Deaf readers' comprehension of relative clause structures

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ABSTRACT
It is commonly found that most deaf readers display an overall depressed level of reading performance in conjunction with specific difficulties in complex syntax. In this study, deaf good and poor readers' comprehension of relative clause structures was tested in written English, signed English, and American Sign Language. It was found that the behavior of deaf good and poor readers was parallel across relative clause sentence types, and that the deaf readers generally performed similarly to hearing readers tested in a different study. These results support the hypothesis that a specific syntactic disability does not differentiate deaf good and poor readers. Instead, it is suggested that a processing deficit may underlie the poor readers' comprehension difficulties.

Most deaf individuals attain reading levels far below those of their hearing counterparts. Karchmer, Milone, and Wolk (1979) reported that hearing-impaired high school graduates read only at the fourth- or fifth-grade level, and those who are profoundly deaf (i.e., greater than 90 decibel loss) score only, on the average, at the second- or third-grade reading level. It is therefore important to discover what abilities underlie the distinction between deaf successful and less successful readers. In this article we report the results of a study comparing the performance of adult deaf good and poor readers on several tests of syntactic comprehension to determine if deficient syntactic knowledge underlies the poor readers' difficulty. Comprehension was tested in three modalities: written English, signed English (SE), and American Sign Language (ASL). We included a test of written English to examine any effects of processing written language on comprehension. We employed signed tests to separate out any effects of reading ability from syntactic knowledge. Sentences with relative clauses were the focus of our syntactic tests.

The motivation for this investigation lies in studies of syntactic comprehension with hearing good and poor readers. These studies have suggested that phonological coding ability underlies apparent syntactic difficulties. It has been claimed that hearing poor readers experience a syntactic structural deficit, indicating a pervasive linguistic immaturity. For example, Byrne (1981) found that poor readers were inferior to good readers in demonstrating an understanding of (spoken) adjectival constructions exhibiting control phenomena, such as, "The bird is easy to bite." He also found that poor readers were inferior to good readers on sentences with improbable center-embedded relative clauses, such as, "The bird that the worm is eating is yellow." Byrne suggested that the poor readers' deficit indicates a lack of knowledge of these syntactic forms and is evidence for a lag in syntactic development, since comprehension of these particular sentence types is often thought to occur late in spoken language acquisition. However, Shankweiler and Crain (1986) and Crain and Shankweiler (1987) argued that poor readers do have knowledge of these structures. They proposed that a processing limitation associated with phonological processing in the service of working memory underlies poor readers' reading and syntactic comprehension difficulties. When the working memory load is eased by using experimental techniques that do not impose excessive processing demands on the child, poor readers show improved performance, and they show similar error patterns to good readers across different sentence types.

Taking these studies as our starting point, we decided to examine deaf readers' syntactic abilities. It is well documented in the literature that deaf readers have difficulty with English syntax (Quigley, Steinkamp, Power, & Jones, 1978). The present study was designed to investigate whether this documented difficulty arises from a lack of knowledge of specific structures or from a processing deficit, as suggested by the work of Shankweiler and Crain for hearing readers.

We chose to begin with the relative clause structure, since English and ASL have different grammatical rules for forming relative clauses, and since data was available from studies with hearing good and poor readers to enable us to make comparisons with the deaf readers.

PREVIOUS RELATIVE CLAUSE STUDIES

Hamburger and Crain (1982) examined hearing children's acquisition of relative clause structures and suggested that many preceding experiments had underestimated children's syntactic knowledge by using inappropriate testing procedures. For example, when syntactic comprehension is tested using an act-out task, subjects are usually given one prop for each noun phrase in the test sentence and asked to act out the meaning of the sentence. For the sentence, "The horse kicked the sheep that jumped over the fence," a horse, a sheep, and a fence are usually presented. Hamburger and Crain noted that the use of only one prop for the head of the relative clause (i.e., the sheep) violates the pragmatic conditions on the felicitous use of restrictive relative clauses. The relative clause modifying "sheep" – "that

jumped over the fence" – is only necessary when that sheep stands in contrast to other sheep who did not jump over the fence. Thus, at least two sheep props are necessary in order to satisfy pragmatic conditions on the use of relative clauses. When Hamburger and Crain made this modification, high rates of comprehension and production of relative clauses were obtained even from 3-year-old children. They suggested that failure to meet the pragmatic felicity conditions in experimental settings adversely affects children's performance by introducing extraneous processing demands that stress working memory limitations in young children. They bolstered their argument that processing limitations, not a lack of syntactic knowledge, underlies children's performance by comparing children's responses, even when correct, with adults' responses. Adults act out a sentence like the one above first by making the sheep jump over the fence and then by making the horse kick that sheep. This meets the pragmatics of the relative clause, but requires the two actions to be made in the opposite order from which they were uttered. However, children first make the horse kick the sheep and then make the sheep jump over the fence. Even though this order is inconsistent with the pragmatics, it is easier on working memory to produce the actions in the same order as the sentence.

