

# A comparison of comprehension and production abilities of good and poor readers

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## ABSTRACT

Research from several sources indicates that reading disability is often associated with difficulty in comprehending some complex spoken sentences, including those with relative clauses. The present study exploits a new methodology, elicited production, to identify the source of comprehension difficulties of poor readers. Both the elicited production task and a conventional act-out task were employed in a study of 30 children (aged 7-8), who were selected for reading ability. On the act-out task, the poor readers displayed a high error rate on two relative clause structures (SO and OO relatives), as had been found by Mann, Shankweiler, and Smith (1984), but these structures were elicited from the poor readers as successfully as from the good readers (on more than 80% of trials). The findings constitute strong evidence of childrens' competence with relative clause syntax. Thus, the poor readers' difficulties in demonstrating comprehension on the act-out task stem from nonsyntactic causes.

Learning to read is difficult for the average child. As Gough and Hillinger (1980) indicated, the average American 6-year-old can produce and recognize nearly all the vowels and consonants of English, as well as thousands of words and sentences in everyday situations. But, as these authors also pointed out, reading does not follow as an automatic consequence of the child's ability to speak and comprehend language. Unlike speaking, reading in an alphabetic script requires explicit awareness of phonological structure. Full phonological awareness does not typically develop in the absence of instruction. Indeed, research shows that children who develop problems in learning to read often exhibit a lack of phonological awareness in decoding individual words. Measures of decoding regularly account for half or more of the variance in other comprehension measures of reading ability (Chall, 1967; Perfetti, 1985; Shankweiler, 1989; Shankweiler & Liberman, 1972; Stanovich, 1986).

In addition to the problems at the level of the word, many poor readers give unequivocal evidence of difficulties in understanding sentences, even in spoken language (Macaruso, Bar-Shalom, Crain, & Shankweiler, 1989; Mann et al., 1984; Smith, Macaruso, Shankweiler, & Crain, 1989; Stein, Cairns, & Zurif, 1984). Among the structures that have been found to cause difficulty are sentences containing relative clauses, as in (1).

1. The boy tickled the clown who pushed the girl.

The purpose of this article is to identify the source of the difficulties that poor readers experience in understanding spoken sentences containing relative clauses.

## TWO ACCOUNTS OF COMPREHENSION DIFFICULTIES OF POOR READERS

One account of the comprehension problems of poor readers would suppose that these children are delayed in language development. According to this account, the grammars of poor readers fail to generate the requisite structures, which explains why their comprehension of sentences containing those structures is impaired.<sup>1</sup> We refer to this view as the structural lag hypothesis (SLH) (Byrne, 1981; Fletcher, Satz, & Scholes, 1981; Stein et al., 1984).

A basic premise of the SLH is that the acquisition of linguistic knowledge occurs in stages. Simple sentences are mastered first, while more complex sentences are produced and understood only later. This viewpoint is often expressed in the literature on language development. For example, Tavakolian (1981) observed that many normal preschool children have not yet mastered relative clause sentences, such as (1), and act them out as if the main and relative clauses were conjoined clauses: that is, these children appear to interpret the first noun phrase in sentence (1) as the subject of both the main clause and the relative clause. Although this interpretation is incorrect for (1), it is correct for a sentence with conjoined clauses, such as (2):

1. The boy tickled the clown *who* pushed the girl.
2. The boy tickled the clown *and* pushed the girl.

Based on the nature of the errors that children make in responding to sentences with relative clauses, Tavakolian called her account of children's errors Conjoined-Clause Analysis of relative clauses. To buttress the account, Tavakolian noted that conjoined clauses are produced earlier than relative clauses in children's spontaneous speech.

Appealing to the literature on language development, proponents of the SLH attribute poor readers' mistakes in comprehension of some sentences to a delay in language acquisition. On this view, poor readers misinterpret certain constructions, such as relative clause sentences, because these constructions have not yet become part of their grammars.

Although the SLH gives a coherent account of some of the phenomena associated with reading disability, it makes predictions that run contrary to several recent studies of comprehension by poor readers. These studies demonstrated a high rate of correct comprehension of spoken sentences containing various syntactic complexities, including relative clauses (Macaruso et al., 1989; Smith et al., 1989). These researchers found that, by varying the memory demands in the tasks used to assess comprehension, the performance of poor readers could be raised or lowered. It stands to reason that, if poor readers' grammars did not generate the relevant syntactic structures, reduction in memory load would not result in significant improvement in their performance. Another notable weakness of the SLH is that it fails to explain problems of poor readers at the level of the word. Although poor readers' difficulties in word recognition are acknowledged by the advocates of the SLH, they make no attempt to tie together the problems experienced by poor readers at the word level with those experienced at the sentence level.

In contrast to the SLH, some researchers have pursued the idea that poor readers' word-decoding and spoken-language comprehension problems arise from the same source, namely, their difficulties in processing phonological information (Crain & Shankweiler, 1988; Shankweiler & Crain, 1986). By tying together the sentence-level and word-level difficulties of poor readers, this viewpoint offers a parsimonious account of the symptom complex of poor readers. We call this view the processing limitation hypothesis (PLH).

The PLH paints a different picture of the course of language acquisition than the SLH. According to the PLH, even preschool children have mastered most complex syntactic structures, especially those that adhere to principles that follow from Universal Grammar (Chomsky, 1981). Universal Grammar is viewed as a set of principles and parameters within which children construct their grammars. These principles are taken to be innately specified as part of the human biological blueprint for language acquisition. Assuming innate specification leads us to expect the early emergence of linguistic competence (Crain, 1991). Consistent with this perspective, a number of studies have found that the vast majority of preschool children evince competence with several complex aspects of syntax. This knowledge is well in place before children begin to receive their earliest instruction in reading (Crain, 1982; Crain & McKee, 1985; Crain & Nakayama, 1987; Crain, Thornton, & Murasugi, 1987; Hamburger & Crain, 1982).

The PLH contends that, in contrast to their levels of syntactic knowledge, good and poor readers differ in their ability to process phonological information. Several facts can be cited. First, poor readers are generally inferior to good readers on short-term recall of verbal material (Lieberman, Shankweiler, Liberman, Fowler, & Fischer, 1977; Wagner & Torgesen, 1987). Because linguistic material is initially coded in phonological form, these memory limitations are attributable to difficulties in the access or use of phonological structure. There is some direct evidence for this interpretation. For example, a study by Shankweiler, Liberman, Mark, Fowler, and

Fischer (1979) found that poor readers' performance in recall of visually and auditorily presented linguistic material is only marginally affected by phonetic confusability (rhyme, in this study). Good readers, on the other hand, were penalized to a significantly greater extent by phonetic similarity. (Other studies indicating that individual variations in phonetic coding ability distinguish between good and poor readers include: Mann, Liberman, & Shankweiler, 1980; Mann et al., 1984; and Olson, Davidson, Kliegl, & Davies, 1984.)

In addition to problems in assigning a phonetic code, poor readers also exhibit problems in phonemic awareness, such as the ability to segment spoken words into phonemes and consciously manipulate them (Bryant & Bradley, 1985; Cossu, Shankweiler, Liberman, Tola, & Katz, 1987; Lundberg, Oloffson, & Wall, 1980; Morais, Cluytens, & Alegria, 1984). Poor readers also do less well than good readers in naming pictured objects (Denckla & Rudel, 1976; Wolf, 1981). Moreover, their errors are predominantly based on phonological, rather than semantic, confusions (Katz, 1985).

