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COMPREHENSION PROCESSES IN READING

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LEA LAWRENCE ERLBAUM ASSOCIATES, PUBLISHERS
1990 Hillsdale, New Jersey Hove and London

25 EXPLAINING FAILURES IN SPOKEN LANGUAGE COMPREHENSION BY CHILDREN WITH READING DISABILITIES

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INTRODUCTION

For some years our research has had the broad aim of understanding the processes whereby the language apparatus, which is biologically specialized for speech, becomes adapted to accept orthographic input. Only with such basic knowledge in hand can we hope to discover why some children fail to learn to read, and only then can we meet the challenge of effective prevention and remediation. Early work of the research group at Haskins Laboratories centered on the role of awareness of phonological segments in learning to read in an alphabetic system. It soon became evident that children who are failing to learn to read have a range of problems in the phonological sphere. In addition to problems in segmental awareness, poor readers have difficulties in naming objects, in processing speech under difficult listening conditions, and they are slower and less accurate in producing tongue twisters. The co-occurrence of these problems suggested that the nature of the children's difficulty in learning to read might lie in the underlying phonological processes themselves (Liberman & Shankweiler, 1985; Liberman, Shankweiler, & Liberman, 1989).

If the fault is in phonological processes, poor readers would also be expected to have difficulties in working memory, as this form of memory relies heavily on coding based on phonological structure (Baddeley, 1966; Conrad, 1964; 1972). The memory limitations of poor readers have been noted time and again on a variety of measures that tax the phonological aspects of language processing. Some of these measure have been shown to have predictive value, singling out preschool children who will develop reading problems later. (By "poor readers" we mean those children who show a marked disparity between their measured reading skill and the level of performance that could be expected given their [normal] intelligence and opportunity for instruction. Our research compares performance by these children with age-matched controls – children who are proceeding at the expected rate in the acquisition of reading skills.)

The hypothesis that reading disability reflects a limitation in phonological processing is challenged by two findings that have emerged from the classroom as well as the laboratory. One is that some children fail to comprehend a sentence in text even when they manage to decode all the words it contains. A second challenge to a phonological explanation is the finding that some children who are poor readers fail to correctly comprehend certain sentences, in particular those with complex syntactic structure. These difficulties would seem to implicate language problems beyond the level of phonology, possibly originating in the syntactic component of language. Our recent research has taken up these challenges to the phonological explanation.

Because the question is so important, we have devoted much effort to exploring the possibility that some poor readers have underlying problems that are *not* phonological in origin. In this chapter we focus on poor readers' ability to comprehend spoken sentences. Although the findings are not wholly consistent – a few studies have failed to turn up evidence of reader group differences (e.g., Shankweiler, Smith, & Mann, 1984; Vogel, 1975) – there is evidence that good readers are significantly more accurate than age-matched poor readers in comprehension of spoken sentences with relative clauses, temporal terms, and adjectives with exceptional control properties (Byrne, 1981; Mann, Shankweiler, & Smith, 1984; Smith, Macaruso, Shankweiler, & Crain, 1990). The indications that poor readers do not always comprehend spoken sentences as well as good readers lend support to the possibility that limitations in phonological processing is only one of the barriers to comprehension.

It must be underscored that the comprehension difficulties noted in poor readers are typically restricted to sentences containing complex syntactic structures. From these observations it has often been inferred that the problem structures are absent or incompletely represented in the grammars of many poor readers (e.g., Byrne, 1981; Stein, Cairns, & Zurif, 1984). As each of these structures has been claimed to be late-emerging in the course of language development, it has been proposed that many poor readers are in some sense language delayed. Our research has sought to test a version of this hypothesis that holds that these poor readers suffer from a developmental lag in *syntactic* knowledge. We have called this the *structural lag hypothesis*.

The structural lag hypothesis has a great deal to recommend it. It explains why many children who experience difficulty learning to read also suffer in spoken language comprehension. It also explains why their comprehension difficulties are selective; poor readers should fail to comprehend those linguistic constructions that emerge late in the course of language development but should be the equals of good readers in comprehending early-appearing constructions. As these observations suggest, the structural lag hypothesis is tied to an assumption about the course of language acquisition and to an assumption about linguistic complexity. It supposes that certain linguistic structures develop before others, with the order of acquisition determined by the relative complexity of the structures.