Smith (1987) and Smith, Macaruso, Shankweiler, and Crain (1988) used these improved pragmatic conditions in tests of relative clause comprehension by second-grade hearing good and poor readers. Smith used both act-out and picture choice tasks, with sentences of the following five types:

1. SS   The lady who _____ held an umbrella kissed the man.
2. SO   The man who the lady kissed _____ held an umbrella.
3. OS   The lady kissed the man who _____ held an umbrella.
4. OO   The lady kissed the man who an umbrella covered _____.
5. CC   The lady kissed the man and _____ held an umbrella.

The four relative clause sentence types (1)–(4) can be characterized by two factors, which are notated using Ss and Os (for Subject and Object) in these examples. The first letter indicates the position of the relative clause in the sentence (whether the NP that the relative clause modifies functions as the subject or object of the main verb). The second letter indicates the position of the gap in the relative clause (whether the head of the relative clause is the subject or object of the relative clause verb; the gap is indicated using a short blank line in its position). The fifth sentence type (5) (Conjoined Clause) is a control. Earlier studies of children's relative clause comprehension (e.g., Goodluck & Tavakolian, 1982; Tavakolian, 1981) have suggested that children choose a CC analysis when they err in the interpretation of relative clause structures.

If poor readers have a syntactic deficit, they would be expected to perform poorly across the relative clause sentence types without any particular pattern of errors. If, however, they have the grammatical knowledge associated with relative clause structures, but suffer from a working memory

overload due to inefficient phonological coding, they would be expected to show the same pattern of errors across the five sentence types as good readers, even with an overall depressed level of performance.

Smith (1987) found that good and poor readers achieved a high level of performance on both tests, and that the good readers were slightly better than the poor readers (this difference was marginally significant in the picture choice task and not significant in the object manipulation task). Sentence type was highly significant in both tests, and in neither test was a Sentence Type × Reader Group interaction significant. Thus, the good and poor readers were parallel in their response patterns across sentence types for both tests.

The results of Smith's study can be compared to results of an earlier study by Mann, Shankweiler, and Smith (1984), in which third-grade good and poor readers were tested using an object manipulation task on the four relative clause structures (no picture choice task was performed in the Mann et al. study). In the Mann et al. study, the felicity conditions on relative clauses were not observed. The results, like Smith's results, showed that good and poor readers exhibited the same patterns of errors across the four relative clause sentence types. Overall, however, both groups performed worse on the Mann et al. test than on the Smith test. These results have been interpreted as indicating that the poor readers do not suffer from a structural syntactic deficit, but from a lower level processing deficit. This deficit is hypothesized to be associated with inefficient use of phonological coding in the service of working memory.

We chose to begin examining syntactic ability of deaf good and poor readers in tests of relative clause comprehension to be able to make direct comparisons between the deaf groups as well as comparisons with the results from hearing populations. Do deaf poor readers show systematic syntactic deficits when tested using tests analogous to those used with hearing students, or might processing limitations associated with an inefficient use of phonological coding in working memory underlie deaf poor readers' impaired performance on tests of syntactic comprehension? If a syntactic deficit underlies deaf poor readers' performance, we should expect to see a pattern of performance quite different from that of good readers without a syntactic deficit. That is, we should expect a Reader Group × Sentence Type interaction. Also, we should expect that the types of errors made by poor readers would be qualitatively different from those made by good readers. On the other hand, if deaf poor readers have syntactic knowledge equivalent to that of the deaf good readers, then the performance of the two groups should be parallel. Further, if deaf readers overall have knowledge of English syntax equivalent to that of hearing readers, we should expect the pattern of performance for deaf readers on this test to be similar to the patterns of performance for hearing readers on previous tests.

We tested deaf college students in a battery of tests designed to examine their knowledge of relative clause structures. This battery included tests employing written English, SE, and ASL. We chose to test written English to detect any effects of processing written language. We tested SE and

ASL in order to separate out any effects of reading ability from syntactic knowledge. We chose to test SE to determine whether deaf subjects display any deficits in the grammar of English when this is separated from processing written text. Finally, we chose to test ASL to see whether subjects knew the differences in the rules used for constructing relative clauses in English as compared to ASL.

ASL is the visual-gestural language used by most deaf people in the United States and parts of Canada. It has its own grammar, which is distinct from the grammar of English in many ways. The construction that we examined – relative clauses – represents one such construction in which the grammatical rules used in ASL are different from the rules used in English. In addition to the autonomous ASL, most deaf people are fluent in some such form of sign communication based on English. Schools for the deaf that use manual communication generally employ some form of SE, in which the signs used for individual words in ASL are combined using English grammar and supplemented or changed where needed so as to follow English rather than ASL rules.

METHOD

Subjects

To compare adult deaf good and poor readers with approximately equal ages and educational backgrounds, we chose subjects from the freshman class and preparatory school at Gallaudet University. Subjects were 26 undergraduates who had severe to profound hearing loss;[1] they were paid for their participation. We limited our subjects to severely to profoundly deaf children of deaf families who stated that they learned ASL from their parents at home from birth.

Subjects were assigned to either the "good" or the "poor" reader group on the basis of the comprehension subtest of the Gates–MacGinitie Reading Test (1978), which was administered as part of our test battery. In this test, the subjects read paragraphs of English text and answered 43 four-choice comprehension questions on a separate answer sheet. The test provided grade-equivalent scores. The two groups that were formed by dividing subjects on the basis of their reading scores performed at the ninth-grade level (the good readers) and the fifth-grade level (the poor readers). Notice that both these groups are above the national average for profoundly deaf high school graduates, which is at the second- to third-grade level (Karchmer, Milone, & Wolk, 1979). Furthermore, even our good readers are not reading at their grade level. For these reasons, our groups should be considered "more successful" and "less successful" readers, although for convenience we will continue to call them good and poor readers, respectively.