Recall, furthermore, that poor readers also have problems in the comprehension of spoken sentences. The PLH attempts to reconcile this observation with the other limitations exhibited by poor readers. The PLH proposes that phonological processing limitations are the origin of the difficulties that poor readers experience in understanding spoken sentences. According to the PLH, the sentence comprehension problems of poor readers derive from a deficiency in phonological processing. The next section elaborates the ways in which the comprehension problems of poor readers arise from their phonological limitations. To begin, we sketch the architecture of the language apparatus that underlies the PLH. (For a fuller description of this model, see Crain, Shankweiler, Macaruso, & Bar-Shalom, 1990.)

### *The organization of the language apparatus*

The conception of the organization of the language apparatus assumed by the PLH derives in part from Fodor's modularity hypothesis (Fodor, 1983). According to the modularity hypothesis, the function of the language faculty is sealed off from influence of real world knowledge and is governed by specific principles that are not shared by other cognitive systems.<sup>2</sup>

The PLH extends the modularity hypothesis to the architecture of the language apparatus itself. The language faculty is viewed as consisting of autonomous subcomponents (or "submodules"): the phonology, the lexicon and the syntax, and the semantics. In addition, there are processors dedicated to each of these subcomponents: the phonological, syntactic, and semantic parsers. Each parser is a special purpose device that is responsible for rule access and, possibly, ambiguity resolution. The PLH assumes, further, that information within the language faculty flows in a bottom-up direction, from lower level to higher level subcomponents. During listening or reading, information must be rapidly transferred between components

to make possible continuous "on-line" processing possible. The analysis of linguistic input must take place rapidly at the lower levels (such as the phonology level) in order to transfer the material to the higher levels of analysis and to free up resources for subsequent linguistic input.

An additional processing component is needed in sentence production and perception. This is the system of verbal working memory. The verbal working memory system has two components, according to the PLH. First, there is a storage buffer where phonological analysis of phonetically coded information takes place. The storage buffer has the properties that were formerly attributed to the concept of short-term memory. It can hold information only briefly (perhaps just for one or two seconds) unless the information is maintained in memory by continuous rehearsal.

The second component of working memory is a control mechanism which is responsible for shunting information through the series of parsers. According to the PLH, the duties of this mechanism begin when phonetic input comes into contact with phonological rules for word-level analysis. The analyzed word-level information is then transferred to the syntactic and semantic processors. The control mechanism ensures the immediate analysis of linguistic information at all levels of the language apparatus. It not only causes phonological information to be processed rapidly, but also ensures that syntactic and semantic information is processed without delay (Altmann & Steedman, 1988; Crain & Steedman, 1985; Ni & Crain, 1990).

According to this model, if a disruption occurs at a low level of analysis (perhaps because of some difficulty in maintaining or reactivating phonological information), this would create a "bottleneck" which would curtail the flow of information to higher level components (Crain et al., 1990; Perfetti, 1985; Perfetti & Lesgold, 1977). This is exactly what happens to poor readers, according to the PLH. The apparent breakdown that occurs in processing spoken sentences is a manifestation of poor readers' difficulties in phonological processing. Even though the syntactic component of their language apparatus is intact, proper functioning at this level is impeded because of their difficulties in processing phonological material. In sum, the basic claim of the PLH is that insufficiencies at the phonological level impair higher level syntactic and semantic processing.

Having sketched this view of the spoken language difficulties of poor readers, we now turn to examine some types of sentences that are predicted to cause difficulties for poor readers. According to the PLH, they will have problems in comprehending any sentences that are especially taxing of working memory resources. Some sentences containing relative clauses have this property. An example is illustrated in (3):

3. The boy kissed the girl who hit the ball.

Sentence (3) presents a difficulty for working memory because of a conflict between the order of arrival of the linguistic input and the conceptual order of the actions mentioned in the sentence. According to the preferred interpretation of (3), the action denoted by the relative clause should have occurred prior to the action mentioned in the main clause.<sup>3</sup> That is, the

most common interpretation of sentence (3) is that the girl hit the ball and then the boy kissed her. Notice, however, that the propositional content of the relative clause arrives only after the main clause has been received. One of the requirements of acting out this sentence correctly under the preferred interpretation is to retain it in memory long enough to mentally rearrange the actions to the correct conceptual order (i.e., with the relative clause first).

Another type of relative clause structure that may be demanding of working memory resources uses center-embedded "object gap" relatives, such as (4) (De Villiers, Flusberg, Hakuta, & Cohen, 1979):<sup>4</sup>

4. The girl who the boy kissed \_\_\_\_ hugged the teddy bear.

In (4), the relative clause *who the boy kissed* intervenes between the subject (relativized noun phrase) and the verb of the main clause and contains an object gap. The difficulty of sentences such as (4) may be seen in the fact that the grammatical function of the relativized noun phrase cannot be determined until the embedded clause has been interpreted.

To summarize, in this section we have reviewed two types of relative clause sentences. The PLH predicts that both types of sentences will cause difficulties for poor readers in ordinary circumstances because of the special demands these structures impose on working memory. We now discuss how to test subjects on these structures in a way that might minimize memory demands.

#### *The elicited production technique in research on language acquisition*

In order to test between the SLH and the PLH, it is important to select a method that can unequivocally assess linguistic competence. Accordingly, in this research we compare the syntactic abilities of good and poor readers using the technique of elicited production. This technique has been employed in studies of language acquisition, but has not been applied to date in the diagnosis of the linguistic competence of poor readers.

Our choice of the elicitation technique was governed by several considerations. First, this method, when successful, enables us to draw out of the subjects tokens of the structure of interest without modeling the structure for them. Second, as Crain and Thornton (1991) pointed out, there are so many possible ways to combine words inappropriately that, when one succeeds in eliciting a well-formed sentence that fits the context, this cannot be attributed to chance. This makes elicited production data compelling evidence of linguistic competence. The elicited production technique has proven to be a successful tool in assessing very young children's competence with several complex syntactic structures, including sentences containing relative clauses (Crain & Thornton, 1991; Hamburger & Crain, 1982) and *wh*- questions (Sarma, 1991; Thornton, 1990). By observing the necessary precautions, these researchers obtained evidence in preschool children of linguistic competence that previous comprehension studies had failed to uncover.<sup>5</sup>

Based on the previous success of the elicited production technique in estimating children's knowledge of syntactic structures, it seemed evident that this method could enable us to obtain an accurate measure of poor readers' knowledge of relative clauses. We hypothesized that if the performance of poor readers equaled that of the good readers, this would constitute evidence against the syntactic lag hypothesis. Conclusive evidence of equivalent linguistic competence of good and poor readers would add further support to the findings of previous comprehension studies that have favored the PLH (Macaruso et al., 1989; Smith et al., 1989).

In addition to the elicited production task, comprehension was also assessed using an act-out task. The inclusion of this further test of linguistic knowledge had two purposes. First, we wanted to learn whether the same subjects who participated in the elicited production task would exhibit comparable linguistic competence with relative clauses on a typical comprehension measure. Second, we wanted to discover which of the experimental manipulations that were used in previous studies may have brought about improved performance on the part of poor readers.<sup>6</sup> The next section reviews earlier comprehension studies.