The structural lag hypothesis draws support from some classical studies in language acquisition that find the late emergence of sentences with temporal terms, relative clauses, and adjectives, such as *easy* as in *The doll is easy to see* (C. Chomsky, 1969; Clark, 1970; Sheldon, 1974). In light of these findings from research on child language, the hypothesis can readily explain the observed differences between good and poor readers on spoken sentences involving these constructions. As we saw, comprehension problems are anticipated on late-emerging structures that are beyond the developmental level of poor readers.

It is important to recognize, however, that by allowing at least two basic deficits in poor readers the structural lag hypothesis abandons a unitary explanation of reading disability. The limitations of poor readers in comprehension of spoken sentences are seen to be independent of their deficits in analyzing phonological information. We have proposed an alternative hypothesis that attempts to explain the entire symptom complex of poor readers, including their difficulties in spoken sentence comprehension, as a consequence of deficient phonological processing. We call this the *processing limitation hypothesis* (see also Shankweiler & Crain, 1986; Shankweiler, Crain, Brady, & Macaruso, in press).

To explain how the difficulties in understanding spoken sentences might be derived from deficient phonological processing, a few remarks are in order about our conception of the architecture of the language apparatus. Within this framework it is explained how the failures of poor readers to comprehend sentences can be directly related to their limitations in processing at the phonological level. Then we turn to the laboratory to present evidence in support of the view that the differences between good and poor readers in spoken language comprehension are a manifestation of their differences in ability to process phonological structures.

COMPREHENSION AND THE LANGUAGE APPARATUS

We hold that language processing is accomplished by a biologically coherent system in isolation from other cognitive and perceptual systems. In contemporary terms, language forms a module (Fodor, 1983; Liberman & Mattingly, 1989). We extend this notion of modularity to differentiate subcomponents of the language faculty (Forster, 1979). We see the language apparatus as composed of a hierarchy of structures and processors. The structures include the phonology, the lexicon, syntax, and semantics. Each level of structure is served by a special-purpose processing mechanism, or parser. A parser consists of algorithms for accessing the rules used to assign structural representations, and it may also contain mechanisms for resolving ambiguities that may arise.

We assume that the transfer of information within the language apparatus is unidirectional, beginning at the lowest level with phonological processing and proceeding upward to the syntactic and semantic parsers. A further assumption is that, in the course of sentence processing, the entire system works on several levels in parallel, with the operations of the various components interleaved in time, rather than in strict sequence. This permits the system to function on-line. The responsibility of synchronizing the transfer of information between levels is relegated to the verbal working memory system. Given the prominent role that this system plays in explaining the symptom complex of disabled readers, it will be worthwhile to describe our conception of working memory in slightly more detail.

The Verbal Working Memory System

Along with other researchers, we envision the verbal working memory system as having two parts (e.g., Baddeley & Hitch, 1974; Daneman & Carpenter, 1980). First, there is a storage buffer, where rehearsal of phonetically coded information takes place. This buffer has the properties commonly attributed to short-term memory: It can hold linguistic input only briefly, perhaps just for a second or two, in the order of arrival, unless the material is maintained by continuous rehearsal. The limits on capacity of the buffer mean that information must be rapidly encoded in a more durable form, beginning with phonological processing, if it is to be retained for subsequent analysis at higher levels of the language apparatus.

The second component of working memory is a control mechanism, whose primary task is to relay the results of lower-level analyses of linguistic input upward through the system. To keep information flowing smoothly, the control mechanism must avoid unnecessary computation that would stall the rapid extraction of meaning. We would speculate that the language faculty has responded to limited working memory capacity by evolving special-purpose parsing mechanisms. The parsers organize information (and resolve ambiguities), which the control component of working memory then shunts upward to the next level of the system, allowing the previous contents of the parsers to be abandoned. Rapid on-line parsing, in turn, explains how individuals with drastically curtailed working memory capacity – capable of retaining only two or three items of unstructured material – are sometimes able to comprehend sentences of considerable length and complexity (Martin, 1985; Saffran, 1985).