To assess subjects' nonverbal intelligence level, the screening test from Raven's Progressive Matrices (Raven, 1965) was given. In this test, subjects were presented with a test item consisting of a drawn figure that is missing one segment. They were asked to choose the correct missing segment out of

Table 1. *Characteristics of the subjects*

Mean score	Good readers ($N = 13$)	Poor readers ($N = 13$)	
Raven	8.9	8.7	n.s.
Gates–MacGinitie	9.34	5.08	$p < .001$

a choice of eight segments. There are 12 test items. As shown in Table 1, the good and poor reader groups differed significantly in reading ability, but not on our measure of nonverbal intelligence.

Relative clause test battery

All subjects were given a battery of tests including five relative clause (RC) tests (RC Reading, ASL Pictures, ASL Objects, SE Pictures, and SE Objects). The English tests and the ASL tests were presented in separate blocks; half the subjects received the ASL block first, and half the subjects received the English block first. Within each block, the order of Pictures and Objects tests were varied across subjects. All tests were administered by a deaf signer.

RC reading. Comprehension of written English sentences containing relative clauses was examined using a standardized English test for deaf students, the Relativization 1: Comprehension subtest of the Test of Syntactic Abilities (TSA) (Quigley, Steinkamp, Power, & Jones, 1978). This subtest contains 70 four-choice, multiple-choice items using five different relative clause structures. We chose the first 6 items from each of four relative clause structures (SS, SO, OS, OO) for a total of 24 items in our version of this test. An example is given in (6):

6. The boys who waited for Susan picked the flowers.
   a. The boys waited for the flowers.
   b. The boys picked the flowers.
   c. Susan picked the flowers.
   d. The boys picked Susan.

The subjects were given test sheets with all the items printed on them. There is no context given for the test sentences; just the sentences themselves are given. The subjects were instructed to read each test sentence and the four choices below and then circle the letter of the sentence that was correct, given the test sentence.

RC signs. The materials used in Smith's study were adapted for presentation in ASL and SE. We decided not to use the OO type of relative clause,

since that structure introduced many complexities in both English and ASL.[2] Although there are several types of relative clauses in ASL (see Coulter, 1979; Liddell, 1980); we chose to consistently use a head-internal relative clause with a relative clause final THAT unambiguously agreeing with the head via spatial marking. Examples of the four ASL (7–10) and SE (11–14) sentence types are:[3,4]

ASL relative clauses

7. SS $\overline{\text{aWOMAN HAVE BOX aTHAT aKISSb}}$ bMAN.
   'The woman who has the box kissed the man.'

8. SO $\overline{\text{bMAN bKISSa aWOMAN aTHAT}}$ HAVE BOX.
   'The woman who the man kissed has the box.'

9. OS bMAN bKISSa $\overline{\text{aWOMAN HAVE BOX a THAT.}}$
   'The man kissed the woman who has the box.'

10. CC bMAN HAVE BOX, bKISSa aWOMAN.
    'The man has the box and kissed the woman.'

SE relative clauses
11. SS THE WOMAN WHO HAVE THE BOX KISS THE MAN.
12. SO THE WOMAN WHO THE MAN KISS HAVE THE BOX.
13. OS THE MAN KISS THE WOMAN WHO HAVE THE BOX.
14. CC THE MAN HAVE THE BOX, AND KISS THE WOMAN.

Five sets of the four types were constructed, for a total of 20 test sentences in each of four versions of the test (ASL Pictures, ASL Objects, SE Pictures, and SE Objects). The sentences were semi-randomly ordered, so that no two sentences in a row were of the same type. The ASL sentences were randomized with respect to spatial location of subjects and objects. Each test was preceded by four practice sentences, which included three subject–verb–object simple sentences and one SVO–SVO conjoined sentence. The test sentences were produced by a deaf native signer of ASL and videotaped for presentation to the subjects.