## PREVIOUS STUDIES WITH RELATIVE CLAUSES

Before discussing the previous research with relative clause constructions, a few words are in order about the syntactic, semantic, and pragmatic properties of this structure. One of its syntactic characteristics is the presence of a superficially missing noun phrase. For example, in sentence (5), there is a phonologically empty noun phrase in the subject position of the relative clause. To interpret this sentence successfully, the perceiver must realize that this phonologically null noun phrase is coreferential (refers to the same entity) with the overt object noun phrase *the boy* in the main clause. Based on the grammatical functions of the coreferential noun phrases, we refer to this type of structure as an OS (object/subject) relative clause sentence.

5. The girl kissed *the boy* that \_\_\_\_ threw the teddy bear.

O                      S

In addition to their syntactic and semantic properties, relative clauses serve several pragmatic functions. As mentioned, one of the pragmatic properties of restrictive clauses is that the action they contain has occurred prior to the action in the main clause; in other words, it is presupposed (Hamburger & Crain, 1982). The other pragmatic function turns on the distinction between restrictive and nonrestrictive relative clauses. Restrictive relative clauses are appropriate when several objects corresponding to the head of the relative clause are present in the context. Adding a relative clause is one way of restricting this set. For example, sentence (6) is felicitous if there is more than one table in the context. The relative clause *that has a vase on it* identifies a particular table that Mary likes from a set of tables. Sentence (7), on the other hand, contains a nonrestrictive relative

clause. It is appropriate in the context in which only one table is present and Mary likes it.

6. Mary likes the table that has a vase on it.
7. Mary likes the table, which has a vase on it.

Having reviewed the essential properties of relative clauses, we will briefly summarize the results of two previous studies on comprehension of this structure by good and poor readers. The findings of the Mann et al. (1984) and Smith et al. (1989) studies were notably different. While there was a significant difference in the performance of good and poor readers studied by Mann et al., Smith and colleagues found no significant difference between the two groups. The authors of the latter study hypothesized that the improvement in poor readers' performance was due to the diminished load on working memory brought about by changes in the experimental methodology.

In the Mann et al. study, there was no attempt to vary working memory demands of the task systematically. In order to pinpoint the source of comprehension errors found by Mann and colleagues, Smith et al. (1989) introduced two changes in methodology with the purpose of reducing the burden imposed on working memory. One change consisted of reducing the number of animate noun phrases in the test sentences from three, as in (8), to two, as in (9) (cf. Goodluck & Tavakolian, 1982). The other methodological innovation was to satisfy one of the presuppositions inherent in the use of relative clauses: their restrictive function (Hamburger & Crain, 1982). This was accomplished by presenting two figures corresponding to the head noun phrase in the experimental work space.

8. *The dog chased the sheep that stood on the turtle.*
9. *The boy is kicking the girl who is holding a ball.*

Both sentences (8) and (9) contain restrictive relative clauses. In sentence (8), there is more than one sheep present in the discourse, but only one of them performs the action of standing on the turtle. Similarly, in sentence (9), there is more than one girl present in the discourse, but only one of them performs the action of the relative clause. In the absence of an extra figure, an inappropriate context is created for the restrictive relative clause interpretation. This forces subjects to augment their mental model in order to accommodate an unmet presupposition (Lewis, 1979). The extra computation of accommodating presuppositional failure is assumed to take up additional working memory resources.<sup>7</sup>

Not only does the increased processing burden on working memory delay the construction of a semantic representation, it also slows down the flow of information from lower levels to the semantic component. As mentioned, since linguistic material decays in memory very quickly, rapid on-line interpretation is required at all levels of linguistic processing, including the semantic level. There is much experimental evidence showing that contextual cues, including knowledge of presuppositional support, are used by the perceiver during the process of sentence comprehension (Crain &



Steedman, 1985). Thus, incorrect contextual support can delay or disrupt the rapid word-by-word construction of a semantic representation, whereas correct contextual support can facilitate it.

Experimental evidence from studies of poor readers indicates that they have special difficulties in comprehending sentences when the appropriate context is not provided in the task, as in cases where the presupposition of restricting a set of objects in restrictive relative clauses is unmet. Good readers, on the other hand, are only marginally affected by inappropriate contexts (Mann et al., 1984; cf. Smith et al., 1989). An explanation for the difference between the two groups can be offered by taking into account poor readers' difficulties in lower level processing. Poor readers suffer from a double handicap. In addition to problems at the level of phonology, their working memory resources are significantly taxed by their inefficiency in accommodating unmet presuppositions. Consequently, any additional delay in constructing a semantic representation with unmet presuppositions only adds to their difficulties.

In this section we have reviewed some properties of restrictive relative clauses as well as previous studies with this type of structure. We cited the differences in findings of the Mann et al. (1984) and the Smith et al. (1989) studies. Taken together, these studies show that improvement in poor readers' performance in the comprehension of relative clause sentences is associated with a reduction of the working memory load. Poor readers perform significantly worse than good readers on tests of comprehension of relative clause sentences under conditions of heavy memory demands, but are able to interpret relative clauses well when memory load is minimized. We have also elaborated on the causes of poor readers' difficulties in interpreting restrictive relative clause sentences with unmet presuppositions (i.e., inappropriate experimental context).

## EXPERIMENT 1: ACT-OUT TASK WITH RELATIVE CLAUSES

This experiment used an act-out task to determine which of the methodological changes discussed in the previous section raised the level of performance of poor readers in the Smith et al. (1989) study. One of the changes in method in that study consisted of satisfying the presuppositions of restrictive relative clauses, and the other change was the reduction of animate noun phrases from three to two. To determine the importance of each factor, only one change was implemented in the present study. The test sentences in the act-out experiment contained only two animate noun phrases, as employed by Smith et al., but unlike that study, the present experiment did not satisfy the presuppositions of the relative clauses contained in the test sentences. Specifically, only one figure corresponding to the relativized noun phrase was present in the experimental work space. We reasoned that if there occurred a significant difference in the performance of good and poor readers, it could be inferred that satisfying the presuppositions of the relative clauses was the key factor in bringing about a substantial reduction of errors in the study by Smith et al. If, on the

Table 1. *Subject characteristics*

Measures	Good readers ( <i>N</i> = 15)		Poor readers ( <i>N</i> = 15)	
	Mean	<i>SD</i>	Mean	<i>SD</i>
DST score	79.7	23.1	9.9	7.6
Age (mos.)	90.0	4.97	92.0	6.84
PPVT score	104.4	10.2	102.4	10.7
Block Design score	11.8	3.26	11.2	3.18

other hand, no significant difference was found between the two reader groups, this would argue that providing contextual support did not play an important part in improving the performance in that previous study. Such a result would favor the alternative possibility that reducing the number of animate noun phrases from three to two brought about the higher level of performance by poor readers in the Smith et al. study.<sup>8</sup>

## METHOD

### *Subjects*

The subjects were second graders at a suburban public school. Each child's reading ability was tested using the Decoding Skills Test (DST) (Richardson & DiBenedetto, 1986).<sup>9</sup> A DST for each child was calculated by adding their number of correct responses to a list of 60 words and 60 nonwords. Subjects' vocabulary skills were tested using the Peabody Picture Vocabulary Test - Revised (PPVT) (Dunn & Dunn, 1981). As in previous research, the PPVT was included to ensure that reader group differences could not be attributed to discrepancies in vocabulary skills (Mann et al., 1984; Smith et al., 1989). The PPVT also provided an IQ measure, inasmuch as it is highly correlates with individual and group intelligence scales (Anastasi, 1968). In addition to this verbal measure of intelligence, subjects were tested on the Block Design Test of the Wechsler Intelligence Scale for Children (WISC) (Wechsler, 1955) in order to provide a measure of performance IQ. Based on their DST scores and teachers' evaluations, nonoverlapping groups of good and poor readers were formed. The criteria for including a child in the good reader group was (a) a DST score greater than 43 and (b) a "high" reading assessment performance by the reading instructor. This group comprised 15 children (8 boys, 7 girls). Subjects with a DST score less than 30 and those with an evaluation by the reading instructor as "low" were included in the poor reader group (6 boys, 9 girls).<sup>10</sup> The mean age, DST, PPVT, and WISC Block Design scores are presented in Table 1. As the table shows, there were no significant differences between good and poor readers in this study on either the PPVT or Block Design Test.

