used to determine whether structure-independent questions such as (5) would be produced, as opposed to correct question forms like (6).



Crain and Nakayama found that the children *never* produced structure-independent utterances. Thus, the structure-independent strategy was not adopted in spite of its simplicity and in spite of the fact that it produces the correct question forms in many instances. Crain and Nakayama also provide evidence that even children as young as three base their rule for forming yes/no questions on the syntactic properties of sentences; they do not restrict its application to referential NPs, as claimed by Stemmer (1982), who advocates a *semantic* account of the acquisition of this construction. In this connection, Crain and Nakayama's subjects proved to be totally insensitive to the semantic properties of the noun phrases they encountered, which included abstract NPs (e.g., running, love) and expletives (e.g., it, there) in addition to referential NPs (e.g., the boy). Thus, yes/no question formation proved to be an instance of the developmental autonomy of syntax.

This experiment on structure-dependence serves to sustain the modularity hypothesis. Notice that each of the criteria of a modular system is met in this aspect of language development: early acquisition of complex structures, system-internal constraints on hypothesis testing, as illustrated by the formation of yes/no questions, and informational encapsulation, in the form of the developmental autonomy of syntax and semantics. It is worth emphasizing the importance of universal constraints on grammar formation, such as structure-dependence, for language learnability. By forestalling wrong turns that might otherwise be taken, these constraints obviate the need for "negative data," which are presumably unavailable. The findings of Crain and Nakayama, then, provide striking support for the biological efficacy of Universal Grammar.

The concept of language as a modular system has implications both for the acquisition of syntax and for reading. If the language faculty is truly modular, then the primary language abilities of both good and poor readers should be in place before reading instruction begins. It is surprising that research addressing the comprehension of syntax by good and poor readers is so sparse. In the following section, we present the results of recent studies conducted by one of us on the acquisition of relative clauses by young children, and in section 3C we present a study, by the other author, that suggests that poor readers have these structures, though their processing of them is to some extent impaired.

## B. The Acquisition of Relative Clauses

Full syntactic competence is revealed by performance with complex linguistic constructions such as the restrictive relative clause. This construction is complex in its syntactic, semantic, and pragmatic properties. For instance, because it is the product of a movement transformation, it contains a superficially empty noun phrase as one of its constituents. This empty constituent must be assigned an interpretation based on some overt noun phrase elsewhere in the sentence. Difficulties of interpretation may be encountered at sites like these where movement

leaves a gap (indicated by “—” in (8)). At these positions principles of semantic interpretation must be applied. For instance, in sentence (8) the relative clause, “who we visited — in Amherst,” depends on the preceding noun phrase “the man” for its interpretation.

- (8) The man who we visited — in Amherst listens to WFCR.

Often, the head noun phrase of a restrictive relative clause refers to a set of entities in the surrounding context. Thus, a sentence like (8) would normally be used when more than one man has been introduced into the discourse. The set referred to by the general term “man” is then restricted in scope by the content of the clause; in the present example, reference is restricted to just the man who was visited in Amherst. Both of these properties of sentences containing relative clauses may contribute to processing complexity, and indeed, such sentences are frequently misinterpreted, especially by people with language impairment, like mentally retarded people (Crain & Crain, in preparation) and aphasics (Caramazza & Zurif, 1976).

The examples in (9) display four types of relative clauses, the characteristics of which are indicated by the preceding code letters. The first letter refers to the grammatical role of the noun phrase that bears the relative clause. In the first two examples the subject of the main clause is modified by a relative clause, whereas, in the last two examples, the relative clause is attached to the direct object. The second code letter refers to the grammatical role of the missing noun phrase in the relative clause. In the first and third examples, the relative clause has a missing subject. The direct object is superficially empty in the second and fourth. These varieties of relative clauses have received the greatest amount of attention in the literature (but also see deVilliers, Tager-Flusberg, Hakuta, & Cohen, 1979).

- (9) SS The dog that — chased the sheep stood on the turtle.  
 SO The dog that the sheep chased — stood on the turtle.  
 OS The dog stood on the turtle that —chased the sheep.  
 OO The dog stood on the turtle that the sheep chased —.