To see what is most costly of memory resources, we have found it useful to consider situations that are amenable to straightforward transfer of information between levels (Crain, Shankweiler, Macaruso, & Bar-Shalom, 1990; Hamburger & Crain, 1987). In the simplest case: (a) each well-formed fragment of language code at lower levels of representation is associated with a single constituent of code at higher levels; (b) the fragments of code at each level can be concatenated to form the correct representation of the input; (c) the fragments can be combined in the same order that they are accessed; and (d) each fragment is processed immediately after it is formed, permitting the source code to be discarded. These four conditions form a straightforward translation process of sequential look-up-and-concatenation familiar in the compiling of programming languages. However, all these conditions are rarely met in ordinary language. And when they are not, the computations involved in reaching the target code, for example, the semantic interpretation of a sentence, could stretch the resources of verbal working memory.

We are now prepared to show how the various difficulties manifested by poor readers can be explained in terms of the functional architecture of language. A modular view of the language apparatus raises the possibility that a deficit at the level of phonology may be the source of the entire complex of language-related deficits that characterize reading disability. As the other features of the symptom complex can be seen as stemming from a phonologic-based deficiency, the task that remains is to explain how the difficulties that poor readers encounter in spoken language comprehension also implicate the phonological component.

Put simply, our account is as follows. We saw that the regulatory duties of working memory begin at the lowest level by bringing phonetic (or orthographic) input into contact with phonological rules for word-level analysis. In our view, this is the site of constriction for poor readers. One thing leads to another: A low-level deficit in processing phonological information creates a bottleneck that impedes the transfer of information to higher levels in the system. In other words, the constriction arises because in language processing the bottom-up flow of information from the phonologic buffer is impeded by the difficulties in accessing and processing phonological information. Therefore, all subsequent processes in the language system will be adversely affected. (Perfetti, 1985, presents a similar proposal.)

TESTING COMPETING HYPOTHESES ABOUT THE SOURCE OF COMPREHENSION FAILURES

Much of our recent research has centered on testing alternative explanations of the sentence comprehension problems of poor readers. Our research strategy has two components. First, we have investigated structures that are thought to emerge late in the course of normal language acquisition. Then, for each construction we designed a pair of tasks that vary memory load while keeping syntactic structure constant. If reading disability stems from a structural lag, then children who have reading problems should perform poorly on both tasks. But according to the processing limitation hypothesis, poor readers should have greater difficulty than their age-matched controls only in tasks that place heavy demands on working memory, whatever the inherent complexity of the pertinent linguistic structures. When the same test materials are presented in tasks that minimize processing load, poor readers should do as well as good readers.

The early emergence of grammatical competence by both good and poor readers follows, in part, from our adherence to the theory of Universal Grammar. Universal Grammar maintains that many basic organizational principles of linguistic structure are innately specified (N. Chomsky, 1965, 1981). In keeping with the precepts of the theory, acquisition of syntactic structures seems to be essentially complete by the time instruction in reading and writing begins. The early emergence of syntax is seen to be a consequence of the innate specification of many syntactic principles that either come prewired or are subject to rigid system-internal constraints on grammar construction (see Crain & Fodor, 1989, for a sample of empirical research). As syntactic structures are largely built into the blueprint for language acquisition, it follows that inherent complexity of grammatical structures, as such, will not be a source of reader group differences (Crain & Shankweiler, 1988). Poor readers will be at a disadvantage, however, in contexts that stress verbal working memory.

Comprehension of Temporal Terms

To illustrate how we have tested the competing hypotheses, let us consider one way that linguistic input can deviate from the simple look-up-and-concatenate procedure that is hypothesized to impose minimal demands on working memory. Recall that condition (c) of this best-case scenario would have the order of the linguistic input mirror the order in which it is composed into structural representations at higher levels. We will call a violation of this condition a *sequencing problem* (Crain, 1987). A sequencing problem arises in sentences containing temporal terms such as *before* and *after*. These terms explicitly dictate the conceptual order of events, but they may present problems of sequencing if the order in which events are mentioned conflicts with the conceptual order. This kind of conflict is illustrated in sentence (1). Note that the order in which the events are mentioned in the sentence is opposite to the order in which one would respond to the request.

1. Push the motorcycle after you push the helicopter.

It is reasonable to suppose that sequencing problems exact a toll on the resources of working memory because both clauses must remain available long enough to enable the perceiver to formulate a response

plan that represents the conceptual order. The conceptually correct response requires the formation of a two-slot template and a specification of the sequence in which the two actions are to be carried out. The information in both clauses must be held in memory long enough to put the first-mentioned action into the second slot.