### *Materials*

Fifteen relative clauses of three types (five of each) were auditorily presented to each subject.<sup>11</sup> Examples of the types of relative clauses are given below:

10. OO The girl kissed the boy that the ball bumped into.
11. OS The puppy jumped on the horse that ate the hay.
12. SO The cat that the monkey scratched climbed up the tree.

As noted, each sentence contained two animate and one inanimate noun phrase, and each noun phrase was represented in the experimental area by a single object. So, for example, there was one girl, one boy, and one ball in the situation corresponding to (10). The pretest and test sentences are provided in Appendix 1.

### *Procedure*

The subjects were tested individually in three sessions. In the first session, the DST, PPVT, and Block Design Test were administered. During the second session, half of the subjects were given the act-out task with relative clauses; the other half were given the elicited production task. The sequence of tests was reversed in the third session to eliminate any effects of test order.

During the act-out task, the subject was asked to listen to a sentence and then act it out with the toys that had been placed in front of him or her. A sentence was repeated upon the subject's request. Two pretest sentences were administered to ensure that the subjects understood the task. Each response was recorded on an answer sheet for subsequent analysis. A response was considered correct if the actions in both the main clause and the relative clause were acted out according to the adult meaning of the sentence. The order in which children acted out the clauses was also recorded.

## RESULTS

Two types of statistical analyses were performed: a multiple regression and an analysis of variance (ANOVA). The purpose of the multiple regression analysis was to examine the relation between individual differences in reading and sentence comprehension; another purpose was to determine whether individual intelligence and/or vocabulary scores contributed to performance on the act-out task. An ANOVA was performed to examine whether good and poor readers exhibited significant group differences in their performance on the relative clause comprehension task.

### *Multiple regression*

The multiple regression analysis treated sentence comprehension as the dependent measure and DST, PPVT, and Block Design as independent variables.<sup>12</sup> The analysis revealed a significant contribution of word and pseu-

Table 2. *Experiment 1: Act-out task with relative clauses (percentage of errors by reader group)*

Sentence type	Poor readers		Good readers	
	Mean	SD	Mean	SD
SO	51.0	6.0	9.0	3.6
OS	1.4	1.4	0.0	0.0
OO	40.0	5.9	14.0	4.3

do-word reading scores in the DST test,  $F(1, 23) = 15.26, p < .0007$ , whereas the contribution of the vocabulary test scores (PPVT) and the IQ performance measure (Block Design) were not significant:  $F(1, 23) = .99, p < .327$ , and  $F(1, 23) = .01, p < .935$ , respectively.

By partialing out Block Design, it was found out that approximately 51% of the variance in subjects' responses was accounted for by DST and PPVT ( $R^2 = .516$ ),  $F(1, 24) = 12.8, p < .0002$ . By also partialing out PPVT, it was found that approximately 50% of the variance in the subjects' responses on the act-out task was accounted for by DST ( $R^2 = .50$ ). This was highly significant,  $F(1, 24) = 24.50, p < .0001$ .

#### ANOVA

The ANOVA revealed that the good readers performed significantly better than the poor readers,  $F(1, 25) = 26.00, p < .0001$ . Overall, the error rates of good and poor readers were 7.7% and 31.0%, respectively. The main effect of sentence type (OO, OS, and SO relative clause sentences) was also significant,  $F(2, 12) = 9.08, p < .004$ . As Table 2 indicates, poor readers made more mistakes than good readers on the comprehension of relative clause sentences of all types. However, there was an interaction between group and sentence type,  $F(1, 2) = 21.24, p < .0001$ . Differences in the error pattern of the reader groups are evident on the SO and OO sentences. The good readers did somewhat better on the SO type than on the OO sentences; the difference between the two types was 5%. By contrast, the poor readers did better on the OO sentences; the difference in error rate was 11%. Moreover, both reader groups performed almost without error on the OS relatives.

#### DISCUSSION

An important finding of the first experiment was obtained in the multiple regression analysis. It was found that word-reading ability significantly contributed to the comprehension of relative clause sentences when the presuppositions inherent in their use remained unsatisfied. The analysis also revealed that individual differences in vocabulary and intelligence did not contribute additionally to performance on spoken language comprehension. An absence of correlation between PPVT scores, Block Design scores,

and comprehension performance on the act-out task indicates that differences in intelligence and word knowledge were not of sufficient magnitude to place limits on comprehension of the relative clause structures presented in this experiment. In sum, individual variation in decoding ability, and not intelligence or vocabulary knowledge, correlated with subjects' comprehension performance in the act-out task.

The ANOVA revealed that poor readers as a group made significantly more errors than good readers in the comprehension of relative clauses. Recall that the presuppositions associated with the use of these structures were not satisfied in this experiment, whereas the number of animate noun phrases was held to two. Despite the lower number of animate noun phrases, a significant difference between reader groups was obtained. This invites us to infer that contextual support, and not the reduced number of animate noun phrases, brought about the significant improvement in the performance of the poor readers in the Smith et al. study (1989).

In contrast to the results obtained by Mann et al. (1984) and by Smith et al., an interaction between reader group and sentence type was found in the present study. In this connection, it is relevant to note that the PLH predicts that good and poor readers should show similar patterns. That is, the PLH predicts that good and poor readers should differ only in the total number of errors on each sentence type – not in the relative proportions of errors across sentence types. There should be a main effect of reader group, but no Reader Group  $\times$  Sentence interaction. An interaction was found, however, in this experiment.

To explain the interaction in the present study, it should be noted that proportions of errors on SO and OO relatives were reversed for the two reader groups. The good readers performed slightly better on the SO than on the OO sentences, with a difference in error rate of 5%. The poor readers, by contrast, did better on the OO sentences; the difference in error rate between the two types of relatives was 11%. Both groups performed at ceiling on the OS relatives. The good readers were 100% accurate, and the poor readers made only 1.4% errors on this sentence type. In view of the overall superior performance of the good readers and the small difference in error rate between the SO and OO type, the interaction between reader group and sentence type may not be meaningful and, probably, should not count as evidence against the PLH.