It is commonly believed that children even beyond the 5th year frequently misinterpret sentences with relative clauses, especially OS and SO relatives. Both Sheldon (1974) and Tavakolian (1981) found that many children would act out an OS relative, like the example above, by having the (toy) dog stand on the turtle and then chase the sheep. Tavakolian observed that this action sequence is a correct response to a sentence in which the two clauses are conjoined, as in (10).

- (10) The dog stood on the turtle and chased the sheep.

This kind of misinterpretation led Tavakolian to suggest that children younger than six have not yet developed the grammatical competence needed to comprehend syntactic structures as complex as relative clauses. She argued that the "conjoined-clause" response reflects a stage of acquisition at which children have not yet attained full competence with the hierarchical constituent structure of relative clauses. She points out further that children are already productively using conjoined clauses at the age at which they misinterpret relative clauses (cf. Brown, 1973; Limber, 1973). It was concluded, therefore, that they tend to adopt a less differentiated conjoined-clause analysis when confronted with sentences with relative clauses, until some later stage of acquisition.

Although Tavakolian's conjoined-clause hypothesis is still widely accepted, several researchers have found that children can be diverted from the conjoined-clause response to relatives by careful selection of test sentences. Solan and Roeper (1978) found that sentences containing relative clauses evoke very different error rates depending on their semantic content. Their subjects produced more errors with sentences like (11) than with sentences like (12), which contain a relative clause that can be interpreted more naturally as modifying the object of the matrix sentence rather than its subject. In addition, Goodluck (1978) found that children made fewer incorrect responses when the number of *animate* noun phrases was reduced, as in (13).

- (11) The dog kicked the sheep that jumped over the pig.
- (12) The girl petted the sheep that licked the cow.
- (13) The dog kicked the sheep that jumped over the fence.

In accord with the PDH, these findings favor a performance account, rather than a competence account, of children's errors. Given that children misinterpret only a subset of sentences bearing the same structure, a nonstructural explanation of their errors seems to be required.

A direct test of the conjoined-clause hypothesis was conducted using a picture verification paradigm (Crain, Epstein, & Long, in preparation). In this study, 3- to 5-year-old children heard sentences containing relative clauses like (14). Then they were asked to select one of two pictures, which depicted the events expressed in sentences (14) and (15). According to the conjoined-clause hypothesis, children should have preferred the picture corresponding to (15).

- (14) A cat is holding hands with a man that is holding hands with a woman.
- (15) A cat is holding hands with a man and is holding hands with a woman.

Conjoined-clause responses were evoked only 10% of the time in this task. That is, children matched sentences containing relative clauses with the appropriate pictures and not with pictures representing a conjoined clause interpretation of the sentence. This finding suggests that children's misinterpretations of OS

relatives in earlier studies should not be viewed as a reflection of incomplete syntactic development. Instead, misinterpretations in these studies were probably attributable to task complexity. By contrast, the picture verification technique appears to be a simple and direct test of comprehension. Sentences like (14), tested in this way, proved to be well within the capacity of three-year-old children.

Additional evidence that children have mastered the relative clause comes from an elicited production study by Hamburger and Crain (1982) who found that 4-year-old children consistently produced and understood restrictive relative clauses in contexts that were appropriate for them but inappropriate for conjoined clauses. These authors argue that previous research ignored what they called the "felicity conditions" on the use of relative clauses. One felicity condition is that the events depicted by the relative clause are presupposed to be true. For example, an utterance of sentence (16) is normally felicitous only if it is already known to both speaker and hearer that a particular cow has previously jumped over some contextually salient fence.

(16) The sheep pushed the cow that jumped over the fence.