There is evidence from research on language acquisition that this kind of deviation from the simple translation process is costly to working memory resources. Several studies have found that young children frequently misinterpret sentences like (1) by acting out their meanings in an order-of-mention fashion (Clark, 1970; Johnson, 1975). This response presumably reflects the simple translation process that children adopt as a default procedure for interpreting sentences that exceed their memory capacity.

An alternative explanation of the difficulties that children encounter with such sentences has been offered, however. It has been suggested that children's order-of-mention response to sentences like (1) reflects the absence in child grammar of structural knowledge that is essential to comprehension of sentences with temporal terms. This interpretation of children's errors is buttressed by the finding that they have difficulty with temporal term sentences like (1), which pose conflicts between order-of-mention and conceptual order, and not with sentences with similar meaning but with simpler syntax such as the coordinate structure sentence in (2) (Amidon & Carey, 1972).

2. Push the motorcycle last; push the helicopter first.

However, we have questioned the assumption that sentences (1) and (2) are equivalent in meaning. Earlier studies which obtained differential responses to (1) and (2) failed to control for a presupposition that is present just in sentences like (1) (Crain, 1982; Gorrell, Crain, & Fodor, 1989). The presupposition associated with this sentence is that the hearer intends to push a helicopter. To satisfy this presupposition, the subject should have established this intention *before* the command in (1) is given. A procedure that allows subjects to establish in advance their intent to perform the action mentioned in the clause introduced by the temporal term was incorporated into a study by Crain (1982). Children are asked, before each test sentence is presented, to identify one object they want to play with in the next part of the game. The experimenter subsequently incorporates this information in the subordinate clause introduced by the temporal term. For instance, sentence (1) would have been presented only after a subject had selected the helicopter, which makes the use of the temporal term felicitous.

When young children were given this contextual support, they displayed unprecedented success in comprehending sentences with temporal terms. Thus, the mistake in research that resulted in high error rates was to present sentences like (1) in the null context, which fails to satisfy the presupposition inherent in the use of temporal terms. In the null context, un-met presuppositions must be accommodated into the listener's mental model of the discourse setting (Lewis, 1979). Compensating for un-met presuppositions requires the hearer to revise his or her current mental model (to make it match the model of the speaker). The process of revising one's model of the discourse is seen to highly tax processing resources (see Crain & Steedman, 1985; Hamburger & Crain, 1982). If this reasoning is sound, children's grammars should be exonerated from responsibility for the errors that occurred in research that failed to satisfy the presuppositions of the test sentences.

Returning to the comprehension problems of poor readers, we saw that according to the processing limitation hypothesis their performance should suffer appreciably in contexts that tax working memory. It seems reasonable to suppose, therefore, that poor reader's special limitations in working memory would cause them to have greater difficulty than good readers in processing sentences containing temporal terms *if they are presented in the null context.* However, the processing limitation hypothesis would anticipate that both good and poor readers would display a high rate of successful comprehension in felicitous contexts. The structural lag hypothesis, on the other hand, would anticipate the same differences between good and poor readers both with and without contextual support, because lightening the burdens imposed on working memory should not result in improved comprehension of a structure that is absent from a child's internal grammar.

We investigated these contrasting predictions in a figure-manipulation task in which sentences with temporal terms were auditorily presented to good and poor readers (Macaruso, Bar-Shalom, Crain, & Shankweiler, 1989). Our experiment was designed to exacerbate the processing load on both reader groups by including an additional prenominal modifier in half of the test sentences. As exemplified in (3), the main clause of these sentences contained complex NPs with an ordinal quantifier (*second*) and a superlative adjective. Adjectives combine to introduce added complexity to the plan that one must formulate in order to respond accurately to the sentence. The remaining test sentences contained simple NPs, that is, with no additional ordinal modifier in the main clause, as in (4).

3. Push the *second smallest horse* before you push the blue car.
4. Pick up the *largest truck* after you pick up the blue horse.

The stimuli consisted of 16 sentences with the temporal terms *before* and *after*. Four sentences were presented in which the order-of-mention of events was the same as the conceptual order, as in (3). In the remaining 12 sentences, the order of mention was opposite to the conceptual order, as in (4). Children encountered the test sentences in two contexts: one that satisfied the presupposition associated with the use of temporal terms, and one that did not (the null context).