It is worth noting in this connection that both good and poor readers in previous studies (Mann et al., 1984; Smith et al., 1989) made more errors on the OS relatives than their counterparts in the present study. This discrepancy may reflect the peculiarities of the OS sentences created for this experiment. The high rate of correct responses may be due to semantic cues that were available for sentences of this type. Thus, the right response to the sentence, *The cat scratched the boy who threw the teddy bear*, may have been given for a wrong reason: that is, the correct interpretation of the cat scratching the boy is also the more plausible one.<sup>13</sup> On the other hand, the two noun phrases in corresponding OS sentences in the Smith et al. study were semantically reversible, so semantic clues could not be used to infer the correct response.<sup>14</sup>

### *Order of responses*

The order of responses refers to the sequence in which subjects acted out the content of the main and relative clauses. The order of acting out the two clauses was recorded to find out if good and poor readers differed in this respect. We wanted to know whether both groups were equally affected by the memory requirements of restrictive relative clauses. As mentioned, the difficulty of these sentences for memory may be seen in the fact that the preferred interpretation exhibits a conflict between the arrival of the linguistic input and the actual order of events.

Our conclusions about the preferred interpretation of the order of actions in restrictive relative clause sentences were based on the results of the following study of adults. To ascertain whether adults perceive the action of the relative clause as having occurred first, we conducted an experiment with 26 college undergraduates. The subjects were given answer sheets with a list of 16 OO and 16 OS relative clause sentences and were instructed to circle the action that occurred first in each sentence. We found that the action in the relative clause was judged by subjects to be prior to the action in the main clause 94.2% of the time. This shows that there is a strong preference by adults to conceptualize the action mentioned in the relative clause as occurring before the action mentioned in the main clause.<sup>15</sup>

Returning to the study of the group of good and poor readers, subjects' responses in the act-out task were examined to see if the groups differed in the order of responses in acting out either OO or OS sentences. The analysis revealed that good and poor readers did not differ in this respect. On the OS sentences, the relative clause was acted out first 51.8% and 50% of the time by good and poor readers, respectively. On the OO type, the relative clause was acted out first 45% of the time by good readers and 44% of the time by poor readers.

It is of interest to compare the results of the present study with those of Smith et al. (1989). In that experiment, as in the present study, the good and poor readers did not differ in the frequency of acting out either the relative or the main clause first. However, the overall percentage of relative clauses acted out first by both groups was much higher in that study. On the OS relatives, good and poor readers acted out the relative clause first 86.3% and 88.3% of the time, respectively, while on the OO type, the relative clause was acted out first 80.0% and 76.4% of the time, respectively.

This difference between the two studies deserves further comment. One possible source of the difference lies in the observation that in the Smith et al. study, but not in the present experiment, the presuppositions associated with the use of restrictive relative clauses were satisfied (Hamburger & Crain, 1982). Recall that in that study, there were two figures, rather than one, corresponding to the relativized noun phrase in the experimental work space. In the present study, only one figure appeared. This may have prompted subjects to interpret the relative clauses as nonrestrictive. As explained, restrictive relative clauses are appropriate when several objects

corresponding to the head noun phrase are present in the context. The relative clause restricts the set to one particular object. Nonrestrictive clauses, on the other hand, are used to provide information about a single object corresponding to the head noun phrase. Under nonrestrictive interpretation, one would not expect the relative clause to be consistently acted out first.<sup>16</sup>

To summarize, the act-out task revealed significant differences in the performance of good and poor readers. One purpose of this experiment was to try to clarify which change in the method may have caused the significant improvement in the performance of poor readers in the Smith et al. (1989) study. While that experiment determined that poor readers' performance improves significantly with the lessening of memory demands, the present study suggests that satisfying the pragmatic properties of restrictive relative clauses, and not the reduced number of animate noun phrases, serves to reduce memory load.

## EXPERIMENT 2: ELICITED PRODUCTION OF RELATIVE CLAUSES

The purpose of this experiment was to provide a more stringent test between the SLH and the PLH. The task investigated the ability of good and poor readers to produce sentences with relative clauses. It stands to reason that if poor readers can exhibit a mastery of relative clauses in production, then the claim of the SLH that this group suffers from a syntactic delay will be seriously called into question. Further, if poor readers demonstrate a level of linguistic performance equivalent to that of the good readers on the elicitation task, this would confirm the inference that their inferior performance on the act-out task was not due to the absence of relevant structural knowledge of relative clauses. This would lead us to infer, by extension, that previous failures in spoken language comprehension tasks by poor readers were also not attributable to a delay in syntactic development.

In regard to methodology, we kept in mind the conditions that must be met to successfully elicit a construction (Crain & Thornton, 1991). First, one must satisfy the presuppositions of the structure in question. Second, one must create contexts that are uniquely felicitous: that is, contexts that are not open to linguistically simpler expressions of the same message. If there are simpler ways to verbalize the intended message, it will be difficult to elicit only the structure under investigation. As mentioned, when these prerequisites of successful elicitation were observed, preschool children showed a higher level of linguistic competence than in previous comprehension studies with the same structures (Crain & Thornton, 1991; Thornton, 1990).

## MATERIALS

This study consisted of 16 mini-stories (see Appendix 2). None of the stories contained relative clause sentences. Each mini-story was followed by two questions designed to elicit noun phrases with relative clauses. Recall that

in the act-out task, subjects were asked to act out entire sentences with relative clauses, not just noun phrases with relative clauses. This discrepancy between tasks may have resulted in a reduction of STM demands in the present elicitation task.

As in the act-out task, relative clauses with both subject and object gaps<sup>17</sup> were included in this experiment.<sup>18</sup> They are designated as relative clauses in "subject gap" (13)–(14) and "object gap" contexts (15)–(16). For example, (13) elicits a relative clause, *the one who ate the ice cream*. This corresponds most closely to the SS-type relative clause sentence, *the boy who ate his ice cream is happy*. There were 20 trials on which relative clauses with subject gaps (SS and OS) were elicited and 12 relative clauses with object gaps (OO and SO).

### Subject Gap Contexts

13. *SS context*: Which boy is happy? The one who ate his ice cream.  
Which boy is sad? The one who spilled his ice cream.
14. *OS context*: Which girl is the boy teasing? The one who is eating ice cream.  
Which girl is the boy pointing to? The one who is eating soup.

### Object Gap Contexts

15. *OO context*: Which cat is the dog licking? The one who the milk spilled on.  
Which cat is the dog jumping on? The one who the ball bumped into.
16. *SO context*: Which puppy is chewing up a tennis shoe? The one that the dog is licking.  
Which puppy is drinking milk? The one who the girl is petting.

## PROCEDURE

The procedures in this experiment were similar to those used in a study by Hamburger and Crain (1982) which successfully elicited relative clauses from 4- and 5-year-old children by telling stories that were acted out with toy figures. These stories were followed by questions. In the present experiment, picture illustrations, rather than toy figures, were used. As each story was told, the experimenter held a blindfolded puppet who, the child was told, could not see the description of the pictures. The experimenter then asked the child to explain to the puppet what had happened in the story by asking him or her a question that was designed in such a way as to elicit a relative clause. The procedures are illustrated by the following example:

17. There are two monkeys in this story. One of them is packing his suitcase, and the other one is throwing his suitcase out of the window.  
Question 1: Which monkey likes to travel?  
Question 2: Which monkey doesn't like to travel?

In answering question 1, the most reasonable response is a noun phrase bearing a relative clause, for example, "The one that is packing his suit-



Table 3. *Experiment 2: Elicitation of relative clauses (percentage of different types by group)*

	Good readers	Poor readers
Subject gap relatives	79.3	74.6
Object gap relatives	31.2	25.4
Passivized	10.0	13.1
Errors (resumptive)	10.0	8.3

case." Similarly, a reasonable response to question 2 is, "The one that is throwing his suitcase out of the window."