In the Objects tests, the experimenter placed four props in front of the subject in a predetermined random order and instructed the subject to watch the sentence signed on videotape and then act its meaning out using the props. After each sentence, the experimenter gave the subject a new set of four props. In the Pictures tests, the experimenter showed the subject two pictures arranged one over the other on a page. The experimenter instructed the subject to watch the sentence signed on videotape and then point to the picture that matched the sentence. In all cases, the experimenter recorded the subject's response on an answer sheet; if a subject requested to see a sentence a second time, the experimenter rewound the videotape to the appropriate position and played the sentence again.
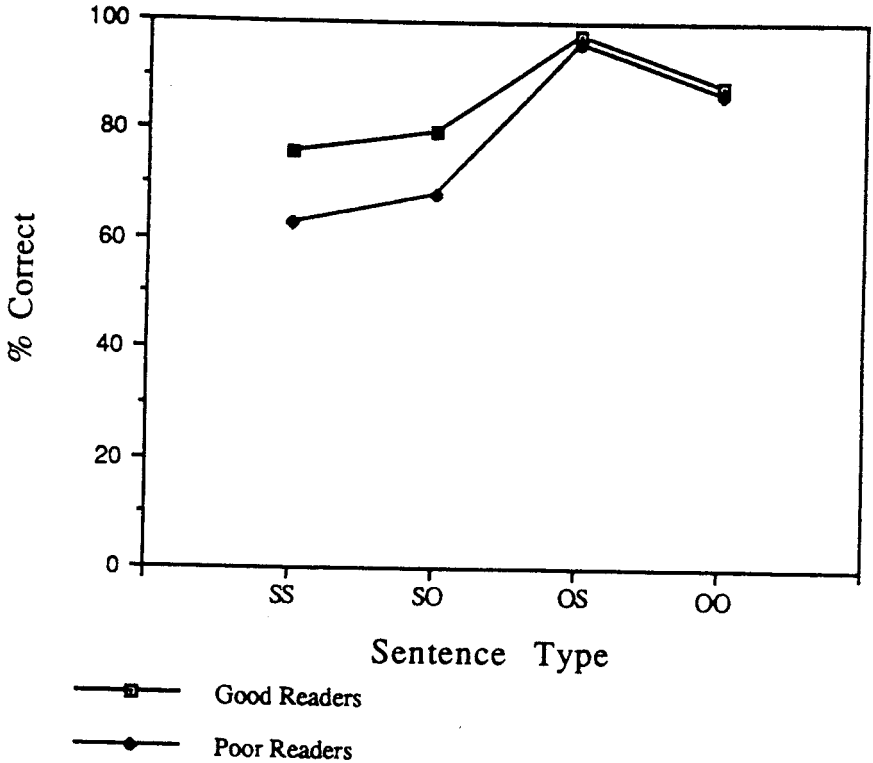
Figure 1.   RC reading.

RESULTS

RC reading

The average score (percent correct) on the TSA for the good reader group was 85.26, while the average score for the poor reader group was 78.53. In an analysis of variance on the between-subjects factor of group and the within-subjects factor of sentence type, neither the group difference, $F(1, 24) = 1.44$, $p > .10$, nor the interaction ($F < 1$, n.s.) was significant, although there was an effect of sentence type, $F(3, 72) = 15.74$, $p < .0001$. Post-hoc analysis of the significant sentence type effect shows that the source of this effect is the difference between the SS and SO versus the OS and OO sentence types ($p < .01$, Newman–Keuls). The results of this test are illustrated in Figure 1.

RC signs

Overall, the good readers scored 95.8% correct on the ASL tests and 91.9% correct on the SE tests; the poor readers scored 94.1% correct on the ASL tests and 87.7% correct on the SE tests. Comparing the ASL tests with the

SE tests, there is a significant effect of language, $F(1, 21) = 15.37$, $p < .001$, but neither the group effect nor the interaction was significant. The four tests on which this comparison is based will be discussed by language.

RC/ASL

Overall, both groups performed quite well on the signed relative clause tests. The average score (percent correct) on the ASL Pictures test for the good reader group was 96.92, while the average score for the poor reader group was 95.83 ($F < 1$, n.s.). The average score on the ASL Objects test for the good reader group was 94.62, while the average score for the poor reader group was 93.08 ($F < 1$, n.s.). For both of these tests, like the TSA, the only effect was for sentence type: $F(3, 69) = 2.74$, $p < .05$, for the Pictures test; $F(3, 72) = 9.85$, $p < .0001$, for the Objects test. Unlike the TSA, however, on the ASL Objects test, the source of the significant difference between sentence types was between the SO and all other sentence types ($p < .01$, Newman–Keuls). On the ASL Pictures test, the only significant sentence type difference was between the lowest (OS) and highest (CC) sentence types ($p < .05$, Newman–Keuls). See Figures 2 and 3 for illustrations of the results of these two tests across sentence types.

The subjects' responses on the Objects test were also scored for conceptual accuracy. As mentioned earlier, adults usually respond to an act-out relative clause task first by acting out the relative clause, which is pragmatically presupposed, and second by acting out the main clause, which is the new information. Using this criterion, all subjects' responses were scored as conceptually accurate or inaccurate.[5]

The good and poor reader groups showed parallel performance for the conceptual accuracy of their responses. As with the error analysis, a significant effect was found for sentence type, $F(2, 48) = 47.673$, $p < .0001$, while no effect was found for reader group or the interaction. The SS, SO, and OS sentence types were all significantly different from each other, in descending order of percent of conceptually accurate responses. See Figure 4 for an illustration of this effect.

