

## Attention Factors Mediating Syntactic Deficiency in Reading-Disabled Children

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Syntactic context effects on the identification of spoken words, and the involvement of attention in mediating these effects, were examined in seventh-grade children with reading disabilities and children who were good readers. The subjects were asked to identify target words that were masked by white noise. All targets were final words embedded in unveiled sentences. Relative to a syntactically neutral context, the identification of targets whose morpho-syntactic structure was congruent with the context was facilitated and the identification of syntactically incongruent targets was inhibited. Reading-disabled children were less inhibited by syntactic incongruence than good readers. Presenting congruent and incongruent sentences in separate blocks reduced the amount of inhibition in good readers while having no effect on the reading-disabled. The percentage of correct identification of incongruent targets in the mixed presentation condition was larger for reading-disabled than for good readers, whereas in the blocked presentation condition the percentage of correct identification was equal across groups. The amount of facilitation was not affected by blocking the congruent and incongruent conditions, and was equal across reading groups. It is concluded that, in both reading groups, the syntactic structure of the context triggers a process of anticipation for particular syntactic categories which is based on a basic assumption that linguistic messages are syntactically coherent. Reading-disabled children are, however, less aware of this process and therefore less affected when the syntactic expectations are not fulfilled. © 1996 Academic Press, Inc.

### INTRODUCTION

The existence of an impairment in the syntactic ability of children with severe reading difficulties is a matter of controversy. One view is that children with reading difficulties lack basic syntactic abilities due to delayed development of language skills (Byrne, 1981), or due to structural deficiencies in the

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language system (Stein, Cairns, & Zurif, 1984). This view is supported by ample evidence that reading-disabled children are inferior to good readers on various tests of syntactic ability (Bohannon, Warren-Leubecker, & Hepler, 1984; Bowey, 1986; Brittain, 1970; Byrne, 1981; Goldman, 1976; Guthrie, 1973; Flood & Menyuk, 1983; Siegel & Ryan, 1984; Stein, Cairns, & Zurif, 1984; Tunmer, Nesdale, & Wright, 1987; Vogel, 1974; Wigl, Semel, & Crouse, 1973; Willows & Ryan, 1986). An alternative view is that syntactic deficiency is not characteristic of reading disability. The proponents of this view point out, for example, that the speech of reading-disabled children is grammatically correct most of the time, and that they do not differ from their normally reading peers in using syntactic rules for generating sentences. Accordingly, those authors suggest that the deficient syntactic ability observed in reading-disabled children reflects a limitation of short-term memory caused by a basic difficulty in generating phonological codes (Fowler, 1988; Shankweiler & Crain, 1986; Shankweiler, Crain, Brady, & Macaruso, 1992; Shankweiler, Smith, & Mann, 1984; Smith, Macaruso, Shankweiler, & Crain, 1989).

The two opponent views can be brought closer together by assuming that the apparent syntactic inferiority of children with reading difficulties does not reflect the absence of basic syntactic knowledge, but rather a poor ability to use this knowledge proficiently. Thus, this view agrees with those who assume that the syntactic knowledge of reading-disabled children is basically intact, yet it does not consider poor phonological skills to be the only cause of the poor syntactic performance observed in these children. Instead, a metalinguistic problem is suspected, which does not significantly affect the natural process of speech, but may interfere with less natural linguistic activities such as reading, or complex linguistic processes that may be required in specially designed experimental procedures.

Empirical support for a metalinguistic account of the impaired performance of the reading-disabled in tests of syntactic processing was provided in a study of syntactic-context effects on the identification of spoken words (Bentin, Deutsch, & Liberman, 1990). Previous studies showed that words are processed faster and more accurately when they are embedded in a congruent than in an incongruent syntactic context. This syntactic-context effect was demonstrated in fluently reading adults using visual word recognition (Carrello, Lukatela, & Turvey, 1988; Goodman, McClelland, & Gibbs, 1981; Gurjanov, Lukatela, Moskovljevic, & Turvey, 1985; Lukatela, Kostic, Feldman, & Turvey, 1983; Lukatela, Moraco, Stojonov, Savic, Katz, & Turvey, 1982; Miller & Isard, 1963; Seidenberg, Waters, Sanders, & Langer, 1984; Tanenhaus, Leiman, & Seidenberg, 1979; West & Stanovich, 1986; Wright & Garret, 1984) and in the identification of spoken words (Katz, Boyce, Goldstein, & Lukatela, 1987; Marslen-Wilson, 1987; Tyler & Wessels, 1983). In their study, Bentin *et al.* (1990) found that the effect of syntactic context on the identification of white-noise-masked spoken words was lower in a group of reading-disabled children than in normally reading matched controls. More specifically, it was found that the reading-disabled identified syntacti-

cally incongruous targets *better* than controls, while being equal on the identification of congruent targets. Furthermore, although reading-disabled children performed worse than the good readers in judging the grammaticality of the sentences, as well as in correcting the ungrammatical sentences, the difference between the groups was significantly larger in the correction task.

Our interpretation of these results was based on the assumption that the interference with the identification of incongruent targets resulted from a mismatch between context-based general expectations regarding the grammatical form of the target and the incomplete phonetic information provided by the masked input. We suggested that this mismatch inhibited the identification process in the good readers more than in the reading-disabled, because good readers are more likely to take into account the available syntactic information in the process of target identification. Since inhibitory processes are assumed to reflect the operation of mechanisms that require attention resources (Becker, 1985; Neely, 1991; Posner & Snyder, 1975), we suggested that the deficient syntactic performance observed in reading-disabled children is related to inefficient or impaired application of attention-mediated strategies in processing syntactic structures.