## RESULTS

The most important result of the elicitation experiment is that all subjects in both groups produced noun phrases with relative clauses.<sup>19</sup> Further, both good and poor readers uttered a high percentage of these structures in relation to the total number of opportunities: 79.3% and 74.6%, respectively.

Turning to the individual productions, the greatest number of relative clauses – 39 – was produced by a poor reader. The greatest number<sup>20</sup> of relative clauses produced by a good reader was 29. The lowest number of relative clauses produced by a subject in either group was 22. In short, all subjects in both groups produced a high number of relative clauses.

In addition to the anticipated responses, children produced passivized relative clauses, such as (18), ungrammatical relative clauses without gaps, as in (19)–(21), and occasional lexical errors as in (22)–(24). This is reported in Table 3.

18. *Passivized*: Which girl is sad? The one that got hit on the head with the apple.
  19. *Resumptive pronoun*: The cat is licking the one who the milk spilled on it.
  20. *Resumptive noun*: Which boy is sad? The one who the apple fell *on the boy*.
  21. *Partial repetition*: Which girl is the boy hugging? The one who the apple fell *on the girl's head*.
- Lexical errors:*
22. The boy is jumping over the one *with* the tree fell over.
  23. The man is touching the one who got the apple *fell* on him [wrong form of the verb].
  24. It's the one that's *getting spilled* on the head by the milk [passivization in the wrong context].

Table 3 summarizes the percentages of different types of relative clauses that both groups produced. Table 4 summarizes the percentage of production of object and subject gap subtypes. As Tables 3 and 4 indicate, similar

Table 4. *Experiment 2: Elicitation of relative clauses (percentage of different subtypes by group)*

	Good readers	Poor readers
SS context	79.1	87.3
OS context	70.2	68.4
OO context	37.4	32.2
SO context	25.3	22.1

proportions of different types of relative clauses were evoked from each group. These responses include passivized relative clauses in contexts designed to elicit relative clauses with object gaps. All the good readers and all but one poor reader used at least one passivized relative clause. Two poor readers produced the highest number of these structures: 17 and 13, respectively.

Further, both reader groups showed a preference for relative clauses with subject gaps. Some examples of relative clauses with subject gaps in place of object gaps are given in (25)–(29):

25. The dog is jumping on the one that got milk on it [instead of *that the milk spilled on*].
26. The dog is jumping on the one that had the milk spilled on him.
27. The man is touching the one who got the balloon on him [instead of *that the balloon hit*].
28. The boy that had the apple fall on his head is crying.
29. The man is hugging the one that had the balloon jump on her head.

When sentences with subject and object gap contexts were further analyzed into individual types (SS, OS, and OO vs. SO), a similar pattern of responses for good and poor readers emerged (Table 4). Within subject gaps, both groups produced more SS than OS utterances. In the poor reader group, this difference was more noticeable. Turning to subtypes with object gaps, both groups produced more OO relatives, and the percentage of productions for each group was similar as well.

Next, subjects' individual responses were examined. Turning first to sentences with object gaps, two good and two poor readers failed to produce any relative clauses of this type. Instead, these subjects passivized, as in (30), or, occasionally, used a resumptive, as in (31).

30. *Question:* Which girl is crying?  
*Subject's response:* The one who is being smacked.  
*Expected response:* The one who the boy is hitting.
31. *Question:* Which fence is the boy pointing to?  
*Subject's response:* The one that the cat is on it.  
*Expected response:* The one that the cat is (sitting) on.

In the OO context, 13 good readers and 13 poor readers produced at least one relative clause (in eight trials). In the SO context, only 9 good

readers (60%) and only 5 poor readers (33%) produced at least one relative clause (out of four trials).

In addition to grammatically well-formed relative clauses, some good and poor readers (61.5% and 50.0%, respectively) produced at least one ungrammatical relative clause with a resumptive pronoun or noun instead of a gap. These resumptive nouns and pronouns were evoked only in response to the 12 object gap contexts.<sup>21</sup> It is important to note, however, that all subjects who produced resumptive nouns or pronouns also produced well-formed sentences with object gaps. Each group also made a very small number of lexical errors, as illustrated in (22)–(24).

## DISCUSSION

The results of the relative clause elicitation task demonstrated competence with relative clauses in all subjects. Upon examination of types of relative clauses produced by each group, a similar pattern of responses emerged. As mentioned, both groups showed a preference for sentences with subject gaps. Within this type, both groups produced a somewhat higher number of sentences in SS context. This difference was more apparent in poor readers. Within sentences with object gaps, both groups produced a higher percentage of utterances in the OO context. When individual productions within SO and OO contexts were examined, a similarity was noted, as well as an asymmetry between good and poor readers. A similarity was found in the higher number of subjects who produced sentences in the OO context than the SO context in both groups. A difference between reader groups was found upon examining individual productions of subjects. Only 2 good and 2 poor readers failed to produce a single utterance of the OO type. In the SO context, however, 6 good readers (40%) and 10 poor readers (66%) did not produce a single SO-type utterance.

First, we comment on the lower production of object gap utterances by both groups. Research indicates that relatives with object gaps are more difficult to process for normal adults than subject gaps. This discrepancy may result from heavy working memory demands of relative clauses with object gaps (Ford, 1983; Grodzinsky, 1987). A cause of the high memory demands of object gap relative clauses may be the distance between the “filler” and the “gap.”

Second, we will examine the reasons for lower productions of the SO type by both groups, and by poor readers in particular. Carpenter and Just (1988) commented on the high number of errors that normal adults make in auditory word-by-word processing of center-embedded relative clause sentences, such as (32), versus right-embedded sentences, such as (33).

32. The paper that the senator *attacked* *admitted* the error. (SO)

33. The paper that *attacked* the senator *admitted* the error. (SS)

They pointed out that the sheer memory requirement of retaining the initial noun phrase cannot be the source of the difficulties. Notice that both (32) and (33) require that the perceiver holds the subject of the main clause in

memory, while processing the relative clause.<sup>22</sup> The difference between (32) and (33) is in the same or different grammatical roles of filler and the gap. In sentence (32), the filler is a subject, while the gap is an object. In (33), on the other hand, both the filler and the gap are subjects. The difficulty of sentences such as (32) disappears, according to Carpenter and Just, in passive constructions, as a comparison of (34) and (35) illustrates:<sup>23</sup>

34. The salesman that the doctor met departed.
35. The salesman that was met by the doctor departed.

As mentioned, both good and poor readers tended to passivize relatives in the SO context, thus creating sentences with a subject gap, as well as eliminating the differences in the syntactic roles of the filler and the gap. It was mentioned that poor readers avoided giving SO relatives more often than good readers. It is possible to attribute the lower incidence of productions of SO relatives by poor readers to their lower working memory span. However, in interpreting these results, we must keep in mind that both passives and SO sentences were correct responses on the elicitation task. Thus, we really cannot speak of the percentage of errors in this case, but rather of using one correct option versus another. Poor readers simply opted for passivizing sentences in the SO context somewhat more often than good readers, possibly choosing a less difficult sentence type, according to the explanation by Carpenter and Just.

