

Syntactic Competence and Reading Ability in Children

SHLOMO BENTIN AND AVITAL DEUTSCH

*Aranne Laboratory of Psychophysiology, The Hebrew University Medical School,
Jerusalem, Israel*

AND

ISABELLE Y. LIBERMAN

Haskins Laboratories, New Haven, Connecticut

The effect of syntactic context on auditory word identification and on the ability to detect and correct syntactic errors in speech was examined in severely reading disabled children and in good and poor readers selected from the normal distribution of fourth graders. The poor readers were handicapped when correct reading required analysis of the sentence context. However, their phonological decoding ability was intact. Identification of words was less affected by syntactic context in the severely disabled readers than in either the good or poor readers. Moreover, the disabled readers were inferior to good readers in judging the syntactical integrity of spoken sentences and in their ability to correct the syntactically aberrant sentences. Poor readers were similar to good readers in the identification and judgment tasks, but inferior in the correction task. The results suggest that the severely disabled readers were inferior to both good and poor readers in syntactic awareness, and in ability to use syntactic rules, while poor readers were equal to good readers in syntactic awareness but were relatively impaired in using syntactic knowledge productively. © 1990 Academic Press, Inc.

Fluent reading involves a complex interaction of several parallel processes that relate visual graphemic stimuli to specific entries in the lexicon and combine the semantic and syntactic information contained in those

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entries to apprehend the meaning of sentences. Some of these processes relate to the decoding of the phonological code from print while others relate to the assignment of meaning to the phonological units. Although the decoding of the phonological code can, in principle, be based solely on "bottom-up" application of grapheme-to-phoneme transformation rules, it is well documented that this process is supported by "top-down" streaming of lexical knowledge and contextual information. The common denominator of the "bottom-up" and "top-down" processes in reading is that both are components of the human linguistic endowment (see Perfetti, 1985; Rozin & Gleitman, 1977).

The relative contribution of context dependent (top-down) processes to visual word recognition is determined by many factors among which reader competence is particularly important. Although some authors have argued that as fluency develops, the reader increasingly relies on contextual information during word recognition (Smith, 1971), more recent studies have disconfirmed this hypothesis. For example, semantic priming facilitates lexical decisions more in children than in adults and more in younger than in older children (Schvaneveldt, Ackerman, & Semlear, 1977; West & Stanovitch, 1978). Similarly, context effects are greater in poor readers than in good readers both in lexical decision (Schwantes, Boesl, & Ritz, 1980) and naming tasks (Perfetti, Goldman, & Hogaboam, 1979; Stanovitch, West, & Feeman, 1981). Within the same subject, large context effects occur when bottom-up processes are inhibited by degrading or masking the target stimuli (e.g., Becker & Killion, 1977; Massaro, Jones, Lipscomb, & Scholz, 1978; Meyer, Schvaneveldt, & Ruddy, 1975). These results imply that the increased role of higher-level contextual processes in visual word recognition is caused by a need to compensate for deficiencies in lower level, decoding processes, such as those that occur with poor readers or degraded stimuli (Perfetti & Roth, 1981; Stanovitch et al., 1981).

The observation that context effects are larger in poor than in good readers does not imply, however, that poor readers are better or more efficient users of contextual information than good readers. In fact, the opposite may be true. Both Perfetti et al. (1979) and Schwantes et al. (1980) reported that when subjects are required to use the context for predicting the target word before seeing it, skilled readers do better than poor readers. The magnitude of semantic priming effects in visual word recognition may therefore be a rather poor indicator of the real ability to use contextual information. A relatively unbiased method for comparing good and poor readers' awareness of contextual information would be to evaluate context effects on word recognition in situations that either eliminate the need for decoding of print, as in auditory presentation, or that force all readers, regardless of skill, to use contextual processes to the same extent.

As a language in which efficient use of contextual information is essential for fluent reading, Hebrew provides an excellent channel through which to examine syntactic effects. In Hebrew orthography, letters represent mostly consonants, while vowels are represented by diacritical marks placed below, within, or above the letters. The vowel marks are usually omitted in writing except in poetry, holy scripture, and children's literature. Because different words may be represented by the same consonants but different vowels, when these vowels are absent up to seven, eight, or more different words may be represented by the same string of letters. In addition to being semantically ambiguous, these Hebrew homographs are also phonemically equivocal because the (absent) vowels of the words that are responsible for the different meanings vary from word to word. Therefore, fluent reading of "unvoweled" Hebrew requires heavy reliance on contextual information.

Reading instruction in Hebrew starts, as a rule, with the "voweled" orthographical system in which the diacritical marks are presented with the consonant letters. The vowels are gradually omitted from school texts starting at the beginning of the third grade. During the third grade, the children begin to learn to read without vowels. By grade four, they are expected to be fluent readers of unvoweled texts. Informal discussions with teachers, however, revealed that the transition from reading voweled to reading unvoweled material is not equally easy for all children. According to teachers, some children are good readers as long as the diacritical marks are present but are slow in acquiring the skill of reading without the vowels. Because without vowels the context of the sentence is a primary source of phonological constraints on reading, we suspected that the children in this group, although knowing the grapheme-to-phoneme transformation rules, do not (or cannot) use contextual information efficiently. Thus, despite being phonologically skilled, those children may be poor readers. Thus, Hebrew may be a convenient medium through which to test the hypothesis that at least some deficient readers are less able than good readers to use context.

We decided to manipulate syntactic rather than semantic context in the present research. The main reason for this decision is that syntax is probably a more basic linguistic ability than semantics (see Chomsky, 1969) and less affected by reading experience (Lasnik & Crain, 1985). In addition, syntactic violations are more clearly defined than are manipulations of semantic association strength.

The effect of prior syntactic structure on the processing of visually presented target words has been investigated in a number of studies. Lexical decisions regarding target words are faster when they are preceded by syntactically appropriate primes than when preceded by syntactically inappropriate primes (Goodman, McClelland, & Gibbs, 1981; Lukatela, Kostic, Feldman, & Turvey, 1983). Lexical decision (West &

Stanovitch, 1986; Wright & Garret, 1984) and naming (West & Stanovitch, 1986) are facilitated when targets are syntactically congruent with previously presented sentence fragments relative to when targets follow a syntactically neutral context.