The involvement of attention factors may also explain why the reading-disabled could judge the grammaticality of sentences better than they could correct them (see also Fowler, 1988). Although both tasks require explicit syntactic knowledge, they differ in their degree of complexity and in the amount of attention required to perform them. While both tasks require recognizing the syntactic structure and finding deviations from known syntactic rules, the sentence correction task requires, in addition, the utilization of syntactic knowledge in the creation of new syntactic structures. Therefore, correcting syntactically aberrant sentences is perceived to require more attention than judging their grammaticality (de Villiers & de Villiers, 1974; Fowler, 1988). On the basis of our interpretation of the Bentin *et al.* (1990) results, we propose that a comparison between the syntactic ability of good and disabled readers should distinguish between (1) the ability to automatically apply basic syntactic rules and (2) the ability to strategically use this syntactic knowledge while processing sentences. Our hypothesis is that the difference between good and disabled readers in the syntactic domain is best characterized in terms of the second process.

The validation of the above hypothesis required two steps. The first was to demonstrate that the effect of syntactic context on the identification of spoken words is indeed composed of an inhibitory attention-based component and a facilitatory automatic component. The second was to show that the distinction between the syntactic ability of good and of disabled readers is determined by the attention-mediated component of the syntactic-context effect.

The first step was accomplished in a recent study in which the subjects were fluently reading adults (Deutsch & Bentin, 1994). Using a neutral condition, we first determined that congruent syntactic context facilitates the identification of white-noise-masked words, whereas incongruent context interferes

with their identification. In comparison with a randomly mixed presentation of syntactically congruent and incongruent sentences, isolating the presentation of congruent and incongruent sentences in separate blocks reduced the interference of syntactic incongruence but had no effect on the identification of congruent targets. Also, increasing the ISI between context and target enhanced the interference of the incongruent context without affecting the identification of congruent targets. Together, these results demonstrated that the syntactic context effect includes a source of inhibition which is sensitive to the manipulation of attention. The present study was designed to examine whether, conforming to our hypothesis, the syntactic context effect is less sensitive to the manipulation of attention in reading-disabled children than in good readers. If, relative to a neutral baseline, syntactic incongruity interferes less with the identification of white-noise-masked words in reading-disabled than in good readers, and if blocking congruent and incongruent sentences reduces this interference more in the latter than in the former reading group, then our hypothesis would be supported.

### METHODOLOGICAL CONSIDERATIONS

As in our previous studies (Bentin *et al.*, 1990; Deutsch & Bentin, 1994), the subjects' task in the present experiments was to identify white-noise-masked spoken words embedded in unmasked sentences. This task was used because studies of visual word identification have suggested that the degradation of stimulus intelligibility magnifies context effects (Becker & Killion, 1977; Meyer, Schvaneveldt, & Ruddy, 1975; Neely, 1991; Stanovich & West, 1983). The auditory modality was used in order to avoid confounding genuine syntactic processing difficulties, which may distinguish disabled from good readers, with poor performance which may result from the basic difference between the two groups in their ability to decipher written words.

The addition of noise may alter the normal process of word identification (for example by overemphasizing contextual influences) and therefore may hamper the generalization of the present results beyond the particular experimental circumstances. However, it should not interfere with our use of this method to examine the nature of syntactic contextual processes whenever the linguistic system sets them in motion and utilizes them for word identification.

In the present study, we manipulated the Hebrew agreement rule between subject and predicate for gender and number and the rule of conjunction of the pronoun and the preposition. The essential role of agreement rules in Hebrew, which has no effect on semantic processing, is to specify the syntactic relation between the constituents of a sentence. For example, the predicate agrees with the subject in person, gender, and number but, because specification of the gender and number is already available in the subject, violation of one or more of these types of agreements does not affect the meaning of the sentence (Shanon, 1973). Moreover, since the agreement rule is at the level of inflectional morphology, its violation does not cause changes in word class (changes that may have semantic implications; Carello, 1988). Take,

for example, the sentence "A nice boy is writing" which translates into Hebrew as "Yeled (sub.) yafeh (attrib.) kotev (pred.)." The morphological unit "yeled" (boy) contains information about gender (masculine) and number (singular). The same root (y.l.d) with different affixes is used to form the feminine "yaldah" (girl) or the plural "yeladim" (boys). The agreement rules require that attributes and predicates agree with the subject in gender and number: "yafeh" (nice) is a singular masculine form, as is "kotev" (is writing). The sentence "Yaldah yafah kotev" contains a syntactic violation because the predicate is in the masculine form while both the subject and attribute are in the feminine form. The conjunction rule provides that a pronoun and a preposition appear in a conjoined form. For example, the preposition "el" (to) and the pronoun "ata" (you) are composed into one form "alecha." The decomposition of this form into "el" + "ata" is illegal. (See additional examples and details in the "Test and Materials" section.)