As anticipated, poor readers performed less well overall than good readers in acting out sentences containing temporal terms. However,

by satisfying the felicity conditions and thereby reducing memory demands, we obtained a significant reduction in errors for both groups combined. Moreover, the satisfaction of presuppositions benefited poor readers more than good readers. This lends credence to the hypothesis that, without contextual support, poor readers' limitations in working memory are exacerbated. However, the poor readers performed at a success rate of 82.4% when the felicity conditions were satisfied, even when half of the test sentences contained complex NPs. This calls into question the claim of the structural lag hypothesis that poor readers lag in their mastery of complex syntactic structures.

Further support for a processing interpretation of poor readers' comprehension difficulties comes from the finding that poor readers were more adversely affected by changes in NP complexity than good readers. The special problems that poor readers had with the complex NP sentences presumably reflect the fact that these sentences are more taxing on working memory resources, as discussed earlier.

Additional evidence of processing difficulty was obtained when we compared responses to the two types of sentences that present a conflict between order-of-mention and conceptual order. Notice that the presence of a temporal term in the initial clause eases the burden on working memory by indicating in advance that a two-slot template is required, as in (5). Here, the use of *before* in the initial clause delays execution. This contrasts with the corresponding sentences with *after*, such as (6), where the temporal conjunction is contained in the second clause.

5. Before you push the helicopter, push the motorcycle.
6. Push the motorcycle after you push the helicopter.

Based on the account of working memory that we have proposed, we would predict the sentences with *after* to be harder, because the subject has no warning that information should be maintained in memory while awaiting subsequent material. As expected, poor readers were least successful in responding to *after* sentences that presented a conflict between order-of-mention and conceptual order and no contextual support in the form of satisfied presuppositions. Good readers, on the other hand, were not as handicapped by the memory demands imposed by these sentences.

Taken together, the findings of the experiment by Macaruso et al. (1989) indicate that, as processing demands are increased, poor readers' performance involving temporal terms sentences is eroded much more than good readers' performance. Decreasing processing demands, either by satisfying the felicity conditions or by using less complex NPs, elevates performance by poor readers such that group differences diminish. In the best case, both reader groups perform at a high level of success.

Comprehension of Garden Path Sentences

Another way to address the question of a processing limitation versus a structural deficit is to examine the pattern of errors across constructions for each reader group. A processing limitation, and not a structural deficit, can be inferred if both reader groups reveal a similar pattern of errors across sentence types. Pursuing this research strategy, another study (Crain et al., 1990) asked how good and poor readers would respond to the kind of garden path sentences that are created when listeners follow a parsing strategy for resolving structural ambiguities, called *right association* by Kimball (1973) and *late closure* by Frazier (1978).

Late closure encourages listeners or readers to connect an incoming phrase as low as possible in the phrase marker that has been assigned to the preceding material. It seems reasonable to suppose that this parsing strategy reflects the functional architecture of the language apparatus, which has many computations to perform and little available space for their compilation and execution. Although strategies such as this may have evolved to enable the parser to circumvent the limitations of working memory, they may introduce new problems of their own, because the decision dictated by a strategy may turn out to be incorrect in light of subsequent input. Clearly, recovery from these so-called garden paths is possible only within the limits of working memory, because these limits determine whether the grammatically correct analysis is still available. Because sentences that tax working memory heavily have been found to present special difficulties for poor readers, they should be less able than good readers to recover from garden paths prompted by late closure.

We tested this prediction by asking good and poor readers to respond to several types of garden path sentences. In each of these, the parse favored by late closure tempts one to make an ungrammatical analysis, in which the extraction of the *Wh*-phrase violates a putatively innate constraint called *subjacency*. Subjacency establishes the boundary conditions on the movement of *Wh*-phrases in the formation of questions. Specifically, it prohibits movement over more than a single bounding node (NP or S in English). One consequence of subjacency is that *Wh*-phrases cannot be extracted out of complex NPs like those in the test sentences in this study, which were taken from Crain and Fodor (1986).

Three types of garden path sentences were created. These varied in severity of processing load. The subsequent examination of the error pattern by the two reader groups across sentence types was used to distinguish between the competing hypotheses about the source of comprehension difficulties in poor readers. The different syntactic constructions are illustrated in (7) - (9).