Although the syntactic context effect on word recognition is reliable, information on the relation between this effect and reading ability is comparatively scarce and controversial (for a review see Vellutino, 1979). Several studies report that poor readers are inferior to normal readers in dealing with complex syntactical structures in speech (Brittain, 1970; Byrne, 1981; Cromer & Wiener, 1966; Goldman, 1976; Guthrie, 1973; Newcomer & Magee, 1977; Vogel, 1974). Other authors, however, have challenged a simple interpretation of these results (Glass & Perna, 1986). For example, Shankweiler and Crain (1986) have suggested that the poor readers' apparent deficiency in processing complex syntactic information may be an epiphenomenon of limitations of the working memory processor, rooted in a difficulty in generating phonological codes.

The present study sought to examine the relation between word recognition and syntactic awareness; i.e., sensitivity to syntactic structure and the ability to use syntactic knowledge explicitly, in children who vary in reading competence. Experiment 1, using a group of adult fluent readers of Hebrew, was designed to establish the validity of the procedure of testing the effect of syntactic context on the identification of auditorily presented words masked by white noise. Experiment 2 examined syntactic context effects in two groups of children. One group was composed of children with learning disorders drawn from a population of students who were selected by the school system for special supplementary training in reading; a comparison group was formed of good readers drawn from the population of fourth graders of two elementary schools. In Experiment 3, the same group of good readers was compared with a group of poor readers from the same elementary schools. The poor readers were matched with the good readers for their ability to apply grapheme-to-phoneme transformation rules in reading voweled pseudo-words, but they were significantly inferior in reading sentences when the words were printed without the diacritical vowel marks.

EXPERIMENT 1

The purpose of the present experiment was to establish the effect of syntactic context on the identification of auditorily presented words that were masked by white noise. The auditory modality was used to attenuate the deficient readers' excessive reliance on contextual information in reading (which is presumably caused by the need to compensate for their difficulty in decoding the print). Stimulus masking was incorporated in the procedure because previous studies suggest that degradation increases the tendency of all subjects to use contextual information for

word recognition (Becker & Killion, 1977; Stanovitch & West, 1981). We chose to use identification rather than reaction time measures in order to keep the measurement as simple and direct as possible.

Subjects were presented with a list of three- or four-word sentences that were prerecorded on tape. In each sentence, white noise was superimposed on one or several (target) words. The subjects were instructed to identify the masked words. Half the targets in the list were congruent with the syntactic structure of the sentence in which they appeared whereas the other targets were incongruent, that is, caused a syntactic violation. We predicted that the percentage of correctly identified targets would be higher for syntactically congruent words than for syntactically incongruent words.

Method

Subjects

The subjects were 28 undergraduate students (14 males) who participated in the experiment for course credit or for payment. They were all native speakers of Hebrew with normal hearing.

Test Materials

The auditory test included 104 three- or four-word sentences. Each sentence was used in two forms: (a) syntactically correct and (b) syntactically incorrect. The incorrect sentences were constructed by changing the correct sentences in one of the following 10 ways.

Type 1. In this category there were 12 sentences in which the gender compatibility between the subject and the predicate was altered. In 6 of these sentences a masculine subject was presented with a feminine predicate and in the other 6 a feminine subject was presented with a masculine predicate. The masked target was the predicate, which was always the last word in the sentence.

Type 2. In this category there were 12 sentences in which the compatibility of number between subject and predicate was altered. In 6 of these sentences a singular predicate followed a subject in plural form, and vice-versa in the other 6. The masked target was the predicate which was the last word in each sentence.

Type 3. There were eight sentences in this category. The compatibility of gender and number between the subject and the predicate was altered in each sentence. The masked target was the predicate which was the last word in each sentence.

Type 4. In Hebrew, prepositions related to personal pronouns (e.g., "on me") become one word. The violation in this category consisted of the decomposition of the composed pronoun into two separate words

(the pronoun and the preposition) which kept the meaning but were syntactically incorrect. Eight different prepositions were used, four times each, totaling 32 sentences. The masked target words were the composed or decomposed pronouns. Because the decomposition of the pronoun and preposition added one word to the sentence, another word was excluded from each of the incorrect sentences.

The syntactical violations of Types 5 to 10 were based on changing compulsory order of parts of the sentence. Therefore, the sentences of these types were masked from the first to the last word.

Type 5. In the 10 sentences of this type, the order of the attribute and its nucleus was reversed.

Type 6. In each of the six three-word sentences of this type, the predicate was incorrectly introduced between the subject and its attribute.

Type 7. In Hebrew, the negation always comes before the negated predicate. We altered this fixed order in six sentences, using three different negation words.

Type 8. In six sentences, the interrogative word was moved from its fixed place at the beginning of the sentence to the second place.

Type 9. In six sentences, the fixed order of preposition and noun was reversed so that the noun appeared before the preposition.

Type 10. In six sentences, the copula that should occur between the subject and the predicate was moved to the beginning or the end of the sentence.

All 104 correct and 104 incorrect sentences were recorded on tape by a female native speaker of Hebrew. The tapes were sampled at 20 KHz. The masked intervals were marked and white noise was digitally added to the marked epochs with a signal-to-noise ratio of 1:2.75. This ratio was determined on the basis of pilot tests so that correct target identification level was about 50%.

The 208 sentences were organized into two lists. In each list, 52 sentences were syntactically correct and 52 sentences were syntactically incorrect. Each sentence appeared in each list only once, either in correct or incorrect form. Sentences that were correct in List A were incorrect in List B and vice versa. Fourteen subjects were tested with List A and the other 14 with List B. Thus, each subject listened to an equal number of correct and incorrect sentences, and across subjects each sentence appeared an equal number of times in each form.

The sentences in each list were randomized and rerecorded on tape. Subjects listened to the tapes via Semmheiser earphones (HD-420).

Procedure

The subjects were tested individually in a quiet room. The experimenter listened to the stimuli simultaneously with the subject and stopped the tape-recorder at the end of each sentence. The subjects were asked to repeat the masked part of each sentence, and were encouraged to guess whenever necessary. The subjects' responses were recorded manually by the experimenter. Subjects were randomly assigned to List A or B.