These rules have a common ground in that they are based on the use of an inflectional system. Both rules are formal, language-dependent, and based on convention. Both subject-predicate agreement, and preposition-pronoun conjunction are simple and essential in Hebrew grammar and are acquired at a very early age. Moreover, the productive use of these rules and the analysis of their contribution to the verbal message do not involve complex processing or excessive memory load. (To ensure that possible intergroup differences in memory capacity does not influence the results, all the sentences in this study were syntactically simple and short [three or four words]).

They were chosen for two reasons. First, while our hypothesis was that the difference between the good and disabled readers may be related to a difference in their respective ability to use basic syntactic knowledge strategically during sentence processing, we aimed at disentangling this ability from the basic syntactic competence as it is demonstrated by the spontaneous use in everyday speech. These features ensured that the observed performance would reflect the ability to use syntactic knowledge rather than the mere existence of such knowledge. The second reason was that we were interested in isolating the effect of the syntactic context from the effect of the semantic context. Although the agreement rule that we chose operates between subject and predicate, we were not constrained to present these two sentential elements continuously. We could therefore avoid lexical priming effects that may operate between adjacent words and focus on processes related to the syntactic structure of the sentence. Furthermore, in order to avoid lexical priming based on semantic relationships, none of the targets was semantically related to preceding words in the context or could have been predicted on the basis of the semantic context of the sentence. Moreover, although agreement rules are applied mainly by adding or changing suffixes, they usually also involve phonological modifications in the structure of the whole word, as required by phonetic rules. In the above example, for instance, the addition of the plural suffix "im" to the singular/masculine form "kotev" changes the morphological form "kotev" into "kotvim" rather than \*"kotevim." It

should also be noted that there are several suffixes that are used to mark gender and number, some of which are shared by nouns and verbs. For example, the feminine form of the noun "zamar" (singer) is "zameret" while the feminine form of "rakdan" (dancer) is "rakdanit" and the feminine form of "yeled" (boy) is "yaldah." Similarly, in the verbal system, the feminine form of "roked" [(he) dances] is "rokedet" and of "yashen" [(he) sleeps] is "yeshenah." Thus, while the subject and the predicate agree in gender and number, they do not have to end with the same specific suffixes. Consequently, although the morphological form of the predicate can be predicted by the morphological form of the subject, its specific morpho-phonological form is not unequivocal. In summary, targets could neither be activated by semantic network connections nor could they be predicted or easily guessed on the basis of the sentential context.

The children in both reading groups were sampled from the seventh and the eighth grades in junior high schools. This age was selected in order to avoid the possibility that slow maturation of language functions might account for either the reading disorders or the syntactic inferiority of the reading-disabled children. A reading level control group was not examined in the present study for the following reason. A major justification for including control groups matched on reading level, is to dissociate performance differences between good and poor readers that are related directly to reading disability from differences that may be accounted for merely by differences in reading experience. This dissociation was irrelevant in the present study in which we have examined the processing of the most basic syntactic rules in Hebrew. These skills are mastered by all native speakers well before they learn to read and, therefore, there is no theoretical basis for the assumption that reading experience per se could have influenced performance in the word identification task (see also Shankweiler *et al.*, 1992). Furthermore, using an auditory rather than visual word presentation we have technically minimized the possibility that reading-experience biased the children's performance in any way.

## EXPERIMENT 1

In our recent study with fluently reading adults (Deutsch & Bentin, 1994), we demonstrated that the syntactic context effect on the identification of target words, masked by white noise, reflects both the facilitation of syntactically congruent targets and the inhibition of syntactically incongruent targets. The existence of these two separate processes provided the necessary empirical ground for our previous interpretation that the difference between good and disabled readers, which was restricted to incongruent targets, reflected a difference in the inhibitory process (Bentin *et al.*, 1990).

The purpose of the present experiment was to extend these previous results, examining how the inhibitory and facilitatory components of the syntactic context effect interact with reading ability in children. To achieve this goal we compared the pattern of the syntactic context effect relative to a neutral baseline, in children with reading disorders and in good readers. On the basis of our previous results

TABLE 1  
Reading Performance of the Two Reading Groups Tested in Experiment 1

Reading ability	Reading pointed nonwords		Reading unpointed sentences	
	Percentage of errors	Time per item (seconds)	Percentage of errors	Time per item (seconds)
Good readers	2.5%	1.8	2.0%	2.5
Reading-disabled	12.7%	4.2	11.4%	8.6

(Bentin *et al.*, 1990), we predicted that, while the percentage of correct identification of targets in the neutral condition should be equal in the two groups, an incongruent syntactic context should inhibit the identification in good readers more than in disabled readers, whereas the facilitatory effect of a congruent context should not interact with reading ability.

## Method

### Subjects

*The "good readers group."* The good readers were 24 children (10 girls and 14 boys), selected from 39 children in ordinary junior high school classes. Their mean age was 13 years and 6 months (SD = 10 months). Their mean IQ score was 113.4 (SD = 9.9). In order for a child to be included in the good readers' group he or she had to read at least 20 pseudowords correctly (with at most 16% errors) and at least 32 sentences (with no more than 11.11% errors). For a detailed description of the reading tests, see Tests and Materials.

*The "disabled readers group."* The reading-disabled were 24 children (4 girls and 20 boys), selected from a population of 107 children attending "compensatory learning settings" (special classes for learning-disabled children attending regular schools). Their mean age was 13 years and 5 months (SD = 13 months). Their mean IQ score was 96 (SD = 8.6). In order to be included in the disabled readers' group a child had to make at least eight errors (33.3%) in reading pseudowords and at least eight errors (22%) in reading sentences. In addition his or her mean reading time in both tests had to be at least twice as long as the mean reading time of the good readers' group.