A second pragmatic constraint, noted above, requires that there be a set of objects corresponding to the head noun of the relative clause. In the present example, there should be at least one other cow from whom the fence-jumper needs to be distinguished. The relative clause serves to restrict the set, in this case to the cow that jumped the fence. If this constraint is not met, i.e., if only a single cow is present, the sentence without the relative clause (i.e., "The sheep pushed the cow") would convey as much information. In the experiments cited above (that evoked high error rates), sentences like (16) were used with only one cow present in the experimental workspace. This fact alone may have resulted in poor performance by children except, perhaps, when other processing demands were sufficiently reduced. As noted, poor performance has sometimes been attributed to children's ignorance of the syntactic rules for relative clause construction. Suppose, however, that a child had mastered not only the syntax of relative clauses, but also the presuppositions associated with their use. Such a child might still be unable to relate sentences with relative clauses to the (inappropriate) circumstances provided by the experiment. Hamburger and Crain propose that the failure to satisfy presuppositions renders sentences quite unnatural in the experimental context, encouraging subjects to think of the task as unrelated to normal contextually sensitive language use. If so, their responses would not be indicative of their grammatical knowledge.

This brief review shows that different tasks and procedures lead to different conclusions about the acquisition of complex syntax. Resolution of these conflicting results is important for reaching a decision on whether the SDH or the PDH gives a better account of the source of reading difficulty. We would appeal

to the competence-performance distinction as an aid to resolve the conflict. Since performance and not competence is what is directly observed, negative findings are not necessarily indicative of children's incompetence. Though elusive, syntactic competence can be revealed in contexts that minimize semantic and pragmatic processing complexities. By eliciting successful performance in these controlled contexts, we can be confident that competence exists.

These observations underscore the need to disentangle aspects of structure and process. We have just seen that if a test sentence contains presuppositions that go unheeded in an experimental task, it cannot validly assess a subject's knowledge of syntax. The fact that syntax, semantics, inference, and so forth, are normally interwoven in discourse makes it difficult to isolate any one of these, even by experimental design. Although these methodological problems may seem obvious when pointed out, a large proportion of the existing research both on normal and language-impaired populations has paid them little heed. As a result, the research literature may give a misleading picture of the linguistic competence of young children, portraying them as ignorant of complex structures until well after the age at which reading instruction begins. Thus, much of the research appears to support the SDH. However, a reinterpretation of the empirical findings on the acquisition of syntax leads to a different conclusion. Several recent studies, which have respected the methodological problems we have been discussing, seem to show that even 3-year-old children have acquired the complex syntax denied by earlier investigators. These findings, then, support the PDH.

### C. Comprehension of complex syntax by good and poor readers

Until now we have not discussed the problems of the poor reader directly. We have presented several issues in the assessment of syntactic competence in young children, and attempted to show how these issues bear on the two hypotheses about the nature of the obstacles that lie in the way of becoming a good reader. We are now ready to apply the findings on language acquisition to the problems of learning to read with comprehension.

The literature we have reviewed on the acquisition of the restrictive relative clause has shown that very young children sometimes produce and comprehend complex syntactic structures of this sort. We know, however, from other work, including the findings presented in this section, that even much older (school-age) children who are poor readers have difficulties understanding complex spoken sentences, including those containing restrictive relative clauses. Our task in this section is to explain how the difficulties in understanding these structures might have arisen. To that end, we present the results of a recent study designed to locate the source of comprehension failures in poor readers, using a variety of sentences containing the restrictive relative clause. These studies un-

underscore many of the theoretical and methodological problems that concerned us in the preceding discussion.

In the light of the foregoing findings on young children, it is to be expected that relative clause structures should already be well established in the internalized grammars of 8- or 9-year-old children. It is conceivable, however, that even by this age some children (i.e., poor readers) may have attained only partial mastery of these structures. It is important to find out whether certain forms of relative clause structure are missing from their grammars, because, as we have argued, if poor readers were absolutely unable to comprehend some types of restrictive relative clauses, this would be strong support for the SDH.

According to the PDH the difference between good and poor readers should be one of degree. The PDH, too, would predict that poor readers would have difficulties understanding complex structures such as relative clauses, but crucially, they should not fail to comprehend them altogether. If they give the same pattern of responses as good readers, but do not achieve as high a rate of success, this would support the PDH. In this event, we would have to go on to ask what secondary processing mechanisms must be invoked to explain their difficulties.