Results and Discussion

The average percentage of correct responses, across subjects and sentence types, was 41.3%. Overall, correct identification was 67.0% for the syntactically correct sentences but only 15.6% for the syntactically incorrect sentences. The syntactic context effect was evident for each type of syntactic violation (Table 1).

These observations were confirmed by two-factor analyses of variance with subjects and sentences as random variables. The factors were syntactic context (correct, incorrect) and syntactic violation type (Type 1 to 10). The main effect of syntactic context was significant ($F(1, 26) = 588.44$, $MS_e = 629$, $p < .0001$ for the subject analysis and $F(1, 91) = 140.93$, $MS_e = 624$, $p < .0001$ for the stimulus analysis). The main effect of sentence type was also significant ($F(9, 234) = 4.5$, $MS_e = 404$, $p < .0001$ for the subject analysis and $F(9, 91) = 2.21$, $MS_e = 437$, $p < .03$ for the stimulus analysis). The context effect was conspicuous for all syntactic violation types, but, as suggested by an interaction between the two factors, its magnitude differed. This interaction was significant for the subject analysis ($F(9, 234) = 4.73$, $MS_e = 322$, $p < .0001$), but only marginal for the stimulus analysis $F(9, 91) = 1.86$, $MS_e = 624$,

TABLE 1
PERCENTAGE OF CORRECT IDENTIFICATION OF SYNTACTICALLY CORRECT AND SYNTACTICALLY INCORRECT SENTENCES IN EACH VIOLATION-TYPE CATEGORY (SEE TEXT)

| | Type of syntactic violation | | | | | | | | | |
|-------------------------|-----------------------------|------|------|------|------|------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Syntactically correct | | | | | | | | | | |
| Mean | 60.7 | 72.6 | 67.9 | 83.2 | 54.3 | 67.9 | 71.5 | 69.0 | 64.3 | 58.4 |
| (SEM) | 6.2 | 4.4 | 4.5 | 1.7 | 4.6 | 6.6 | 7.1 | 6.9 | 6.1 | 7.0 |
| Syntactically incorrect | | | | | | | | | | |
| Mean | 18.7 | 25.6 | 2.7 | 20.6 | 12.2 | 10.7 | 14.3 | 8.2 | 19.0 | 23.7 |
| (SEM) | 4.9 | 5.0 | 2.6 | 5.2 | 4.2 | 6.9 | 6.6 | 3.4 | 7.6 | 6.5 |

$p < .07$). Tukey-A post hoc analysis of the interaction revealed that the context effect was greater for Type 3 (gender and number), Type 4 (composite pronoun), Type 8 (translocation of interrogative word), Type 6 (separation of subject and attribute), and Type 7 (translocation of negation word) than for all the other sentence types. Within these two groups, the context effects were similar.

The results of Experiment 1 demonstrate that identification of words in sentences is influenced by the syntactic coherence of the sentence. Because, across subjects, exactly the same words were masked and had to be identified in the syntactically correct and incorrect sentences, the difference in the correct identification rate between the two modes of presentation is probably caused by the manipulation of syntactic coherence. The magnitude of this effect seemed to vary across different types of syntactic anomalies but it was reliable and statistically significant for each type. Because we had neither a priori predictions about the effects of particular violation types on identification nor clear post hoc explanations for the observed differences, and because the type of violation is not directly relevant to the issues investigated in this study, the syntactic violation types will be collapsed in all further analyses.

On the basis of these results, we can use the technique of Experiment 1 to assess possible differences in the magnitude of the effect in good and poor readers.

EXPERIMENT 2

Experiment 2 compared the magnitude of the syntactic context effect on the identification of auditorily presented words in children who are good readers and children with a severe reading disability. As was elaborated in the introduction, although several studies reported that poor readers are deficient in syntactic comprehension (see Vellutino, 1979), others could not find solid evidence to support this hypothesis (e.g., Glass & Perna, 1986). If disabled readers are less aware of the syntactic structure of the sentence (as part of their general linguistic handicap), or do not use syntactic information as efficiently as good readers, syntactic context effects should be weaker in disabled than in good readers. Consequently, the effect of syntactic congruity on correct identification of sentences should be smaller in disabled than in good readers.

A second prediction concerns the nature of errors made by good and disabled readers in the identification of words presented in syntactically incorrect sentences. The auditory mask probably induces some degree of uncertainty in the auditory input. If listeners are aware of the sentence context, they may attempt to use it to complement the information that is missing in the auditory stream. Such a strategy would cause errors in the identification of words that violate the syntactical structure because in those sentences the target does not conform to the expected syntactic

rules. Therefore, errors in identification that are induced by syntactic awareness should reflect the use of correct syntactic forms. In an English example, if the sentence were "I would like to have many child" and the word "child" was masked, the subject may erroneously identify the target as "children." On the other hand, if the subjects are not aware of the syntactic structure or not bothered by its violations, their errors in the identification of masked words should not be related to the syntactically correct form of the target. In this case, the response may be a randomly selected word, or may relate to the acoustical form—for example, substituting "mild" for the target "child" in the above example. If good readers are more aware of the syntactic structure of the sentence than disabled readers, the percentage of errors of the first type—"syntactic corrections," and of the second type—"random errors"—should vary with reading ability. In an extreme case, we should find more "syntactic correction" errors than "random" in good readers and vice versa in disabled readers.

Analyses of the errors made by each reading group would be a first step towards understanding the cause of intergroup differences in syntactic context effects, if they exist. However, in order to assess syntactic awareness as a metalinguistic ability rather than automatic use of syntactic structures for word identification, a more direct measure had to be employed. In a recent study, Fowler (1988) compared good and poor readers' ability to detect and to correct violations of syntax in orally presented sentences. In that study, the ability to judge sentences as correct or incorrect in the "judgment" task was not associated with reading ability. In contrast, good readers performed syntactically better than poor readers in the "correction" task. Fowler concluded that poor readers do not differ from good readers in syntactic knowledge but that they may be inferior in manipulating verbal material in short-term memory (see also Shankweiler & Crain, 1986). We used Fowler's technique to supplement our study of syntactic context effects on the identification of orally presented words. If, as in Fowler's study, a difference emerges only for the correction condition, then syntactic awareness is not at fault. Rather, one would ascribe the differences to syntactic processing difficulties that prevent the disabled readers from using their syntactic knowledge productively.