The mean performance of the two groups in each of the reading tests is presented in Table 1.

### Tests and Materials

(A) *Reading tests: (1) Test of phonemic deciphering ability.* This test contained a set of 24 meaningless three or four letter strings (pseudowords) presented with vowel marks. All Hebrew consonant letters and vowel marks were used in constructing 24 pseudowords which were structured to comply with the Hebrew morpho-phonemic rules. They were presented one at a time on a computer screen subtending a mean visual angle of 2.85 degrees. Each

trial consisted of the following events: First, a fixation mark was presented at the center of the screen for 500 ms simultaneously with a warning beep; 600 ms from the offset of the fixation mark, a pseudoword substituted for the fixation mark and remained on the screen until a response was made. The subjects were instructed to read each pseudoword aloud exactly as it was written. Reading accuracy was recorded, as well as reading time from stimulus onset. Self-corrections of initially wrongly read stimuli were recorded but not included in the count of correct responses. Reading time was always measured to the first response. Responses with latencies longer than 2 *SD* from the subject mean were counted as errors. Each subject was assigned two scores: the percentage of correct responses and the average reading time.

(2) *Reading unpointed words in context.* This test contained 36 four-word sentences presented without the vowel marks. (With the exception of prayer books, poetry and children's books Hebrew is generally printed without vowels. By the end of the fourth grade, children are expected to read "unpointed" print fluently). The last word in each sentence was always a noun, designated as the target. There were two target categories: In one, the targets were heterophonic homographs, i.e., consonant clusters each of which could be combined with several different vowel patterns to form several different words. In the absence of vowels, the correct reading of heterophonic homographs in a particular sentence context can be determined only by apprehending the meaning of the sentence. The targets in the second category were unambiguous words, i.e., consonant clusters each of which could take only one vowel pattern. Thus, even in the absence of vowel-marks each target in this category could be meaningfully read in only one manner. Among the 36 sentences, 24 ended with a heterophonic homographic target and 12 with a phonologically unambiguous target. Each of the homographic targets were presented in two sentences. In one, the phonological alternative implied by the context had a low word-frequency value, while in the other the context implied the reading of a high-frequency word. The 36 sentences were presented in quasirandom order, in which sentences containing alternatives of one heterophonic homograph target were separated by at least two other sentences.

As in the pseudoword reading test, each trial began with the presentation of a fixation mark and a warning tone; these were followed by a sentence centered around the fixation point. The subjects were instructed to read each sentence aloud. Reading time was measured for each sentence from its onset to the end of reading. Subject's responses were first coded as correct or incorrect. Incorrect responses were further categorized according to four error types, but a detailed description of reading errors is beyond the scope of the present report. (The subtypes of the incorrect responses were Type 1, the subject substituted one or more words so as to form a syntactically correct meaningful sentence; Type 2, The subject made errors while reading one or more words in the sentence, but read the target word correctly; type 3, The subject substituted an incorrect phonological alternative of a heterophonic



homograph for the one implied by the context; type 4, The subject was unable to read the sentence). As in the pseudowords reading test, responses with latencies longer than 2 *SD* from the subject mean were counted as errors.

(B) *Intelligence tests.* An IQ score for each child was obtained either using the performance score of the WISC (whenever those data were available) or by converting to IQ the subject score on the Raven's Progressive Matrices.

(C) *The syntactic context effect test.* Syntactic context effects were assessed using an auditory word identification test similar to that described in our previous studies (Bentin *et al.*, 1990; Deutsch & Bentin, 1994). The test contained 60 sentences. Each sentence included a clearly presented syntactically congruent context phrase followed by a target masked by white noise. The syntactic congruity between the target and the context was manipulated to form three congruity conditions: (1) "Congruent," in which the target word fit the syntactic structure of the sentence; (2) "Incongruent," in which the target word did not fit the syntactic structure of the sentence, that is, caused a violation of a syntactic rule; (3) "Neutral," in which the context was "The next word will be. . . ."

The syntactic violations were constructed by changing the congruent sentences in one of the following ways.

*Type 1.* Violation of the gender agreement between subject and predicate. For example, the Hebrew sentence "Hasachkan harazeh yashen" (the skinny actor is sleeping) includes a noun, "hasachkan" (preceded by the definite article "Ha"), as the subject, an adjective, "harazeh" (also preceded by the definite article), as the attribute, and a verb, "yashen," as the predicate. In the congruent condition (the above sentence) both the subject and the predicate are in the masculine singular. In the incongruent condition, the same masculine predicate form was presented in a sentence in which the subject and the attribute were in the feminine: "Hasachkanit haraza yashen". (Note that according to another agreement rule in Hebrew the attribute agrees with the subject in gender, number and definite article. In all our examples syntactic structure was kept intact until the last target word.) This category included 12 target words repeated across the three context conditions, forming a total of 36 sentences. In the incongruent condition a masculine subject was presented with a feminine predicate (in 6 of the sentences) or a feminine subject was presented with a masculine predicate (in the other 6 sentences).