We now discuss in some detail the results of an experiment that attempts to test directly the possibility that a certain processing deficit is responsible for poor readers' difficulties in understanding complex sentences not only in reading but also in spoken language. As we will see, the answer turns on the role of working memory in processing connected discourse. In spoken language comprehension, only structures that severely stress working memory will be expected to cause notable difficulties. We maintain that comprehension difficulties that are manifested in spoken language will be magnified in reading because reading places greater demands than speech processing on limited working memory resources. Until orthographic decoding skills are mastered and highly practiced, a reader cannot be expected to perform with print up to the ceiling set by performance in spoken language. The comparison between speech and reading is treated in the next section (3D), and at greater depth in Shankweiler and Crain (1986). See also Perfetti (1985) and Perfetti and Lesgold (1977).

Comprehension and recall of complex sentences containing four relative clause structures (as in sample sentences (9) above) were studied by Mann, Shankweiler, & Smith (1984). The children's comprehension was tested first, using a toy manipulation paradigm; on a later day, the taped sentences were presented again and rote recall was tested. Both tests were administered to the same groups of good and poor readers in the 3rd grade.

The experiment was designed to hold certain processing demands constant while varying the type of relative clause structure. Each of the test sentences mentioned three (animate) objects. As the examples in (9) illustrate, each set of test sentences mentioned the same objects, and each set contained the same ten words. Therefore, any differences in their meanings were carried by syntactic

structure. The importance of controlling sentence length in a test of this kind is well recognized. Indeed, readability formulas assume that this is the most important variable in determining ease of understanding (Dawkins, 1975). But, as we will see, structure has large effects on comprehensibility that are independent of length.

The good and poor readers in this study were compared both with respect to the kinds of errors that occurred and the way these errors were distributed between the groups. As to the kinds of errors, it was expected that a conjoined-clause response might more often be made by poor readers than by good readers. This could mean that poor readers are heavily influenced by nonsyntactic processing factors, just as younger normal children are. Alternatively, these responses could imply, as the SDH would predict, that the grammars of poor readers are less differentiated than those of normal adults and more mature children of the same age.

The way the errors are distributed is also relevant to the two hypotheses. If there exists a specific syntactic deficiency over and above the difficulties of processing, we would expect, other things being equal, to find a different pattern of accuracy between groups on the four sentence types. Figure 7.1 displays the mean errors for each of the four sentence types, separately for good and poor readers. As expected, the types were not equal in difficulty. The poor readers

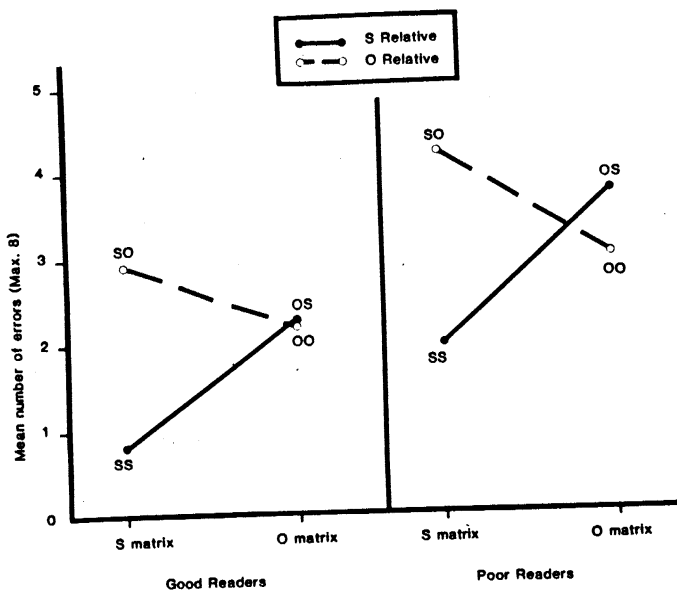


FIGURE 7.1. Mean errors of good and poor readers in the third grade on four types of relative clause constructions (from Mann, Shankweiler, & Smith, 1984).

made more errors than the good readers on each. But when the four types were ranked in order of difficulty for good and poor readers separately, the ordering was the same for both groups. The lack of statistical interaction means that the poor readers were generally worse than the good readers in comprehension of relative clause sentences, but within this broad class, they were affected by syntactic variations in the same way as the good readers. The results give no evidence, then, that the poor readers in this study were deficient on any facet of the grammar pertaining to the interpretation of these relative clause sentences. The competence they displayed was essentially like that of the good readers.