However, Carpenter and Just's conclusions about the difficulty caused by different grammatical functions of the filler and the gap may find some support in the different percentages of productions of sentences in the SS versus OS context in this experiment. In these contexts, there was no way to paraphrase the construction using a different type of relative clause, yet there was a higher incidence of utterances in the SS context by both groups. Unlike in the OS context, the grammatical functions of the filler and the gap are the same. Carpenter and Just's explanation would predict that OS sentences should be more difficult. The difference in the number of SS and OS productions, however, is small. Also, every subject in both groups produced several SS and OS relatives in contrast to the OO and, more significantly, the SO context. Further, there were no errors in the sentences produced by any subject.

In addition to these considerations regarding possible reasons for lower production rates by both groups of sentences in the SO context, other factors can also be mentioned. One of them would appeal to considerations of language learnability. Since the derivation of both SO and OO relatives entails the extraction of a noun phrase from an object position, it would hardly be parsimonious to construct a grammar that includes a restriction against extracting from a certain sentence position in one type of relative clause structure but not in another.

Also, there is independent evidence that poor readers have mastery of SO relatives, as shown in the comprehension study by Smith et al. (1989). Recall that the good and poor readers in that study did not differ significantly in the comprehension of relative clauses, including the SO relatives, when processing demands were minimized.

In summary, even though fewer poor readers produced relatives in the SO context than good readers, this should not be taken to indicate grammatical failures by these children in generating SO relative clauses. An alternative explanation can be given, based on different working memory demands of various types of relatives (Carpenter & Just, 1988; De Villiers et al., 1979; Ford, 1983) and evidence from the Smith et al. study (1989), as well as an argument from language learnability.

It was noted that both reader groups produced occasional ungrammatical sentences with resumptives. This does not signify a grammatical limitation because the same subjects also produced grammatical sentences with gaps.<sup>24</sup> It is possible that some resumptives produced in the context of the present experiment may be attributable to the picture illustrations. For example, in the picture used with sentence (36), the child saw *a balloon touching the girl's head*.

36. The man is hugging the one that a balloon fell *on her head*.

Conceivably, subjects who produced sentences of this type intended to produce an OO relative clause with a gap but were also trying to relate to the puppet what they saw in the picture. It is possible that the child producing (36) was referring to the picture *in which the balloon fell on the girl's head*. If this is the case, then the ungrammatical sentences could not be a reflection of subjects' faulty knowledge (in some cases) of relative clause structures.

## GENERAL DISCUSSION

In the broadest terms, this study presents research designed to distinguish between two hypotheses about the source of reading disability: the structural lag hypothesis (SLH) and the processing limitation hypothesis (PLH). Both hypotheses attempt to explain why poor readers experience difficulties in spoken language comprehension, but account for the difficulties in different ways.

According to the SLH, poor readers exhibit spoken language comprehension failure with types of sentences that have not yet become part of their grammars. Sentences with relative clauses were chosen for investigation in the present study because they have been claimed to be late-emerging by proponents of the SLH (Stein et al., 1984) and because research findings with poor readers show comprehension difficulties (e.g., Mann et al., 1984). The SLH anticipates that poor readers' performance in spoken language comprehension should be less than that of good readers, regardless of the experimental methodology used. If their grammars do not generate the requisite structures, there is no reason to believe that changes in experimental method could help to bring about a higher level of performance. According to the PLH account, on the other hand, the grammars of poor readers do not fail to generate relative clauses. Rather, the performance of poor readers is hampered by their working memory limitations only in certain comprehension tasks. Thus, in this view, their difficulties become apparent only under conditions of heavy memory load (Crain et al., 1990;

Shankweiler & Crain, 1986; Smith et al., 1989). The fact that a reduction of memory load leads to successful comprehension by poor readers is interpreted by the PLH as evidence of their intact grammar.

The second goal of Experiment 1 was to discover the critical manipulation for improving poor readers' comprehension performance. The results suggest that providing contextual support, rather than reducing the number of animate noun phrases, may have been the critical factor that reduced the memory load and brought about the improvement in the performance of poor readers in the previous study by Smith et al. (1989). We base this conclusion on the fact that there were overall significant reader group differences in our study, in which the contextual support was *not* provided. In the Smith et al. study, on the other hand, good and poor readers performed equally well when the presuppositions were satisfied.

Experiment 2, in which the elicited production technique was used, provides the strongest evidence of competence with relative clause structure. The finding that all subjects produced relative clauses in the right circumstances constitutes proof that poor readers have the rules in place for generating this structure. Their difficulties on the act-out task must have a non-syntactic cause. Thus, these results count as evidence against the SLH.

We compared the pattern of responses of both groups on different types of relative clauses and found several similarities. Both groups produced a higher number of relative clauses with subject gaps, and both groups produced a small number of relative clauses with resumptives. Moreover, all the children who produced resumptives also produced grammatical relative clauses with gaps.

We commented on the between-groups similarity, as well as the difference, in productions within the SO context. Children in both groups tended to passivize and use resumptives more often in this object-gap context. However, fewer poor readers produced SO relative clauses. We hypothesized that this discrepancy between the groups does not preclude a knowledge of SO relatives by poor readers. Several considerations converge on this conclusion. First, passivization in the SO context was an acceptable option, rather than a wrong response. Second, the disparity between poor readers' level of comprehension of the SO relative clauses on the act-out task in the present study and the earlier study by Smith et al. (1989) showed that successful comprehension performance of poor readers can be obtained when the working memory load is minimized. We also conjectured that a lower incidence of relatives in the SO context by poor readers may be due to a higher working memory demand of SO relatives (based on the analysis by Carpenter & Just, 1988). Finally, we advanced an argument based on considerations from language learnability.

To conclude, by exploiting the advantages of the elicited production technique, it was shown that poor readers possess knowledge of relative clauses and do not suffer from a lag in syntax acquisition. Thus, the findings constitute evidence against the syntactic lag hypothesis. It was argued that the results obtained in this study, taken together with those of the

Mann et al. (1984) and Smith et al. (1989) studies, are most compatible with the processing limitation hypothesis. By inference, the totality of evidence supports the view that poor readers' problems in spoken language comprehension result from inefficiencies of verbal working memory that are associated with general difficulties in phonological processing.

## APPENDIX 1

### SENTENCES FOR THE ACT-OUT TASK WITH RELATIVE CLAUSES: EXPERIMENT 1

#### *Practice sentences*

1. The girl touched the puppy.
2. Mickey Mouse pushed the boy.

#### *Test sentences*

- OS The puppy jumped on the horse that ate the hay.  
 OS Mickey chased the boy that pushed the carriage.  
 OS The boy hit the cow that jumped over the fence.  
 OS The cat scratched the boy that threw the teddybear.  
 OS The dog licked the boy that picked up the pumpkin.
- OO The girl kissed the boy that the ball bumped into.  
 OO The horse kicked the cow that the pumpkin fell on.  
 OO The girl hugged the puppy that the sign knocked over.  
 OO The puppy licked the girl that the pie hit.  
 OO The cat jumped on the girl that the branch scratched.
- SO The cat that the monkey scratched climbed up the tree.  
 SO The cow that the horse kicked knocked down the sign.  
 SO The hippo that the lion bit ran toward the fence.  
 SO The piggy that the baby kissed ate the cake.  
 SO The boy that the girl pushed touched the carriage.

## APPENDIX 2

### MATERIALS FOR THE ELICITATION TASK WITH RELATIVE CLAUSES: EXPERIMENT 2

#### RELATIVE CLAUSES WITH SUBJECT GAPS

##### *SS context*

There were two brothers in this story. One of them ate his ice cream, and the other one spilled his ice cream. Which boy is happy? Which boy is sad?