*Type 2.* Violation of the agreement in number between subject and predicate. For example, in the sentence "Hamechonit hayafa yekara" (The nice car is expensive) the feminine, singular predicate form, "yekara," agrees with the feminine singular subject, "mechonit." A violation of the number agreement might be "Hamechonyot hayafot yekara," where the same target is presented with a feminine plural subject (and attribute). Twelve target words (different from those in Type 1) were repeated across the three conditions, forming 36 sentences. In the incongruent condition a singular predicate followed a subject in the plural form (in 6 of the sentences), or vice versa (in the other 6 sentences).

*Type 3.* Violation of both gender and number agreement between subject and predicate. For example, in the congruent sentence "Harakdan hamefursam mitragesh" (The famous dancer is anxious) the masculine singular predicate, "mitragesh," is in agreement with the masculine singular subject, "harakdan," whereas in the incongruent sentence "Harakdaniyot hamefursamot mitragesh," the same masculine singular predicate relates to a feminine plural form, "harakdaniyot." This category also included 12 target words (different from those in types 1 and 2), which were repeated across conditions to form 36 sentences. In the incongruent condition the gender and number compatibility between subject and predicate was altered in each sentence. For example, a masculine singular subject might be followed by a feminine plural predicate. (We constructed all 4 possible combinations, with 3 sentences for each.)

*Type 4.* Decomposition of the conjunctive form of preposition and pronoun. This category included 8 target pronouns, each of which was combined with a different preposition, forming 24 sentences. In Hebrew, when a preposition precedes a pronoun, the two are always in a conjunctive form. Thus, in the incongruent condition, the conjunctive form was decomposed into its two elements. For example the conjunctive form "alecha" ("on you") was presented as two separate words: "al" (the preposition "on") and "ata" (the pronoun "you"). In the neutral condition the targets were presented as normal conjunctions.

The sentences of Types 1 to 3 consisted of three words in the following order: subject, attribute, predicate. The masked target was always the predicate. All the words used to construct these sentences were basic in children's vocabulary. The predicate was either a verb or an adjective (participle form in nominal clauses). Type 4 sentences consisted of a subject, a predicate and a verbal completion (the conjunctive pronoun). The masked targets were the verbal completion in their normal conjunctive form (congruent and neutral conditions) or decomposed (the incongruent condition).

The sentences were organized into three lists of 60 sentences, 20 in each congruity condition. Each group of 20 included 4 sentences of each Types 1 to 3, and 8 sentences of Type 4. The targets in the sentences of Types 1 to 3 were rotated so that each subject saw each target only once but, across subjects, each target appeared in each congruity condition. Because the number of pronouns is small, the rotation of pronouns between congruity conditions was within subjects, so that each appeared 3 times in a list (once in the decomposed form). In order to avoid as far as possible the effect of repeating the context, a different sentence was used in each condition. Moreover, the contexts were counterbalanced across the three lists.

All the sentences were recorded on tape by a female, native in Hebrew and a professional radio speaker. The tapes were digitized at 20 Khz and edited as follows. The duration of the mask was equal in all sentences, determined by the duration of longest target (750 ms). The white noise was digitally added to the target, starting slightly before onset with a signal-to-noise ratio of 0.35. This ratio was chosen in our previous study with adult

fluent readers (Deutsch & Bentin, 1994) on the basis of pilot tests, so that the expected correct target identification level was about 50%.

The sentences in each list were randomized and output to tape at a 2-s intersentence interval.

### *Procedure*

The children were tested individually in two sessions which were run consecutively. In the first session the reading and intelligence tests were administered. Only children who met the selection criteria were tested in the second session for syntactic context effects.

In the syntactic context effects test each child was randomly assigned to one of the three test lists. In each reading group, each list was used to test eight children. The experimenter and the subject listened to the stimuli simultaneously, using two sets of interconnected earphones (HD-420). The children were instructed to listen to the sentence and to repeat the last (masked) word during the silent interval at the end of each sentence. No time constraints were imposed; in a few instances, when the subject's response was delayed past the intersentence interval, the experimenter stopped the tape recorder. The responses were recorded verbatim by the experimenter and no feedback was provided. The experimental session began with 12 practice trials (4 sentences in each condition), followed by the test list.

### **Results**

Subjects' responses were initially coded as correct responses (accurate identification of the inflected word) or errors. The errors made in the incongruent condition were further categorized into four types: (1) "Spontaneous syntactic correction" (making a correction of the syntactic violation), (2) "Logical substitution" (reporting a different word, yet forming a semantically and syntactical congruent sentence), (3) "Nonsense" (replacing the target with a word or nonword which yielded a meaningless sentence) and (4) "No response" ("I don't know"). In the neutral and congruent conditions only the last three categories were possible.

Informal inspection of the percentage of correct identification in the different congruity conditions revealed that syntactic congruity had a very similar effect with all four types of violation. Moreover, formal statistical analyses of 10 different types of syntactic violations (in a previous study) also revealed that these four violations were equally affected by syntactic context (Bentin *et al.*, 1990). Therefore, identification performance was collapsed across sentence types.

The percentage of correct identification of target words in the congruent, neutral and incongruent grammatical conditions, across subjects and stimuli, for the good and reading-disabled groups are presented in Table 2.