RC/SE

The average score (percent correct) on the SE Pictures test for the good reader group was 95.0, while the average score for the poor reader group was 93.33 ($F < 1$, n.s.). The average score on the SE Objects test for the good reader group was 88.75, while the average score for the poor reader group was 83.46, $F(1, 23) = 2.82$, $p > .10$. Again, the only significant effects come from sentence type: $F(3, 66) = 7.33$, $p < .0003$, for the Pictures test; $F(3, 69) = 43.06$, $p < .0001$, for the Objects test. As in the ASL Objects test, the source of the significant sentence type effect is the difference between the SO and all other sentence types ($p < .01$ for both Pictures and Objects, Newman–Keuls). See Figures 5 and 6 for the results of the SE tests.
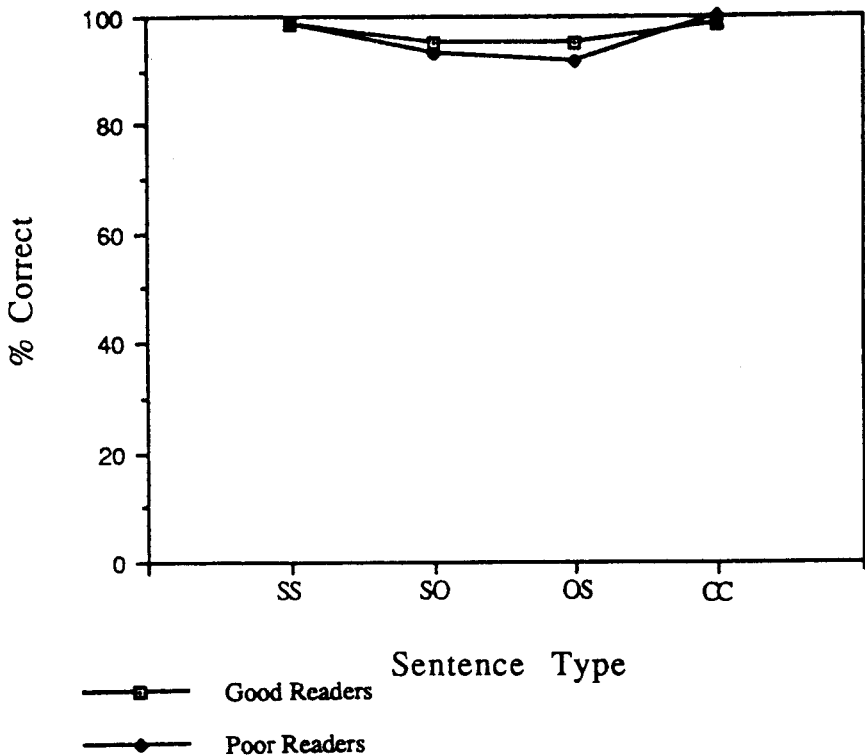
Figure 2. ASL pictures.

As with the ASL Objects test, the SE Objects responses were evaluated for conceptual accuracy. Again, no group difference or interaction was found, although there was a significant effect of sentence type, $F(2, 46) = 54.96, p < .0001$. This time, the source of the sentence type effect was just in the SS sentences versus the SO and OS sentences (see Figure 7).

DISCUSSION

Although the two reader groups we studied are significantly different in their reading scores, with a difference of four grade levels, we would like to point out again that, strictly speaking, they are neither good readers (our "good" reader group only scored at the ninth-grade level), nor poor readers (the fifth-grade average of our "poor" group is still higher than the national average for deaf high school graduates). These groups are more and less proficient readers, and they will be called "better" and "poorer" readers in this discussion.

For our two groups of better and poorer readers, we found no evidence of a relative clause syntactic deficit underlying the poorer reading ability of
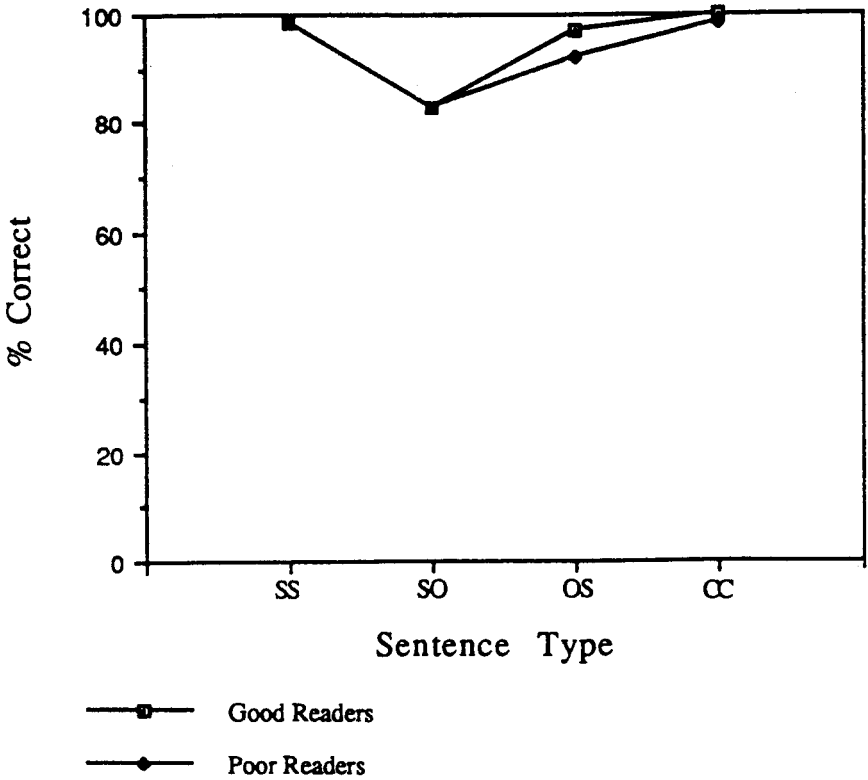
Figure 3.   ASL objects.

the one group. Whether given in written English, SE, or ASL, relative clause structures were comprehended equally well by the subjects in both reader groups. In fact, an analysis of the few errors that were committed by the subjects shows that the pattern is exactly parallel in all aspects of performance: in the distribution of correct responses across sentence types (as evidenced by an effect of sentence type without a group effect or interaction), in the type of erroneous responses given, and in the conceptual accuracy of responses overall.[6] This parallel pattern was not only found for the group of subjects, but also for individual subject data. Since English is not the first language of these subjects, and reading may impose additional demands on the comprehension system, it was important that we performed the tests across the various language and modality domains.