Method

Tests and Materials

(A) *Reading tests.* We were interested in testing two kinds of reading: the ability to decode the phonology from print and the ability to use the sentence context in reading without vowels. Because all the standard reading tests in Hebrew primarily test reading comprehension, we constructed two new reading tests for our purposes. The first was a test of

decoding ability. It contained a set of 24 meaningless three- or four-letter strings (pseudowords) presented with vowel marks. The vowels were chosen according to Hebrew morphophonemic rules, and included all lawful combinations. Each pseudoword was printed individually on a white, 9×12 -cm cardboard. The size of each letter was 0.5 cm. The subject was instructed to read each pseudoword exactly as it was written. The accuracy and naming onset time were measured. The subject's score on this test consisted of the percentage of accurately read pseudowords and the mean latency of naming onset time.

The second test was designed to test the ability to read Hebrew without vowel marks and particularly to use the sentence context to determine the reading of unvoeled Hebrew words that were both phonologically and semantically ambiguous. This test contained 48 four- or five-word sentences printed on white cardboard using the same fonts as for the pseudowords in the former test. The last word in each sentence was the target word. In the absence of vowel marks, 32 out of the 48 targets were phonologically ambiguous, i.e., they could have been assigned at least two sets of vowels to form two different words. Thus, correct reading of those targets could be determined only by apprehending the meaning of the sentence. The 32 ambiguous targets were 16 pairs of identical letter strings each representing a different word in the respective sentence. Eight of these 16 ambiguous targets represented two words of equal frequency. The word represented by each of the remaining ambiguous words differed in frequency such that one member of each pair was a high-frequency word while the other member was a low-frequency word. In a previous study Bentin and Frost (1987) reported that when undergraduates were presented with isolated ambiguous words in a naming task, they tended to choose the most frequent phonological alternative. We assumed that, without context, the children would tend to choose the same. Therefore, insensitivity to the context of the sentence should increase the number of errors in reading the targets, particularly when the correct response requires the use of the less frequent phonological alternative. The remaining 16 targets were words that without the vowel marks could have been meaningfully read in only one manner. Eight of those 16 targets were high-frequency words and the other 8 targets were low-frequency words. The subjects were instructed to read each sentence aloud. The time that elapsed from the moment the sentence was exposed until the subject finished reading it was measured to the nearest millisecond. The score on this test was the average percentage of errors and the average time to read a sentence.

In addition to these two special purpose tests, each subject was tested for reading comprehension by a standard test. The nation-wide average score on this test for fourth graders is 70% with a *SD* of 12%.

(B) *Intelligence tests.* The IQ of each subject was obtained either using

the WISC (Full Scale) (whenever those data were available) or testing the children on the Raven Colored Matrices and transforming their performance into IQ scores.

(C) *Syntactic awareness test.* Syntactic awareness was assessed by testing identification of auditorily presented words masked by white noise as in Experiment 1. On the basis of a pilot study with children, in order to keep the overall correct identification of targets around 50%, we increased the signal-to-noise ratio in Experiment 2 from 1:2.75 to 1:2.25.

Procedure

Each child was tested individually in three sessions. During the first session, reading performance and intelligence were tested. Reading performance was recorded on tape for subsequent error analysis and off-line measuring of time. At the end of the test of reading without vowels, the experimenter verified whether the subject knew the meaning of the targets that had been read incorrectly. In the very few doubtful cases, the sentence was excluded and a substitute sentence of the same type was given. The children who had been selected for this study (see below) were invited to a second session during which the auditory word identification test was given. The procedures for the word identification test were identical to those of Experiment 1. In addition, at the end of the second session, the children were tested for the ability to repeat from memory the sentences presented during the auditory test. This was done by presenting the children with 16 sentences selected from the same pool of sentences from which the test set was selected. Eight of these 16 sentences were syntactically correct and the other eight syntactically incorrect. In the repetition test the sentences were presented without the masking noise. Finally, during a third session (3 months later), all 104 sentences were presented to each child without the masking noise. Following the presentation of each sentence the child was asked whether "this is the way it should be said in Hebrew" (Judgment Task). Whenever the answer was "no," the child was asked to correct the sentence (Correction Task).

Subjects. The good readers were 15 children (7 males) selected from a population of fourth graders of two elementary schools in Jerusalem. Their ages ranged between 8.9 and 9.7 years (mean age 9.3 years). The average IQ (FS) score (as assessed by transforming the Raven score) was 102.5, ranging from 85 to 122.5. They were selected to match poor readers from the same school on decoding ability and IQ. The precise selection criteria will be elaborated in Experiment 3.

The disabled readers were 19 children (12 males), aged from 9.7 to 14 years, (mean age 11.6), selected from a population of 32 children with severe reading disorders who had been referred for special supplementary training in reading. They were within the normal intelligence range (Mean

IQ (FS) = 104.83, ranging between 85 and 130). The disabled readers selected for the present study were chosen because they not only showed poor decoding ability, as compared to good readers, but also performed badly in the test of reading without vowels, thus suggesting special problems in dealing with context. Table 2 presents the reading performance of the good and deficient readers as revealed by our reading tests.

Children in both groups were all native speakers of Hebrew without known motor, sensory, or emotional disorders. All children had been tested for normal hearing.

Results

The overall percentage of correct identification of masked targets was similar in good (44.2%) and disabled readers (48.3%) ($F(1, 32) = 2.52$, $MS_e = 112$, $p > .12$). However, the percentages of syntactically correct and incorrect sentences that were correctly identified were different in the two groups (Table 3). Although syntactically correct sentences were identified better than syntactically incorrect sentences in both groups, the effect of the syntactic context was smaller in the disabled readers than in the good readers.

This observation was supported by a mixed-model two-factors analysis of variance. The between-subjects factor was reading ability, and the within-subjects factor was syntactic context (correct, incorrect). The syntactic context effect was highly significant across groups ($F(1, 32) = 784.47$, $MS_e = 50$, $p < .0001$). A more interesting result, however, was the significant interaction that revealed that the syntactic context effect was greater in good readers than in disabled readers ($F(1, 32) = 11.90$, $MS_e = 50$, $p < .002$). Post hoc analysis revealed that good and disabled readers performed equally well with correct sentences. However, the percentage of correct identifications of words embedded in incorrect sentences was higher in disabled than in good readers ($p > .01$).