A two-factor analysis of variance with subjects (F1) and stimuli (F2) as random variables revealed a significant interaction between syntactic congruence and reading group [ $F(1,92) = 8.48$ ,  $MS_e = 74$ ,  $p < .0004$ ,  $F(2,118)$

TABLE 2  
The Percentage of Correctly Identified Target (SEM) in Each Congruity  
Condition in the Two Reading Groups

Congruity condition	Good readers	Reading-disabled
Congruent	68.96% (10.2)	52.92% (14.3)
Neutral	39.17% (11.8)	29.17% (12.6)
Incongruent	15.00% (10.6)	13.33% (8.8)

= 3.26,  $MS_e = 261$ ,  $p < .0418$ ]. This interaction reflected the smaller effect of syntactic context in the disabled than in the good readers group.

The main effects of syntactic congruence and reading group were also statistically significant. Across groups, the percentage of correct target identification was highest in the congruent condition (61%), second in the neutral condition (34%), and lowest in the incongruent condition (14%) [ $F(2,92) = 358.55$ ,  $MS_e = 74$ ,  $p < .0001$ ,  $F(2,118) = 71.78$ ,  $MS_e = 926$ ,  $p < .0001$ ]. Across congruence conditions, the percentage of correct identification was higher for the good readers (41%) than for the reading-disabled (32%) [ $F(1,46) = 12.16$ ,  $MS_e = 252$ ,  $p < .0011$ ,  $F(1,59) = 22.8$ ,  $MS_e = 313$ ,  $p < .0001$ ]. Post-hoc comparisons (Tukey-A) revealed, however, that the difference between the two groups was statistically reliable only in the congruent and neutral conditions (16.04 and 10%, respectively); in the syntactically incongruent condition, the difference between the reading-disabled and good readers in percentage of correctly identified targets (1.67%) was not statistically reliable (HSD = 7.04).

Because the two reading groups differed considerably in IQ level, we examined the possibility that our results were tainted by differences in general intelligence level. First we matched selected groups of good and disabled readers on IQ level and calculated the performance of these subgroups separately. Second, within each reading group children with relatively high and relatively low IQ levels were selected and their performance on the word identification task was calculated separately. As evident in Table 3, none of these manipulations changed the general pattern of the differences. Moreover, the influence of IQ on the absolute levels of performance did not show any clear effect, suggesting that, indeed, the identification performance was independent of IQ.

The distribution of errors in the reading-disabled and control groups is presented in Table 4.

Because spontaneous corrections cannot exist in the syntactically congruent and neutral conditions, the statistical evaluation of the distributions was based on a two-factor analysis of variance and reading group, within each congruity condition separately. These analyses showed a significant effect of error types in all congruity conditions [ $F(2,92) = 30.63$ ,  $MS_e = 827$ ,  $p < .0001$ ,  $F(2,92) = 85.23$ ,  $MS_e = 478$ ,  $p < .0001$ , and  $F(3,138) = 85.07$ ,  $MS_e = 275$ ,  $p < .0001$ ]

TABLE 3  
Percentage of Correct Identification in Each Congruity Condition for Each Reading Group, Splitted by IQ Level

	Reading-disabled				Good readers			
	IQ	Congruent	Neutral	Incongruent	IQ	Congruent	Neutral	Incongruent
Whole group	96	53%	29%	13%	113	69%	39%	15%
IQ match	104	48%	25%	13%	106	64%	38%	14%
Low IQ	92	58%	31%	14%	106	64%	38%	14%
High IQ	104	48%	25%	13%	123	71%	41%	14%

TABLE 4  
The Distribution of Errors among the Different Types in Each Congruity Condition for Good Readers and Reading-Disabled (Mean Percentage and SEM)

Congruity condition	Reading ability	Error type			
		Spontaneous correction	Logical substitution	Nonsense	No response
Congruent	Good readers	—	44.5% (28.4)	1.3% (4.4)	54.3% (29.8)
	Reading-disabled	—	55.4% (24.8)	12.9% (13.6)	31.6% (28.2)
Neutral	Good readers	—	60.4% (24.0)	0.0% (0.0)	39.6% (24.0)
	Reading-disabled	—	60.0% (20.9)	4.4% (6.6)	31.9% (18.2)
Incongruent	Good readers	12.5% (7.4)	19.8% (13.8)	1.6% (3.6)	66.0% (19.2)
	Reading-disabled	9.8% (7.8)	34.5% (15.9)	11.1% (10.5)	44.5% (24.4)

for the congruent, neutral, and incongruent conditions, respectively]. A significant interaction was found between the effects of error type and reading group in the congruent condition [ $F(2,92) = 5.56$ ,  $MS_e = 827$ ,  $p < .0052$ ] and in the incongruent condition [ $F(3,138) = 11.35$ ,  $MS_e = 275$ ,  $p < .0001$ ] but not in the neutral condition [ $F(2,92) = 0.93$ ,  $MS_e = 478$ ,  $p > .3997$ ].

As is evident in Table 4, the percentage of "no response" errors was higher for the good readers than for the reading-disabled. This pattern was found in the syntactically congruent condition (54 and 32% for good and reading-disabled, respectively) as well as in the incongruent condition (66 and 45% for good and reading-disabled, respectively). Post-hoc analyses of the interactions revealed that these differences were statistically significant in the incongruent condition ( $HSD = 18.42$ ) but not in the congruent condition ( $HSD = 24.23$ ).