Furthermore, the errors on the ASL Objects, SE Pictures, and SE Objects tests are also parallel to the error patterns found in similar studies with hearing subjects. Smith (1987) found that hearing good and poor readers showed similar parallel patterning across sentence types, and she found that the source of the sentence type effect in most cases were the SO sentences. Thus,
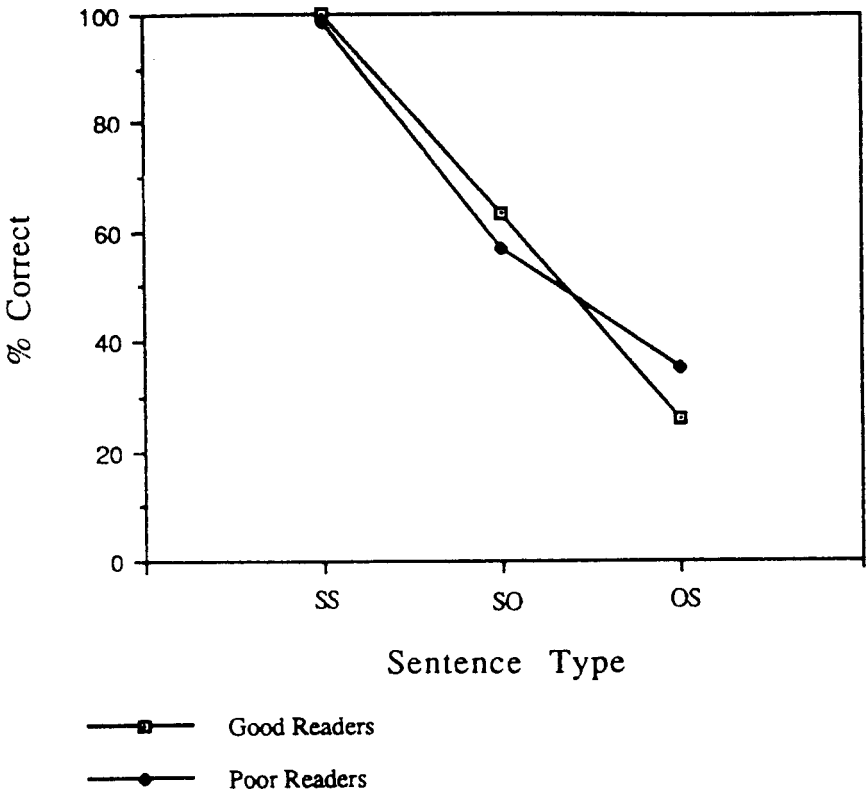
Figure 4. ASL conceptual order.

across the signed tests, and comparing signed tests with spoken tests adminis-
tered to hearing subjects, a parallel pattern of results is found.

We interpret the pattern of results obtained on these tests as evidence that
the deaf subjects we tested are proficient in comprehending the syntactically
complex relative clause structure. Overall reading success by deaf college
students is thus due to syntactic competence – not in spite of syntactic
deficit. In order to support this claim, studies of additional syntactic struc-
tures are required.

Although the results of the tests discussed here are consistent with the
hypothesis that syntactic knowledge (in particular, knowledge of relative
clause structures) is not at fault in poorer readers, there is an important
difference between the signed tests and the English reading test. First, for
both the better readers and the poorer readers, the average score on the
reading test is below the average on all the signed tests. Given that different
procedures were used in the reading and sign tests, we do not know if this
seemingly poorer performance on the reading tests actually reflects more
difficulty on reading than on RC sign comprehension. Because of the dif-
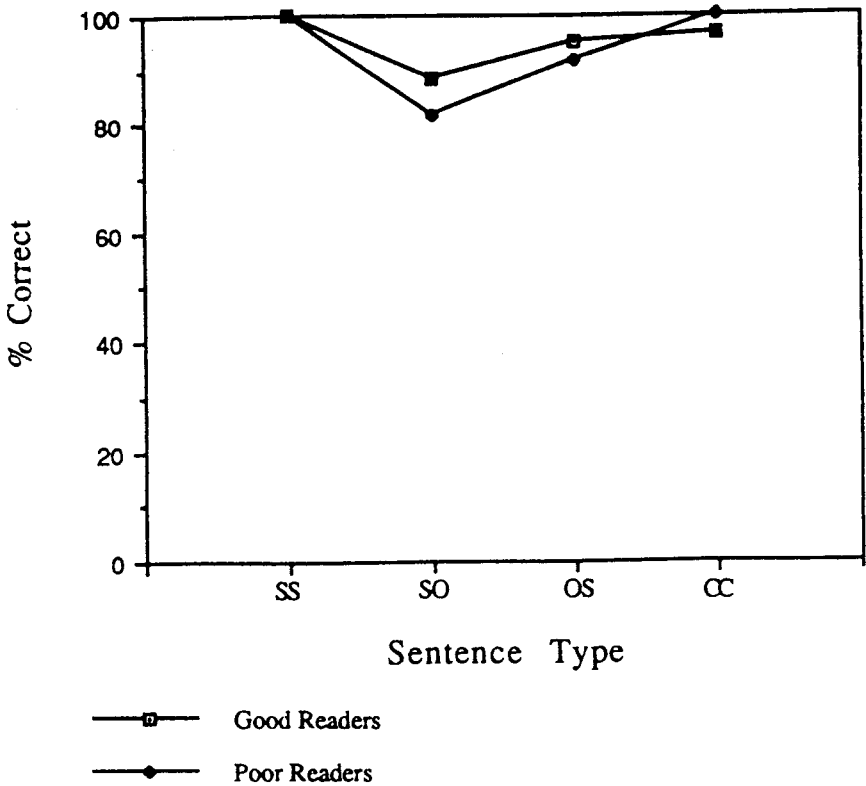ferent procedures, we are unable to directly compare the two. Also, the