The errors that children made were distributed among four error types:

TABLE 2
READING PERFORMANCE OF THE SEVERELY DISABLED AND GOOD READERS

| | Reading voweled nonwords | | Reading unvoweled sentences | | Reading comprehension |
|------------------|--------------------------|---------------|-----------------------------|-------------------|-----------------------|
| | Percentage of errors | Time per item | Percentage of errors | Time per sentence | Percentage correct |
| Good readers | 8.1% | 1.6 sec | 4.1% | 2.9 sec | 81.3 |
| Disabled readers | 38.8% | 2.6 sec | 19.6% | 6.3 sec | 55.7% |

TABLE 3
 PERCENTAGE OF CORRECT IDENTIFICATION OF SYNTACTICALLY CORRECT AND INCORRECT SENTENCES IN THE READING DISABLED AND GOOD READERS

| | Good readers | Disabled readers |
|-------------------------|--------------|------------------|
| Syntactically correct | | |
| Mean | 71.4 | 69.5 |
| (SEM) | 2.2 | 1.9 |
| Syntactically incorrect | | |
| Mean | 17.0 | 27.0 |
| (SEM) | 2.4 | 2.2 |

Type 1 errors were "syntactical corrections," that is, errors that were made in attempt to use the correct syntactic structure of a syntactically incorrect sentence. Type 2 errors were "random errors"—misidentifications that made no sense whatsoever or reflected acoustical confusions. Type 3 errors were "logical substitutions," that is, substitutions of the masked words with other words that gave the sentence a logical meaning. Type 4 were "I don't know" responses, which were not encouraged but were accepted. The percentage of errors of each type (out of the total number of responses) in each group is presented in Table 4.

Because we had clear predictions only for syntactic corrections and random errors, we analyzed the distribution of these two error types in each group by a mixed-model (reading group \times error type) analysis of variance. This analysis showed that, across the two types of error, the good readers made fewer errors than the disabled readers ($F(1, 32) = 5.11$, $MS_e = 18$, $p < .031$). Across groups, the percentage of errors of each type was similar ($F(1, 32) = 3.01$, $MS_e = 16$, $p > .09$). Most interesting, the interaction between reading ability and error type was highly significant ($F(1, 32) = 21.54$, $MS_e = 16$, $p < .0001$). Post hoc

TABLE 4
 PERCENTAGE OF ERRORS OF EACH TYPE (OUT OF THE TOTAL NUMBER OF RESPONSES) MADE BY THE DISABLED AND GOOD READERS IN THE AUDITORY IDENTIFICATION TASK

| | Type of error | | | |
|------------------|---------------|--------|-----------------------|----------------|
| | Corrections | Random | Logical substitutions | "I don't know" |
| Good readers | 6.2 | 3.3 | 17.4 | 28.8 |
| (SEM) | 0.8 | 0.7 | 1.7 | 2.8 |
| Reading disabled | 3.9 | 10.2 | 21.9 | 15.7 |
| (SEM) | 0.4 | 1.5 | 1.7 | 2.2 |

analysis (Tukey-A) revealed that more random errors were made by disabled readers than by good readers, whereas syntactic corrections were more frequent in good than in disabled readers. All the children were able to repeat verbatim all 16 sentences that they heard without the masking noise.

Good readers were better than disabled readers on both the judgment and the correction tests. Among the disabled readers, however, a secondary distinction was evident between four children who were 13–14 years old and those who were younger. The mean percentage of errors made by each group in each task is presented in Table 5.

Because the number of older disabled readers was too small to form a reliable independent level in a factorial design but, on the other hand, clearly formed a distinct group, they were excluded from the statistical evaluation. Thus, the percentage of errors in each task was compared only for good and disabled readers who were more similar in chronological age. As before, a mixed-model analysis of variance was employed where the between-subjects factor was reading group and the within-subject factor was the test (judgment or correction). The analysis of variance showed that good readers made significantly fewer errors than disabled readers ($F(1, 24) = 26.58$, $MS_e = 127$, $p < .0001$) and that more errors were made in the correction than in the judgment task ($F(1, 24) = 79.25$, $MS_e = 35$, $p < .0001$). A significant interaction suggested that the task affected the percentage of errors made by disabled readers more than it affected the good readers ($F(1, 24) = 41.0$, $MS_e = 35$, $p < .0001$). This interaction supports Fowler's results by emphasizing the difference between the judgment and correction tests. However, in contrast to her results, post hoc Tukey-A tests revealed that the good readers made significantly fewer errors than disabled readers not only in the correction task but also in the judgment task. The inclusion of the four older disabled readers in the analysis did not change the pattern of results,

TABLE 5
PERCENTAGE OF ERRORS MADE BY DISABLED AND GOOD READERS IN THE JUDGMENT AND CORRECTION TASKS

| | Task | |
|------------------------|----------|------------|
| | Judgment | Correction |
| Good readers | 1.3 | 5.4 |
| (SEM) | 0.4 | 0.9 |
| Reading disabled | 6.9 | 32.1 |
| (SEM) | 1.9 | 4.5 |
| Older reading disabled | 0.3 | 5.6 |

although these four children clearly performed better than the other disabled readers.

Discussion

For children with a severe reading disability, the syntactic context effect on the identification of spoken words was smaller than for good readers. One explanation for the results might be that disabled readers are worse at identifying auditorily masked words than good readers (Brady, Shankweiler, & Mann, 1983). Such an hypothesis, however, is not supported by the present data. If the disabled readers in the present study had been handicapped in the identification of masked words, any manipulation that increased the difficulty of identifying the words should have had a greater effect on disabled than on good readers. Therefore, we should have observed a stronger rather than a weaker syntactic context effect in disabled readers. Further, if masking had a more deleterious effect on identification of words by disabled relative to good readers, the overall identification performance in the disabled group should have been lower. In fact, the overall correct identification percentage in disabled readers was slightly higher than in the good reader group.