Although a formal analysis of the Error type  $\times$  Reading group  $\times$  Congruency condition interaction could not be made, it is worth noting that the two-way interaction between error type and reading group is caused by opposite trends in the congruent and incongruent conditions. In the congruent condition disabled readers made fewer "no response" than "logical substitution" errors, while good readers showed an inverse tendency. In the incongruent condition, on the other hand, both groups made more no response than logical substitution errors, while the difference was considerably larger for good readers than for reading-disabled.

### Discussion

The results of the present experiment showed that for children, as for adults (Deutsch & Bentin, 1994), the syntactic context effect on the identification of auditory masked words reflects two processes, facilitation and inhibition. Both processes were effective in disabled and in good readers. However, reading ability influenced the size of the relative contribution of each of these two processes to the global syntactic context effect.

A post-hoc analysis of the interaction of reading ability and syntactic context revealed that for good readers syntactic incongruence reduced the percentage of correct target identification (relative to the neutral condition) almost as much as syntactic congruence elevated this percentage (24 and 29%, respectively). In contrast, for disabled readers the relative contribution of the inhibitory process to the global syntactic context effect (15%) was significantly smaller than that of the facilitatory process (24%). Although disabled readers identified fewer targets than good readers in the syntactically congruent and in neutral conditions, the performance of the two reading groups was similar in the incongruent condition. This pattern is in agreement with our previous findings, which suggested that incongruent syntactic context interferes less with the performance of reading-disabled than with that of good readers (Bentin *et al.*, 1990).

In contrast to our previous findings (Bentin *et al.*, 1990), in the present experiment the correct identification rate across syntactic congruity conditions

was lower for reading-disabled (32%) than for good readers (41%). Note, however, that the overall identification performance of good readers was also poorer than that of adults (51%; Deutsch & Bentin, 1994). The reduction in identification performance occurred even though an identical masking intensity, identical stimuli and experimental procedures were used in both studies. It is possible that the masking conditions, which had been calibrated for adults, were too difficult for children, and that this difficulty was more conspicuous for disabled readers possibly because they may have had a phonological disability as well (Brady *et al.*, 1983). It is possible therefore that the similarity between disabled and good readers in the identification of syntactically congruent targets reported in Bentin *et al.* (1990) reflected a reduced level of masking which was not very sensitive to phonological impairments. However, would the relatively inferior phonological ability of the reading disabled children have been the only factor accounting for the differences between the identification performance of the two groups, no interaction between reading level and syntactic congruency condition should have been observed. We had the opportunity to test this interpretation in Experiment 2, where the noise level was reduced.

The analysis of the error distribution yielded additional insights. Consider first the relatively small percentage of "spontaneous syntactic corrections" which was observed in both reading groups. Because only verbatim accurate responses were considered correct, the pattern of facilitation and inhibition might simply reflect that the subjects, facing uncertainty, used some partial phonological information extracted from the noise and the contextual information, to guess the target word. If this interpretation were correct, the difference in the percentage of correct identifications of inflected targets in the congruent and the incongruent conditions would reflect the correspondence or disagreement between the subject's intuition about how the identified word should have been inflected and what was actually presented. Such a strategy, however, would result in a high percentage of "spontaneous syntactic correction" errors in the incongruent condition. But this did not occur: The relatively small percentage of spontaneous syntactic corrections in both groups indicates that the pattern of masked-word identification in our subjects did not simply reflect an intelligent guessing strategy based on partial input.

The difference between the distributions of the different types of errors in the two reading groups provided additional support for the view that reading-disabled were generally less affected by the syntactic context and, in particular, that their performance was less impaired by syntactic incongruence than that of the good readers. In both the congruent and the incongruent conditions good readers produced more "no response" errors than reading-disabled, and disabled-readers produced more "logical substitution" errors than good readers. Within each group, the percentage of "no response" errors was larger in the incongruent than in the congruent condition. On the other hand, the percentage of logical substitutions was smaller in the incongruent than in the congruent condition. The abundance of no response errors for good read-

ers, especially in the incongruent condition, suggests that children may have chosen to abstain from responding when facing uncertainty. This strategy was more appropriate in the incongruent than in the congruent condition because in the former condition the uncertainty caused by masking was increased by the mismatch between the partial information provided by the phonetic input and general expectations raised by the syntactic structure of the sentence context. The fact that reading-disabled group produced fewer no response and (context-unrelated) substitution errors than good readers also supports our suggestion that the disabled readers' identification performance was less affected by the syntactic context than that of good readers.

In summary, the results of the present experiment showed that, for both good readers and reading-disabled, the identification of auditory masked targets presented in sentences is affected by the syntactic structure of the context. However, this syntactic context effect is reduced in reading-disabled, primarily because their performance is less impaired by syntactic incongruity. In our previous study (Deutsch & Bentin, 1994) we suggested that the inhibitory component of the syntactic context effect is mediated by attention. Consequently it is possible that the difference between the reading-disabled and the good readers reflects a deficient attention-mediated syntactic process in the reading-disabled group. Experiment 2 was designed to test this hypothesis.

## EXPERIMENT 2

In the present experiment we tested the interaction between reading ability and the effect of attention-related mechanisms which mediate the inhibitory component of the syntactic context effect (Deutsch & Bentin, 1994). Specifically, we compared the effect of presenting the congruent and incongruent conditions in separate blocks, as opposed to random mixed presentation, for both disabled and good readers.