Figure 5.   SE pictures.

error pattern on this test is not parallel to that of the signed tests. In the reading test, SS sentences caused just as many errors as SO sentences. This result is unexpected, given the results found in many relative clause studies with hearing children and adults, both good and poor readers. However, this can be accounted for by considering the following differences in test and stimuli design between the two test types.

The RC Reading test did not satisfy the pragmatic felicity conditions referred to above, in that no extra referent was used to contrast with the referent in the relative clause. In addition, three animate noun phrases were often used instead of two animate and one inanimate, as in the signed tests. This factor has also been found to be responsible for low performance on relative clause tests with children (see Goodluck & Tavakolian, 1982; Hamburger & Crain, 1982). The most prevalent error type for both good and poor readers – the extra SS errors on the RC Reading test, which can be attributed to these factors – was an order-based response, in which the second NP was considered the subject of the second verb (e.g., response C for question 6 above).

This order-based response was also found by Quigley, Smith, and Wilbur

Figure 6.   SE objects.

(1974), who presented an earlier version of the TSA to deaf children aged 10–18 years and also to hearing children aged 8–10 years. The earlier "Processing Test" used yes–no questions about relative clauses, including the four types described. Overall, the deaf 18-year-olds scored 76% correct on this test, while the hearing 10-year-olds scored 83% correct; but importantly, as in the present study, the deaf and hearing groups in this study also showed parallel performance across the sentence types.[7,8] Furthermore, Quigley et al. reported the percent errors for two of the SS sentences, attributing at least part of the extra difficulty in this sentence type to order-based responses. The two items are given in (15):

15.   The girl who hit the boy went home.
    a.   The boy went home.   yes _____ no _____
    b.   The girl went home.   yes _____ no _____

    The man who bought a dog chased the woman.
    a.   The man chased the woman.   yes _____ no _____
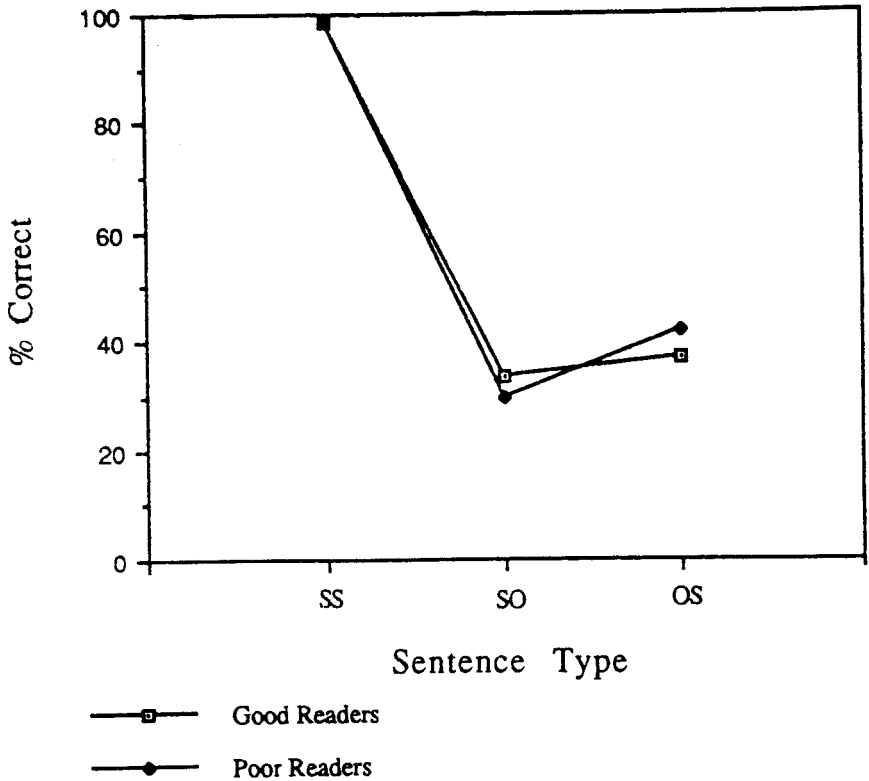   b.   A dog chased the woman.   yes _____ no _____

Figure 7.   SE conceptual order.