We must nevertheless account for the fact that the poor readers made somewhat more errors than the good readers on the comprehension of each type of relative clause sentence. A likely explanation is found by comparing the groups on the test of rote recall of the sentences. As we noted earlier, the taped sentences were presented to the children a second time on another day and immediate recall was tested. In working memory for the sentences, as in the previous test of comprehension, the poor readers made significantly more errors than the good readers, and, again, the differences between the groups did not favor one type of sentence more than another. These results fit well with much earlier work that indicates that poor readers do consistently less well than good readers on a variety of tests of verbal working memory (see Jorm, 1979; Mann, Liberman, & Shankweiler, 1980; Shankweiler, Liberman, Mark, Fowler, & Fischer, 1979).

In keeping with the modularity hypothesis, it is important to appreciate that the memory deficits of poor readers are largely limited to verbal material. Tests of working memory for nonverbal material, such as unfamiliar faces and nonsense designs, do not distinguish good and poor readers (Katz, Shankweiler, & Liberman, 1981; Liberman, Mann, Shankweiler, & Werfelman, 1982). Thus the failure of the poor readers to do as well as the good readers on the test of sentence comprehension is probably largely a reflection of specifically linguistic working memory limitations on the part of the poor readers. But it is a limitation on efficiency of linguistic processing and not a limitation of structural competence. To make a further test of this possibility, it will be important to find out if poor readers have a higher success rate when the same structures are placed in contexts that minimize, not just control for, processing demands (such as presuppositions and parsing) that are otherwise confounded with syntactic complexity.

Having discussed the basis of poor readers' difficulties in sentence understanding in speech, we now turn to the consequences of these problems for reading. We have cited the evidence that poor readers have special limitations in use of the verbal working memory system that supports on-line language processing. We can now guess how handicapping such a limitation must be for reading, since the poor reader is also generally slow in decoding the individual words of the text. If the individual words are read too slowly, comprehension suffers, even if all the words are read correctly, because the integrative processes are disturbed by the slow rate of input. Perfetti and his colleagues have suggested



that working memory limitations create a "bottleneck" that restricts the utilization of the higher level language processing systems, preventing proper comprehension of what is read (see, e.g., Perfetti & Lesgold, 1977).

The bottleneck hypothesis takes us some distance toward an explanation of the high correlation that has repeatedly been noted between (1) the speed and accuracy of identifying words and pseudowords in isolation, and (2) various measures of reading comprehension (Calfee, Venezky, & Chapman, 1969; Perfetti & Hogaboam, 1975; Shankweiler & Liberman, 1972). We view this correlation as a particularly strong indication that a low-level deficit can give rise to apparent deficits at higher levels. Because syntactic structure and propositional content are conveyed by sequences of words, it is generally supposed that working memory is needed for sentence comprehension, whether by speech or by reading. Since the verbatim record of incoming speech or printed text is extremely fleeting, the input to the working memory system is lost unless it is rapidly converted into a more durable form (Sachs, 1967). Because the working memory representation is so brief in duration and so limited in span, it has been proposed that the sentence parsing mechanism works rapidly on small chunks of text to decode linguistic information into more durable memory representations (Frazier & Fodor, 1978; Liberman, Mattingly, & Turvey, 1972).