7. Prepositional Phrase (deep):
   What is Jennifer drawing a picture of a boy with?

8. Prepositional Phrase (distant):
   Who is Susan handing over the big heart-shaped card to?
9. Relative Clause:
   Who is Bill pushing the cat that is singing to?

Sentence (7) is labeled "deep" because the origin of the extracted *Wh*-phrase is a prepositional phrase that is embedded in an NP which is itself embedded in an NP. This contrasts with the "distant" case (8), in which there is only one level of embedding. Although the sentences are matched for length, we anticipated that distant prepositional phrase sentences would be easier to process than either the deep prepositional phrase sentences or relative clause sentences like (9). The depth of syntactic embedding in both relative clause and deep prepositional phrase sentences means that they deviate more than the distant sentences from the simple look-up-and-concatenate translation process.

On each trial, subjects were asked to listen carefully to a tape-recorded set of sentences that described a scene depicted in a large cartoon drawing placed in front of them. Immediately following the description, they were asked to respond to a question about some aspect of the drawing. For example, the context sentences in (10) preceded the test question (9).

10. Bill's father is waiting for Bill to bring him the cat. The cat loves to sing and has made up a song for his toy mouse.

The grammatically correct response to this question is "his father". The response "the mouse" is incorrect, because it represents an apparent violation of subjacency. The processing limitation hypothesis would argue that an examination of the pattern of errors across sentence types for each group may provide evidence that these errors are not actually violations of subjacency; instead, they are the result of the processing burdens these sentences impose on working memory. The structural lag hypothesis makes no definite predictions about the pattern of responses by good and poor readers for any of the sentence types presented in this experiment. It seems reasonable to suppose, however, that under this hypothesis we might anticipate a different response profile for good and poor readers, as these sentences incorporate exceedingly complex structures.

To reiterate, the processing limitation hypothesis predicts that both groups will manifest a similar pattern of errors across sentences of varying syntactic types, with poor readers penalized to a greater degree than good readers on sentences that are most costly to working memory resources (e.g., the deep prepositional phrase and relative clause sentences). This is exactly what we found. There was a general decrement in performance by poor readers, but both good and poor readers responded in a similar way to these different linguistic constructions (see Figure 25.1).

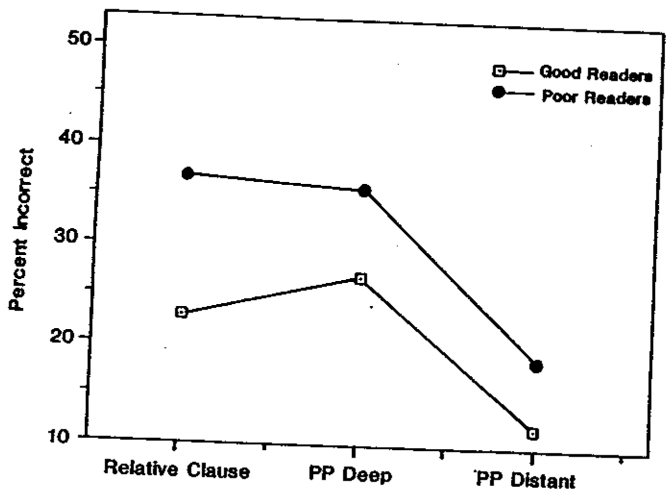

FIGURE 25.1. Percentage of incorrect responses to garden path sentences.

Detection and Correction of Ungrammatical Sentences

An experiment by Fowler (1988) deserves mention as another significant effort to disentangle structural knowledge and processing capabilities in beginning readers. Preliminary tests were administered to assess children's phonological awareness, working memory, and spoken sentence understanding. As in earlier work, there were clear-cut correlations with measures of reading. But in addition, children were compared on a grammaticality judgment task and a sentence correction task. The judgment task is presumed to place minimal demands on working memory, so it was used to establish a baseline of the subjects' structural knowledge for subsequent comparison with the correction task. The expectation that grammaticality judgments do not stress working memory is motivated in part by recent research showing that, despite severe memory limitations, agrammatic aphasic patients are able to judge the grammaticality of sentences of considerable length and syntactic complexity (Linebarger, Schwartz, & Saffran, 1983; Saffran, 1985; Shankweiler, Crain, Gorrell, & Tuller, 1989). These findings suggest that this task directly taps the syntactic analysis being assigned. In the correction task, subjects were asked to change ungrammatical sentences (taken from the judgment task) to make them grammatical. Clearly, correcting grammatical anomalies requires the ability to hold sentences in memory long enough for reanalysis.