A second account of the results might be that the smaller syntactic context effect in poor readers reflects a more general problem, such as disorders of short-term or working memory. There is indeed ample evidence that disabled readers have problems with verbal short-term memory (Mann, Liberman, & Shankweiler, 1980; for a review see Brady, 1986). Therefore, memory disorders might explain why their performance is affected by sentence context less than that of good readers even when decoding difficulties are eliminated; they simply do not remember the sentence well enough. However, a simply reduced short-term memory span cannot easily account for the present results because the children in both reading groups could accurately repeat sentences similar to those used in the identification task without any difficulty. It is still possible, however, that more complex working memory problems could have contributed to the disabled readers' pattern of performance. We will return to this hypothesis in the General Discussion.

We are left with the most direct hypothesis that inferior syntactic awareness is the reason for the relatively poor use of syntactic context by the reading disabled children of Experiment 2. This possibility is supported by the results of the error analysis. The percentage of "syntactic correction" errors made by good readers was almost twice as great as that made by disabled readers. "Syntactic correction" errors could have only been made when the subject knew what the correct structure of the sentence should have been and expected it. In those circumstances, when the physical stimulus was degraded the good readers applied syn-

tactic rules and misidentified the target. In the same situation, getting only partial information from degraded stimuli, disabled readers often applied a random guessing strategy disregarding the sentence context completely. Indeed, the percentage of "random" errors was three times greater in the disabled readers group than in good readers.

An additional question examined in the present experiment was whether the disabled readers had mastered the correct syntactic structures but did not use them properly, or had problems with basic syntactic knowledge. We examined this question by testing the ability of both groups to detect violations of syntactic structure and to correct the detected violations. The good readers performed better than the disabled readers in both tasks. Although the difference between the groups was greater for the correction task, disabled readers were significantly inferior to good readers in the judgment task as well. This latter result contradicts the results reported by Fowler (1988) and suggests that this group of disabled readers were inferior to good readers in their awareness of basic syntactic structures.

The discrepancy between the present results and Fowler's (1988) results, as well as the disagreement between our conclusion regarding the syntactic awareness of disabled readers and previous assertions in the literature that basic phonological disability and deficient use of working memory mechanisms underlies the syntactic inferiority observed in poor readers (e.g., Shankweiler & Crain, 1986; Shankweiler et al., in press), can be explained in two ways. One possible explanation is that different types of mechanisms underly reading deficiencies in different languages. Recall that we selected our deficient reader group to emphasize problems of using context while reading without vowel marks. In doing so, we may have selected a group of children who were poor in syntactic processing. A second explanation is that we have examined children with a reading disability that was considerably more severe than that of the poor readers examined by Fowler. Experiment 3, therefore, attempted to generalize the results of the present experiment to poor readers selected, as in Fowler's study, from the normal student population of regular elementary schools.

EXPERIMENT 3

Any attempt to generalize about the characteristics of reading disability or to predict the performance of children with reading disorders is impeded by the heterogeneity of this population. Indeed, reading disorders can appear as the most conspicuous symptom in children who suffer from attentional disorders or general learning disability; they can be the main symptom (but rarely the only symptom) of developmental dyslexia and, at the other extreme, they may characterize the performance of otherwise normal students who happen to be at the lower end

of a normal distribution of reading ability. It is possible, therefore, that the prior selection of different types of reading disorders underlies most disagreements about this important handicap among educators and scientific investigators.

In Experiment 2, the reading disabled children were selected from a population of children with severe reading disorders. Although they were at least in the fourth grade, had normal IQs, and had no documented neurological symptoms, some of those children could hardly read single words with or without vowel marks. We found that they were inferior to good readers in syntactic knowledge and in using syntactic context to help identify spoken words. In Experiment 3, our aim was to extend these findings to another reader group. Thus, we compared good readers with children in regular classes who, when formally tested, were inferior to good readers in reading performance. In particular, we wished to compare the good readers with a group of relatively poor readers who were equal to the good readers in basic decoding ability (as revealed by their performance on reading voweled pseudowords) but were poorer at reading without vowel marks. We assumed that the relatively poor reading performance of this group primarily reflects inefficient use of the sentence context, and expected to be able to measure this relative disability by our auditory test of syntactic context effects. In addition, the good and poor readers in the present experiment were tested for ability to detect and to correct syntactic violations.

Method

Subjects

The subjects were 30 children selected from a population of 167 fourth graders in two public elementary schools. The selection was based on performance on the test of decoding ability and the test of reading without vowels which were described in Experiment 2. Two reading groups were assembled. The poor reader group included 15 children (9 males); their ages ranged between 8.8 and 9.6 years (mean age 9.1 years). Their average IQ (FS) score (as assessed by transforming the Raven score) was 102.5, ranging from 85 to 122.5. Each of those poor readers made no more than four errors (16.6%) in the test of decoding voweled pseudowords but at least twice as many errors as the good readers while reading meaningful sentences without vowels. On the basis of the assumption that the relatively poor reading performance of those children reflected problems with processing of contextual information, we will label this group the "Poor context" group. The good readers were the same 15 children who were described in Experiment 2. Each child in this group was selected to match one child in the poor context group on the ability to decode voweled pseudowords and on IQ. However, the good readers performance on the unvoiced sentences was at least twice

as good as that of his or her matched subject in the poor context group. The average scores of the two reading groups on the reading tests are presented in Table 6.

Tests and Materials

The reading tests and the auditory word identification test were identical to those described in Experiment 2. The IQ scores were estimated by testing the children with the Raven Colored Matrices test.

Procedure

The procedure was similar to that employed in Experiment 2. The children were tested in two sessions. The first session was dedicated to the selection of subjects for this study. All 167 fourth graders were tested for reading ability and IQ. During the second session only the selected children were tested on the auditory word identification test, and during a third session, their ability to detect and correct the syntactic violations. During the third session the sentences were presented without any masking noise. Sessions one and two were held close to the beginning of the academic year. Session 3 was 3 months later.

Results

The percentage of total correct identifications in the "poor context" group (40.4%) was not significantly different from that of the good readers (44.2%) ($F(1, 28) = 1.03$, $MS_e = 209$, $p > .31$).

The percentages of syntactically correct and incorrect sentences that were correctly identified in each group are presented in Table 7.