We conclude this section with some remarks on the role of context in determining whether or not a sentence will be understood. Consider first the role context plays in spoken language comprehension. It was seen that children who are poor readers sometimes fail to comprehend spoken sentences that impose heavy processing demands on working memory. It was not easy, however, to demonstrate that poor readers are not as adept as good readers in sentence processing. The problems of the poor reader are ordinarily well-masked; they are revealed only under rather stringent conditions of testing, without contextual supports, in the "null context" (see Crain & Steedman, 1985). The difficulty in bringing these problems to light should not surprise us. Under ordinary conditions, listeners do have contextual support. It is only when we artificially deprive poor readers of this support that they are apt to fail. When support is available, 10-year-old poor readers display clear ability to benefit from it (Perfetti, Goldman, & Hogaboam, 1979). This too is not surprising. We have shown that even 3- and 4-year-old children are able to understand complex sentences in appropriate contexts.

In reading, the situation is complicated by the demands of orthographic decoding. It is obvious that young poor readers have a problem in comprehending complex sentences that are set down in print. But why can't they use context here as effectively as they do in perception of spoken sentences? Our response is that a working memory limitation has a more profound effect on reading comprehension than on comprehension of speech. As noted earlier, the beginning reader is required to develop a whole new apparatus for word recognition, incorporating a set of rules for getting from the orthography to preexisting lexical entries. Until

the rules and the strategies for invoking their use are automatized, the would-be reader cannot use syntactic and pragmatic context effectively, because nearly the whole of the processing capacity is consumed by lower-level functions. This, we assume, is the point of the bottleneck hypothesis of Perfetti and his associates. The remainder of this section is concerned with working out the detailed implications of poor readers' lower-level deficits for performance on sentence processing tasks.

#### D. Consequences of a Low-Level Deficit for Higher-Level Processing

The preceding section gives a rough sketch of the source of comprehension difficulties that plague the beginning reader and many others who, though no longer beginners, are still struggling to gain mastery. If our analysis is on the right track, we have now moved beyond the stage of identifying correlates of reading difficulties. To the extent that we now have the beginnings of a theory, we stand in a position to make fairly detailed predictions about what will be difficult for children to read and to offer tentative suggestions about how these difficulties might be circumvented.

Since our concern here is with sentence understanding, our predictions involve syntactic structures and the mechanism that invokes them. We have no reason to suppose that different mechanisms perform this function in reading than in speech. But the bottleneck hypothesis anticipates that the syntactic parsing mechanism will be less efficient in reading at the early stages, when the reader is preoccupied with the identification of words in print. The poor beginning reader, as we saw, labors under a double handicap, since he or she has less than normal working memory capacity to begin with. In this section we discuss two ways that a working memory deficit may affect syntactic parsing: limitations in the use of syntactic parsing strategies, and the consequent overreliance on nonsyntactic parsing strategies.

The syntactic parser is a processor that tends to favor certain structures where more than one grammatical possibility exists partway through a sentence. Demonstrated parsing preferences have been used as an indicator of the relative complexity of syntactic structures. The subject's resolution of structural ambiguities is accomplished by decision-making strategies. Parsing strategies are used on line for ambiguity resolution, but they do not always result in the adoption of the correct structural analysis. When a listener or a reader is led to expect one particular syntactic organization by the first part of the sentence but is later required to reinterpret the structure, one might say that the perceiver has been led down a "garden path." As a consequence of limited working memory storage we would expect poor readers to show greater susceptibility to garden path effects.

Eye movements in reading can reveal these garden path effects, in the view of

Frazier and Rayner (1982). These investigators measured eye fixation times during sentences that would demand restructuring if the syntactic parsing strategy "Minimal Attachment" was being used (Frazier & Fodor, 1978). This is a parsing strategy that induces the reader to resolve local ambiguities most economically, by using the fewest possible nonterminal nodes in the constituent structure being assigned to the fragment of the sentence currently under analysis. Minimal Attachment predicts that a garden path will be pursued in example (17).

- (17) John believed the big burly policeman was lying.