According to the processing limitation hypothesis, both good and poor readers should do equally well on the grammaticality judgment task, but differences should occur on the correction task. This is exactly

what Fowler (1988) found. Reading ability was significantly correlated with success on the correction task but not with success on the judgment task. This is further support for the view that processing complexity, and not structural complexity, is a better diagnostic of reading disability. Two additional findings bear on the competing hypotheses about the causes of reading failure. First, the level of achievement on grammaticality judgments was well above chance for both good and poor readers, even on complex syntactic structures (e.g., *Wh*-movement, and tag questions). Second, results on a test of short-term recall (with IQ partialled out) were more strongly correlated with success on the sentence correction task than with success on the judgment task.

CONCLUSION

The manner in which reading is erected on preexisting linguistic structures led us to predict that the causes of reading disability would lie within the language domain. Accordingly, seemingly normal school children who fail to make the expected progress in learning to read were found to have language-related difficulties, including problems in phonological awareness and unusual limitations in verbal working memory. As both of these problems are arguably grounded in phonology, a central concern has been to determine if all the language-related difficulties evinced by poor readers might stem from a single deficit in processing phonological information.

The observation that poor readers have difficulties in correctly interpreting some spoken sentences seemed, at first, to threaten a unitary phonological deficit account. However, in the context of our assumptions about the architecture of the language apparatus, we argued that a phonological deficit might explain this problem too. If so, this argues against attributing the comprehension difficulties of reading disabled children to a developmental lag in structural competence over and above their well-attested deficiencies in phonological processing.

In order to tease apart the alternatives, two research strategies were implemented. In one, tasks were devised to stress the language processing system in varying degrees while holding syntactic structure constant. We reviewed an experiment that followed this strategy, which yielded large differences between good and poor readers in comprehending spoken sentences in contexts that stress working memory, but much smaller differences when the same materials were presented in a way that lessened memory load. Contrary to the expectations of the structural lag hypothesis, in contexts that minimized memory demands, both reader groups achieved such a high level of accuracy that competence with the construction under investigation would seem guaranteed.

A second research strategy tested for differences between reader groups by comparing performance across a variety of linguistic structures. As anticipated by the processing limitation hypothesis, we found that both reader groups manifested a similar pattern of errors across sentences of varying syntactic types, with poor readers penalized to a greater degree than good readers on sentences that are costly to working memory resources. The absence of a reader group interaction invites the inference that the relatively inferior performance of poor readers is due to parsing pressure, rather than to ignorance of subjacency, a putatively innate constraint on syntax.

In sum, the syntactic component of the language apparatus appears to be intact in poor readers. The source of difficulties that might appear to reflect a syntactic deficiency must be sought elsewhere. It is premature at present to exclude the possibility that the comprehension problems of some poor readers are caused by a deficiency in some other component of the language apparatus (e.g., syntactic parsing). However, we can appeal to the modular architecture of the language apparatus to explain how a deficit in phonological processing may masquerade as a complex of deficits throughout the whole language system. Given the abundance of evidence attesting to poor readers' deficits in the phonological domain, there is reason to prefer the hypothesis that their comprehension problems are part and parcel of their difficulties in phonological processing. If this is correct, it would prove unnecessary to postulate additional impairments within the language system: All of the problems associated with reading ultimately spring from the same source. The possibility of providing a unitary explanation of an apparently disparate set of phenomena is a compelling reason, in our view, for adhering to a modular conception of the language apparatus.

ACKNOWLEDGMENTS

The research discussed in this chapter was supported in part by a Program Project Grant to Haskins Laboratories from the National Institute of Child Health and Human Development (HD-01994). Portions of this chapter are adapted from an earlier paper that will appear in I. G. Mattingly and M. Studdert-Kennedy (Eds.), *Modularity and the motor theory of speech perception*. Hillsdale, NJ: Lawrence Erlbaum Associates.

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