These data were analyzed by a mixed-model analysis of variance as in Experiment 2. As before, the syntactic context was highly significant ($F(1, 28) = 505.56$, $MS_e = 81$, $p < .0001$). However, in contrast to the findings of Experiment 2, the interaction between the syntactic context effect and reading group was not significant ($F(1, 28) = 0.96$).

As in Experiment 2, the errors made by each group were categorized

TABLE 6
READING PERFORMANCE OF THE GOOD AND POOR CONTEXT READERS

| | Reading vowel nonwords | | Reading unvoiced sentences | | Reading comprehension |
|-------------------------|---------------------------|------------------|-------------------------------|----------------------|--------------------------|
| | Percentage of errors | Time per item | Percentage of errors | Time per sentence | Percentage correct |
| Good readers | 8.1% | 1.6 sec | 4.1% | 2.9 sec | 81.3% |
| Poor context readers | 7.8% | 1.7 sec | 18.2% | 4.7 sec | 72.0% |

TABLE 7
 PERCENTAGE OF CORRECT IDENTIFICATION OF SYNTACTICALLY CORRECT AND INCORRECT SENTENCES IN GOOD AND POOR CONTEXT READERS

| | Good readers | Poor context readers |
|-------------------------|--------------|----------------------|
| Syntactically correct | | |
| Mean | 71.4 | 65.3 |
| (SEM) | 2.2 | 3.9 |
| Syntactically incorrect | | |
| Mean | 17.0 | 15.4 |
| (SEM) | 2.4 | 3.6 |

into four types. Type 1 were "syntactical corrections," Type 2 were "random errors," Type 3 were "logical substitutions," and Type 4 were "I don't know." The distribution of errors in each of the two reading groups (out of the total number of responses) is presented in Table 8.

Our a priori predictions concerned only errors of Type 1 (correction) and Type 2 (random errors). A mixed-model analysis of variance showed no significant main effects but a significant interaction between the type of error and reading group ($F(1, 28) = 10.63$, $MS_e = 14$, $p < .003$). Post hoc comparisons (Tukey-A) showed that the percentage of syntactical correction errors was higher in good readers than in the poor context group, whereas the percentage of random errors was higher in the poor context group than in good readers.

The average percentages of errors in the judgment and correction tasks for each group are presented in Table 9.

A mixed-model analysis of variance as in Experiment 2 was used to analyze these data. Across groups, there were more errors in the correction task than in the judgment test ($F(1, 24) = 39.16$, $MS_e = 16$, $p <$

TABLE 8
 PERCENTAGE OF ERRORS OF EACH TYPE MADE BY GOOD AND POOR CONTEXT READERS (OUT OF THE TOTAL NUMBER OF RESPONSES) IN THE AUDITORY IDENTIFICATION TASK

| | Type of error | | | |
|----------------------|---------------|--------|-----------------------|----------------|
| | Corrections | Random | Logical substitutions | "I don't know" |
| Good readers | | | | |
| Mean | 6.2 | 3.3 | 17.4 | 28.8 |
| (SEM) | 0.8 | 0.7 | 1.7 | 2.8 |
| Poor context readers | | | | |
| Mean | 3.5 | 6.9 | 24.5 | 24.8 |
| (SEM) | 0.6 | 1.2 | 2.9 | 3.5 |

TABLE 9
 PERCENTAGE OF ERRORS MADE BY GOOD AND POOR CONTEXT READERS IN THE JUDGMENT
 AND CORRECTION TASKS

| | Task | |
|----------------------|----------|------------|
| | Judgment | Correction |
| Good readers | | |
| Mean | 1.3 | 5.4 |
| (SEM) | 0.4 | 0.9 |
| Poor context readers | | |
| Mean | 1.7 | 11.4 |
| (SEM) | 0.5 | 2.3 |

.0001). Overall, the good readers made fewer errors than poor context readers ($F(1, 24) = 5.24$, $MS_e = 25$, $p < .035$). The interaction between the test and the group factors was significant ($F(1, 24) = 6.32$, $MS_e = 16$, $p < .020$). Replicating Fowler's (1988) results, post hoc analysis revealed that good and poor context readers did not differ in the judgment test, whereas in the correction test good readers made significantly fewer errors than poor context readers.

All children were able to repeat verbatim all the 16 sentences presented to them in the absence of masking white noise.

Discussion

Experiment 3 sought to generalize the results of Experiment 2 to groups of relatively poor readers selected from the normal distribution of fourth graders. Unlike in Experiment 2, the magnitude of the syntactic context effect was similar in the good and in the poor context readers.

The syntactic ability of the children in the poor context group was not, however, entirely equivalent to that of the good readers. Analysis of the identification errors made by each group revealed that the proportion of errors that reflected an attempt to correct the syntactic violation was lower in children who had relatively more difficulties in reading unvoiced words than in good readers who were matched with them for phonological decoding ability. In contrast, the proportion of misidentifications that reflected total ignorance of the sentence's context (either syntactic or semantic) was lower in good readers than in the poor context group. This pattern of errors might suggest that although word identification was similarly affected by syntactic context in both reading groups, the good readers were more aware of the syntactic structure of the sentence than were the children in the poor context group. The results of the judgment test, however, did not support this hypothesis. As it turned out, both groups were equally sensitive to violations of syntactic

structures. It is possible though that part of this result reflected a ceiling effect in that task. The groups differed, however, in their ability to correct those violations.

The common aspect of both the "syntactical correction" errors and the test of correcting syntactic violations is that both measures reflect the child's ability to actively generate correct syntactic structures. This ability is not required by the judgment test and may not be reflected in identification performance. Therefore, the present data suggest that although the good and the relatively poorer readers did not differ in their syntactic awareness—that is, in the sensitivity to and knowledge of basic syntactic structures—the good readers had a superior ability to use their syntactic knowledge, and a tendency to do so.

GENERAL DISCUSSION

In the present study we examined the relation between reading ability and syntactic competence as it is reflected in the ability to use syntactic context for word identification and to detect and correct syntactic violations. In contrast to the great majority of studies of context effects in good and poor readers, we used auditory rather than printed word identification. Auditory presentation was used to circumvent a bias that might have been induced by the reading disorder itself. Thus, we were better able to assess differences in syntactic processing ability that might relate to reading achievement. The sensitivity of our auditory test to syntactic context was verified by showing that undergraduate students, fluent readers of Hebrew, identified target words masked by white noise significantly more accurately if the targets were syntactically congruent with the sentence in which they appeared than if they violated the syntactic structure.