The minimal analysis of the noun phrase beginning "the big . . ." would assign it the grammatical role of Direct Object of "believe." But "believe" also permits a Sentential Complement, and, in this example, the phrase "the big burly policeman was lying" serves this grammatical role. Since sentence parsing strategies are applied on-line, according to Frazier and Fodor, the Direct Object analysis should be pursued first, producing a garden path effect when the word "was" is encountered, since it is this word that indicates the necessity for reanalysis.

Investigation of eye movements in reading sentences like (17) revealed that eye fixations are prolonged on the word that was predicted to initiate reorganization, indicating that the Minimal Attachment analysis had been adopted (Frazier & Rayner, 1982). Measurement of eye movements is useful not only in evaluating models of the sentence processing mechanism by which structural ambiguities are resolved, but it can also potentially inform us about differences in the use of this mechanism by good and poor readers. One testable hypothesis, using the eye-fixation tracking technique, is that poor readers are less likely than good readers to recover from garden paths because of their working memory limitations (see Shankweiler & Crain, 1986, for further discussion of this hypothesis).

The need for working memory in sentence processing might seem to be vitiated by parsing strategies, such as Minimal Attachment, that have the parser operate on small segments of speech or text. In our view, however, the existence of on-line strategies strengthens, not weakens, the argument that working memory plays an essential role in language processing. As Frazier and Fodor (1978) point out, the fact that verbal working memory decays rapidly and has limited capacity requires parsing decisions to be made quickly. Since for many poor readers, working memory limitations are even greater than normal, we would expect them to be more dependent on these on-line strategies for ambiguity resolution.

Overreliance on nonsyntactic processing strategies is another expected manifestation of a working memory limitation. For example, upon encountering a pronoun in extended text, the reader must initiate a search for a referent. Although there are syntactic constraints on which noun phrases can serve as legitimate antecedents (Lasnik, 1976), we expect working memory limitations to lead

poor readers to adopt nonsyntactic strategies based on proximity rather than hierarchical structure. In a recent study of this problem, it was found that poor readers tend to rely on a minimal distance strategy more often than good readers in determining the reference of reflexive pronouns, although the difference did not reach significance statistically (Shankweiler, Smith, & Mann, 1984).

It is worth emphasizing again that even rigid adherence to a structure-independent strategy by poor readers would not necessarily be indicative of syntactic incompetence, since there are so many other factors besides syntax involved in sentence understanding. Parsing preferences must be neutralized or factored out when the objective is assessment of active mastery of a particular syntactic structure. It is crucial that a subject's proclivity to use one structure at the expense of another must not be taken uncritically to indicate an incapacity to use the latter (Crain & McKee, 1986; Hamburger & Crain, 1984; Lasnik & Crain, 1985).

#### 4. SUMMARY AND CONCLUSIONS

Previous research extending across languages and cultures indicates that the abilities that distinguish successful and unsuccessful readers are primarily in the language domain and not in the general cognitive domain, or in visual processing (Katz, Shankweiler, & Liberman, 1981; Liberman et al., 1982; Liberman & Shankweiler, 1985). Our focus, within this domain, has been on the relevance of syntactic complexity to reading acquisition and difficulties in comprehending text. We argued that in order to understand the special problems of comprehension in reading, we must address the problems of sentence understanding more broadly, by considering comprehension of speech as well. In pursuing these questions about the nature of syntactic complexity, we appealed to the distinction between structure and process, a distinction that enabled us to identify two possible sources of linguistic complexity in understanding spoken and written sentences. On one view, linguistic structures are taken to be ordered in complexity; on the other, it is not the structures themselves that make comprehension difficult, but the demands these structures make on the subsidiary processing mechanisms, especially verbal working memory.

Distinct predictions about the course of language acquisition arose from the different views of linguistic complexity. On the one hand, by adopting the thesis that language is a self-enclosed system, a module, the PDH predicts rapid acquisition of complex structures. On the other hand, a premise of the SDH is that some structures are inherently more complex than others. This would lead one to predict gradual, staged acquisition. These different conceptions of the course of language acquisition, in turn, yield different ways of viewing the problems of the beginning reader and the older unsuccessful reader. The SDH holds that these groups may not have acquired some of the language structures needed for learn-

ing to read successfully. The alternative is that the beginning reader has the language structures but has not yet managed to construct an efficient interface between these preexisting structures and the orthography, nor is he able to integrate the words of the text into higher order structures because of limitations on working memory. Each hypothesis can account for most of the basic facts about reading, and indeed, each often makes the same predictions. However, they identify different causes for failure to comprehend complex sentences, and these difference are amenable to empirical test.