There are two monkeys in this story. One of them is packing his suitcase, and the other one is throwing the suitcase out of the window. Which monkey likes to travel? Which monkey doesn't like to travel?

There are two dogs in this story. One of them is pushing the ball with his nose, and the other one is lying down and yawning. Which dog is playful? Which dog is tired?

There are two girls in this story. One of them is watching TV, and the other one is doing her math problems. Which girl is hard-working? Which one is lazy?

*OS context*

There are two girls and a cat in this story. One of them is pouring milk into the cat's bowl, and the other one is drinking milk. The cat scratched one of the girls, and licked the other one. Which girl did the cat lick? Which girl did the cat scratch?

There are two women and a girl in this story. One of the women gave candy to the girl, and the other woman is reading a book to her. The girl is kissing one of the women and touching the other one. Which woman is the girl kissing? Which woman is the girl touching?

There were two puppies and a girl in this story. One of them is drinking milk, and one of them is chewing up a tennis shoe. The girl is petting one of them, and the dog is licking the other one. Which puppy is the girl petting? Which puppy is the dog licking?

There were two boys. One of them is holding a balloon, and the other one is holding a rubber toy. The mother is bathing one of them and dressing the other one. Which boy is the mother bathing? Which boy is the mother dressing?

There are two girls and a dog in this story. One of them is writing in her notebook, and the other one is throwing the ball. The dog is licking one of them, and jumping on the other one. Which girl is the dog licking? Which girl is the dog jumping on?

There are two boys and a girl in this story. One of them is eating ice cream, and the other one is eating soup. A girl is teasing one of them and pointing to the other one. Which boy is the girl teasing? Which boy is the girl pointing to?

**RELATIVE CLAUSES WITH OBJECT GAPS**

*SO context*

There are two boys in this story. Some ice cream fell on one of them, and an apple fell on the other boy. One of the boys is smiling, and the other one is crying. Which boy is smiling? Which boy is crying?

There are two girls and a boy in this story. The boy is hitting one of them and kissing the other one. One of the girls is crying, and the other one is smiling. Which girl is smiling? Which girl is crying?



### *OO context*

There are two cats and a dog in this story. A balloon bumped into one of them, and milk spilled on the other one. The dog is jumping on one of cats and licking the other one. Which cat is the dog jumping on? Which cat is the dog licking?

There are a boy and two fences in this story. A tree fell on one of the fences, and a cat is sitting on the other one. The boy is jumping over one of the fences, and pointing to the other one. Which fence is the boy jumping over? Which fence is the boy pointing to?

There were two ladies. A cat scratched one of them, and the dog is growling at the other one. A man is bandaging one of the ladies, and hugging the other one. Which lady is the man bandaging? Which lady is the man hugging?

There were two women. A pie fell on one of them, and the balloon hit the other one. A man is touching one of the ladies and kissing the other one. Which lady is the man touching? Which lady is the man kissing?

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### NOTES

1. Among the structures claimed to be problematic for poor readers are adjectives of object control (Byrne, 1981), as well as relative clauses and irreversible passives (Stein, Cairns, & Zurif, 1984).
2. Sources of evidence for the modular organization of language come from speech perception studies (Mattingly & Liberman, 1988), studies of brain-damaged patients suffering from aphasia (Linebarger, Schwartz, & Saffran, 1983; Shankweiler, Crain, Gorrell, & Tuller, 1989; Whitaker, 1976), and studies of language development (Crain & McKee, 1985; Crain & Nakayama, 1987; Crain & Thornton, 1991; Hamburger & Crain, 1982).
3. Later in the article we report experimental evidence indicating that adults conceptualize the action of the relative clause as having occurred before the action of the main clause in sentences like (3).
4. Object relatives take longer to process than subject relatives in normal adults (Ford, 1983). Also, agrammatic patients perform only at chance on comprehension of object relatives, whereas they perform above chance on subject relatives (Grodzinsky, 1987).
5. We discuss the prerequisites for the elicited production task in the section on Experiment 2.
6. As will be discussed, the Smith et al. study included two experimental innovations that resulted in better performance levels than in previous research. The

purpose of the comprehension task in the present study was to try to tease apart the relative importance of these manipulations in the successful performance of poor readers.

7. Hamburger and Crain (1982) showed that young children interpret, and even produce, restrictive relative clauses successfully when the presuppositions are satisfied. Previous experiments with young children, in which no attempt was made to satisfy the restrictive presupposition of relative clauses, showed difficulties in comprehension. These difficulties were ascribed to a lack of knowledge of relative clauses; however, Hamburger and Crain's results indicate that children's errors in previous experiments were due to nonsyntactic causes, such as undeveloped working memory resources needed to accommodate unmet presuppositions.
8. Of course, it is possible that only the *combination* of satisfying presuppositions and reducing the number of animate noun phrases would suffice to bring about a significant improvement in poor readers' performance. This possibility will not be addressed here, however.
9. The decoding test consisted of reading individual words and nonwords.
10. All 15 good and 15 poor readers took part in the elicitation experiment, which is reported as Experiment 2; 13 good readers and 14 poor readers participated in the comprehension task. The discrepancy is due to the fact that 3 subjects moved away during the course of these experiments.
11. SS relatives were not tested because a correct response to an SS sentence cannot be distinguished from an erroneous "conjoined clause" response. To see this, consider (i) and (ii), where both the correct response and the conjoined-clause response would have the cat scratch the monkey and climb the tree.
  - i. (SS relative): The cat that scratched the monkey climbed up the tree.
  - ii. (conjoined): The cat scratched the monkey and climbed up the tree.
12. When all the independent variables were included in the MR analysis, the results yielded  $R^2 = .52$ . In other words, all three variables taken together account for 52% of the variance in the range of the dependent variable subjects' responses.
13. In other words, it would be more likely for a cat to scratch a boy than for a boy to scratch a cat.
14. An example of an OS sentence from the Smith et al. study is the following: *The man touched the lady who carried a suitcase.*
15. As controls, we included sentences in which plausibility considerations would dictate that the action of the main clause occurred first: 1. *He cooked the food he ate.* As expected, adults perceived the action of the main clause as having occurred first in the control sentences.
16. There is a problem with this account, however. In adult speech, the complementizer *that* cannot be used to introduce a nonrestrictive relative clause.
17. The term "gap" refers to a superficially missing (phonologically empty) noun phrase of the relative clause.
18. Recall that SS relatives were not tested in the act-out task because a correct response to an SS sentence is indistinguishable from an erroneous conjoined clause response.

19. We mentioned earlier that in this task, subjects were not required to produce a full sentence, but only a noun phrase with a relative clause. This may have lowered the short-term memory demands of this task in comparison with the act-out task and may have contributed to the high number of correct productions. In the act-out task, only full sentences with relative clauses were included.
20. This includes all types of relative clauses.
21. The percentage of resumptive errors reported in Table 3 was calculated as a proportion of the 12 sentences with object gaps.
22. Notice, however, that in (32), the subject has to keep the initial noun phrase in memory longer than in (33).
23. They note that in passives, the filler and the gap have the same grammatical role of subject.
24. It is relevant to mention that relative clause sentences with resumptives are not excluded by the Universal Grammar, since they can be found in some languages (for example, Hebrew).

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