A syntactic effect similar to that found in undergraduates was obtained when the same test was given to fourth graders. However, the difference between the correct identification of syntactically correct and syntactically incorrect sentences was smaller in a group of children with a severe reading disability than in either good readers or relatively poor readers selected from the normal distribution of fourth grade students (the poor context group). The good readers and the poor context group did not differ in the auditory identification test.

A second difference between the severely reading disabled and the children in the poor context group was observed in the judgment task. Children in the poor context group detected sentences that contained an error as well as good readers. In contrast, the reading disabled were worse in this test than either the good readers or the poor context readers.

The relative inferiority of the severely disabled readers cannot be accounted for only by a simple reduction of their short-term memory span. In contrast to the complex sentences and complex syntactic struc-

tures typically used in other studies, we used only very short and simple sentences (three or four words). When formally tested, all the children were able to repeat the sentences verbatim without any problem. Holding a sentence in working memory for syntactic analysis probably requires more mental effort and retention of the whole sentence for a longer time than required by immediate repetition. As was previously reported, the factor of delay influences the memory ability of poor readers more than that of good readers (Lieberman, Shankweiler, Liberman, Fowler, & Fisher, 1977). However, rather than requiring the manipulation of more subtle syntactic aspects, the syntactic violations which we have used in the present study were, as we have said, straightforward corruptions of the basic syntactic relationship between subject and predicate or a word order that clearly violated the syntactic structure of the sentence. Therefore, we agree with Byrne (1981) in doubting that deficient use of verbal memory mechanisms by disabled readers, at least as this deficiency could be revealed by simple repetition, was a major cause for the deficient use of syntactic context in the present study. Instead, we are inclined to believe that the reduced syntactic ability suggested by the performance of disabled readers reflected a genuine deficiency of linguistic endowment (in the syntactic and phonological domains) rather than reduced general cognitive ability or poor metalinguistic insight.

Although the syntactic context effect on the identification task was equal in the good readers and the poor context readers, the syntactic competence of these two groups was not entirely equivalent. In particular, the good readers made significantly more syntactical correction errors than the poor context readers. The difference between the two groups was even more conspicuous in the correction task. Similar to the results reported by Fowler (1988) for American poor readers, the ability of poor context children to correct syntactic violations was significantly inferior to that of good readers. This result is particularly interesting because, as was noted earlier, the syntactic violations used in the present study were much simpler and more direct than those used by Fowler. Moreover, our samples of good and poor context readers were matched for their ability to decode and read voweled nonwords. Therefore, just as for the disabled readers, the difference between the ability of good and poor context readers to correct syntactically incorrect sentences cannot be easily accounted for only by assuming differences between the poor and the good readers in general cognitive skills. Rather, we suggest that, at least for the specifically selected group of poor readers whose reading errors reflected reduced ability to analyze contextual information, both the correction test and the pattern of errors in the identification test suggest a specific impairment in the ability to use their syntactic knowledge in a productive way.

Although both the reading disabled and the poor context readers are

inferior to good readers in syntactic competence, these two groups differ from one another. In comparison to good readers, the disabled readers showed a weaker syntactic context effect in the word identification task, an inferior ability to detect syntactical aberrations in spoken sentences, and an inferior ability to correct detected syntactically incorrect sentences. The poor context children were equal to good readers in the syntactic context effect on word identification, were equally able to detect syntactic aberrations, but were inferior to good readers in the ability to correct the detected errors. This pattern of results suggest that the different tasks tap different aspects of syntactic competence which might develop at different rates.

Some insight into the nature of the syntactic disability reflected by the word identification task comes from the observation that the significant interaction between the reading group and the syntactic context effect was not caused by a symmetrical effect of reading group on both syntactically correct and incorrect sentences. Rather, it seems that syntactically correct sentences were identified equally well by both reading disabled and good readers; however, good readers were affected more than reading disabled by violations of the syntactic structure of sentences. A possible interpretation that is supported by these data is that automatic syntactic processing was equivalent in both groups, but that the disabled readers were less aware of the syntactic structure and did not use identification strategies that were based upon it. A more definite interpretation obviously requires a neutral condition in the identification task, which was absent in this study. However, these results strongly suggest that the identification test is sensitive more to strategic differences and syntactic awareness than to (automatic) syntactic processing.

It is noteworthy to recall in this connection the four older disabled readers: Although they were similar to other disabled readers in the auditory identification task, their performance in the judgment and correction tasks was similar to that of good readers. These older children may have had a higher level of syntactic competence so that when their attention was intentionally directed to the structure of the sentence (as was the case in the judgment and correction tasks in contrast to the identification task), the additional knowledge enabled them to use their syntactic knowledge productively.

In conclusion, the results of the present study suggest that syntactic factors are directly related to reading disabilities, at least in Hebrew. Two distinct populations of poor readers have been identified. One group was formed of children who in the absence of a better term were labeled reading disabled. These children were probably able to use basic syntactic structures, as was evident in their everyday speech ability and in their identification of syntactically correct sentences. However, they were not explicitly aware of the syntactic structures, and therefore were not in-

hibited by semantic incongruity in the identification test; they were less able than good readers to detect syntactically incorrect sentences, and they were less able to correct those errors that had been detected. The second group of poor readers were good decoders but were relatively weak in analyzing the context of the sentence in reading. The performance of these children in the identification judgment tests suggested that they were aware of basic syntactic structures and could use them for perception of speech. However, they were inferior to good readers in using those structures productively as suggested by their relatively worse performance in the correction test. Thus, our data set limits to previous assertions that poor reading is not related to syntactical impairment (Gleitman & Rozin, 1977); Liberman, 1971; Mattingly, 1972; Shankweiler & Crain, 1986).

Of course, we do not claim to have found a causal relationship between syntactic ability and reading disorders. What we have seen is that, at least in Hebrew, there are poor readers of normal intelligence who are good decoders. Their performance suggests that there are aspects of poor reading that are not accounted for by deficient phonological processing. Moreover, we have shown that this impairment is associated with deficiencies in linguistic ability, here exemplified in the syntactic domain.

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