Having developed the predictions, the next step was to examine the relevant empirical findings. First, it was shown that complex structures such as restrictive relative clauses and yes/no questions could be elicited successfully from children as young as three. These studies supported the rapid-acquisition scenario that the modularity hypothesis predicts and offered no support for the alternative staged-acquisition view. This led us to the second step in our argument. We asked whether subsidiary language mechanisms and not the language structures themselves might be the source of observed difficulties in the comprehension of complex syntax in reading. We expected the early stages of learning to read to be the most revealing. Accordingly, we sought an answer to this question by examining good and poor readers in the early grades. Studies of good and poor readers were presented that confirmed earlier claims that poor readers have difficulties in understanding complex sentences even when presented in spoken form. But these studies went on to suggest that the source of these difficulties was not a syntactic deficit as such. Instead, we found that good and poor readers were distinguished in efficiency of working memory, a subsidiary processing mechanism, rather than in syntactic competence. It is not clear whether the limitation is in the capacity of working memory per se, or whether it is in the "executive" or control component (Baddeley & Hitch, 1974). In Shankweiler and Crain (1986) we speculate that the control component of verbal memory is the site of the primary problem. In all events, the memory constraint would be expected to show up beyond sentence boundaries, for example, in relating pronouns to their antecedents.

In the preceding section, we examined the implications of working memory limitations of the poor reader for the reading process itself. Building on the bottleneck hypothesis of Perfetti and his associates, we explained how a working memory limitation could be expected to inhibit higher-level processing of text, by slowing word decoding and making it less accurate. This perspective tells us why poor readers are far less able to understand complex sentences in print than in speech, and it also explains their difficulties with spoken language. Finally, this hypothesis yields fairly specific predictions about the strategies for syntactic parsing on which beginning readers and poor readers should be expected to rely (although the research to test these predictions has not yet been done).

It follows from the bottleneck hypothesis that if our goal is to increase reading comprehension in beginning readers and unsuccessful readers, the first priority is

to improve skills in recognizing printed words. It was argued that deficits implicating lower-level components in the structural hierarchy may have important repercussions at higher levels. In this connection, we would add that there is evidence that the abilities that underlie word decoding can be successfully taught at any age (see Liberman & Shankweiler, 1985; Liberman, Shankweiler, Blachman, Camp, & Werfelman, 1980). If we are correct in our other conclusion that the syntactic structures needed for sentence interpretation are already in place long before children actually encounter these structures in print, then the main thrust of efforts to improve reading should be directed to the inculcation of those lower-level skills that pertain to use of the orthography. Only then can the working memory system be used effectively to gain access to the higher level syntactic, semantic, and pragmatic structures.

The position we have developed has definite implications, we believe, for the design and evaluation of appropriate text materials for beginning readers. It has long been appreciated that the beginning reader has special needs, but what these needs are has often been misunderstood. If the acquisition of the relative clause is indicative of the syntactic capacities of beginning readers, we should suppose that text designed for beginners need not simplify sentence structure. Since, in fact, the child of five or six is producing complex sentences in appropriate contexts, the avoidance of these complex structures in the text would likely be perceived as unnatural.

The findings we presented on early acquisition of complex structures suggest a caution, however. Complex syntactic structures, when used in reading materials, should appear in contexts that satisfy the presuppositions on their use, if good comprehension is to be achieved. We have seen that children as old as ten may have difficulties comprehending some sentences containing relative clauses, when these presuppositions are not met. One can expect, then, that without contextual supports, young children will often fail to display successful comprehension, but with these supports even texts containing complex syntactic structures may be read with understanding.

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