It is clear that for the two examples given, the mistakes involved an order-based response. In their graph of the responses to these two items, Quigley et al. showed that again, deaf and hearing subjects show similar patterns of errors. It is possible that both the hearing and deaf subjects in this study lack knowledge of the grammatical apparatus for relative clause formation. However, given the much higher percentage of correct responses in general (especially for the OO sentences) and the parallel pattern of responses across the two groups, it is much more likely that both deaf and hearing groups share knowledge of the basic syntactic processes in relative clause formation. Since the deaf subjects showed an overall lower performance compared to the hearing subjects, this can be taken as evidence that the deaf subjects might also have a lower level processing impairment that affects the higher levels of language processing in a systematic way.

The Quigley et al. results indicated that grammatical knowledge does not differ between the two reader groups. Given this result and the previous literature cited above, it appears that the reading differences that do exist between the groups we tested are based on processing differences rather

than differences in grammatical knowledge. An underlying processing difference would account for generally lower performance by the poor reader group along with parallel error type performance for the two groups. Note that this does not imply that deaf poor readers never have structural problems. Rather, it shows that some cases that appear to be syntactic problems for deaf readers may, instead, be an incidence of processing deficit.

What kind of processing deficit might be involved? Our hypothesis is that this deficit lies in lower level phonological processing. Studies by Conrad (1979), Hanson (1982, 1989; Hanson & Fowler, 1987; Hanson, Goodell, & Perfetti, 1991; Hanson, Liberman, & Shankweiler, 1984; Hanson & Lichtenstein, 1990), and Lichtenstein (1985) all indicated that deaf better readers use phonological coding for processing English text, and, as Hanson suggested, this may be the most beneficial coding system for reading English. Deaf poorer readers, on the other hand, do not show evidence of phonological coding when dealing with printed English (Conrad, 1979; Hanson et al., 1984; Lichtenstein, 1985), and this could contribute to their overall lower performance in reading English.

Other possible processing codes that the deaf readers could be using include sign- or fingerspelling-based codes. The evidence suggests, however, that sign and fingerspelling codes are less efficient and generally not used by the best deaf readers (Hanson, 1982, 1991; Lichtenstein, 1985; Treiman & Hirsh-Pasek, 1983). It is possible that sign- or fingerspelling-based coding is used by the subjects in this study; since this coding seems to be not as efficient as phonological coding, the use of such coding by the subjects in the present study could contribute to an overall lower level of accuracy with the written English.

Our further work involves investigating additional sentence types. We are investigating whether syntactic deficits are apparent in various types of complex syntax, again comparing performance with written English to performance with signed English and ASL. In addition, we are examining various techniques for examining memory coding in deaf good and poor readers in order to test the hypothesis that a difference in processing capabilities underlies the reading differences found between the two groups.

NOTES
1. Most of the subjects had profound hearing loss of 90 dB or greater, better ear average; three of the good readers and two of the poor readers had severe hearing loss of 70 dB or greater, better ear average.
2. In English, the OO relatives used by Smith employed a different verb than all the other sentences in a paradigm; this was necessary in order to keep constant the number of animate and inanimate objects in the test sentences. In ASL, a translation of this different verb always forced the use of a different sentence structure.
3. The following notation is used for the SE and ASL examples. Signs are written in all capital letters, using an English gloss that approximates the meaning of the sign. For ASL examples, subscripts are used to indicate spatial relations. Subscripts preceding nouns and THAT indicate the spatial locations; subscripts preceding and following verbs indicate the beginning and ending locations of the verb (generally corresponding to the locations of the subject and object, respectively; cf. Padden, 1983); co-subscripting in a sentence indicates the same location. A line above a phrase in an example indicates a facial gesture occurring simultaneously with the phrase; rc indicates the relative clause facial gesture (cf. Liddell, 1980).
4. As Liddell (1980) pointed out, relative clauses are not observed sentence-finally in ASL unless they are followed by the sign THAT (which Liddell calls $THAT_b$). This was one reason we chose this form of ASL relative clauses.
5. Note that many erroneous responses can still be scored for conceptual accuracy; in other words, even if the wrong items are used, the order of actions can be evaluated. Responses of main clause only would be counted as conceptually accurate, while responses of relative clause only would be counted as conceptually inaccurate.
6. Because of the small number of errors on the signed tests, our results could indicate a ceiling effect. However, it should be noted that for some sentence types, performance does drop into the 80% range (and as low as 46% correct for the poorer readers on SO sentences in the SE Objects test). In every case for which performance by the poorer readers drops, performance also drops for the better readers.
7. Quigley et al. did not report on statistics comparing the deaf and hearing groups, but they said that a similar analysis was conducted for hearing and deaf students "and the results were identical" (p. 333).
8. Recall that the Quigley results were obtained by testing 8- to 10-year-old children. We tested 22 hearing college students to see if the parallel with order-based responses was maintained in an adult group. This group only made six errors in total (98.9% accuracy), the majority of which were on the SO sentence type, not SS as with the younger hearing children and deaf subjects.

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