In our previous study (Deutsch & Bentin, 1994) we showed that when the congruent and incongruent conditions are presented in separate blocks the inhibitory component of the syntactic context effect was attenuated while the facilitatory component was not affected. In line with previous interpretations of similar effects on semantic priming (e.g. Fischler & Bloom, 1985; Stanovich & West, 1983; Tweedy, Lapinsky & Schvaneveldt, 1977), we suggested that the blocking manipulation primarily affects an attention-based mechanism which may be reflected more in the inhibitory than in the facilitatory component of the syntactic context effect. Blocking syntactically incongruent targets may, for example, discourage the elaboration of (automatically) generated syntactic expectations based on the structure of the context. Thus we used the blocking manipulation to disentangle the attention-related factors involved in the syntactic context effect from the more automatic factors, and to examine how each of these factors interacts with reading ability.

Our hypothesis was that the observed difference in syntactic performance between reading-disabled children and good readers reflects the malfunctioning of an attention-based mechanism for processing syntax. On the basis



TABLE 5  
Reading Performance of the Two Reading Groups Tested in Experiment 2

Reading ability	Reading pointed nonwords		Reading unpointed sentences	
	Percentage of errors	Time per item (seconds)	Percentage of errors	Time per item (seconds)
Good readers	2.4%	2.1	2.4%	2.5
Reading-disabled	12.0%	4.2	10.2%	7.6

of this hypothesis we predicted that the effect of blocking the congruency conditions would be stronger in good readers than in disabled readers. Specifically, we predicted that discouraging the use of expectations by presenting the ungrammatical sentences in one block would decrease the amount of inhibition for the good readers, while reading-disabled would be significantly less affected by this manipulation.

In the present experiment we also tested our assumption that the inferior identification performance of the reading-disabled relative to good readers in the congruent condition of Experiment 1 was caused by too high level of masking. To this end, the percentage of correct identification in the mixed presentation condition was compared between reading groups, using a higher signal to noise ratio. If our interpretation is correct, then the results reported by Bentin *et al.* (1990) should be replicated, i.e., the two groups should identify a similar percentage of congruent targets, while the disabled readers should identify more incongruent targets than the good readers.

## Method

### *Subjects*

The subjects were 120 children who had not taken part in the first experiment. They included 60 good readers (27 girls and 33 boys), and 60 disabled readers (13 girls and 47 boys), selected from seventh and eighth graders attending regular classes, using the same selection criteria as in Experiment 1 (Table 5). The mean age of the good readers was 13 years, with a mean IQ score of 116 (SD = 10.6). The mean age of the reading-disabled children was 13 years and 2 months, with a mean IQ score of 105 (SD = 11.5).

### *Test and Materials*

The sentences were those used in Experiment 1, with the exception of the neutral stimuli. Thus each stimulus list consisted of 40 sentences, 20 syntactically congruent and 20 syntactically incongruent. In the "mixed" presentation the 40 sentences were randomized and presented in one set of stimuli. In the "blocked" presentation congruent and incongruent sentences were clustered separately in two blocks of 20 sentences each. The sentences

were randomized within each of the two blocks. Each target appeared only once in each list (with the exception of sentences of Type 4). Across lists, each target appeared equally often in the congruent and incongruent conditions.

The intensity of masking was lowered from that of Experiment 1 by increasing the signal-to-noise ratio from 0.35 to 0.40.

### *Procedure*

Different groups of 30 good readers and 30 disabled readers were tested with each presentation condition. The assignment of subjects to experimental conditions was random. The procedure used for the mixed presentation was identical to that used in Experiment 1.

In the blocked presentation, 15 subjects began with the block of syntactically congruent sentences, and the other 15 with the block of syntactically incongruent sentences. Each block was preceded by eight practice sentences in the respective congruity condition. No special instructions were given before the "incongruent" block, but the ungrammatical structure of the sentences was not denied in reply to occasional queries raised by the subjects following practice with ungrammatical sentences (as was true for the mixed condition as well).

### Results

The percentage of correct identification was averaged for each subject and target in each congruity condition. The reading groups did not differ in the percentage of correct identification of congruent targets either in the mixed or in the blocked presentation (about 60% correct). In contrast, the disabled readers differed from the good readers in the percentage of correct identification of target words in the incongruent condition. This difference, however, was influenced by the mode of presentation. The percentage of correct target identification in the incongruous condition was higher for reading-disabled than for good readers. This difference was particularly conspicuous in the mixed condition. Disabled readers identified 20% of the incongruent targets regardless of whether the congruency conditions were mixed or blocked. In contrast, good readers identified twice as many targets when incongruent targets were blocked (16%) than when incongruent and congruent targets were mixed (8%) (Fig. 1).

The statistical significance of these differences was examined by a mixed-model three-factor analysis of variance, with subjects (F1) and stimuli (F2) as random variables. The between-subjects factors were reading ability and presentation mode, while the within factor was congruity condition. The influence of reading ability on the interaction between the syntactic congruity condition and presentation mode was demonstrated by a significant second-order interaction between congruity condition, presentation mode, and reading ability [ $F(1,116) = 4.80$ ,  $MS_e = 125$ ,  $p < .0305$ ,  $F(1,118) = 5.59$ ,  $MS_e = 177$ ,  $p < .0196$ ].

The syntactic congruity effect in the mixed condition was tested separately

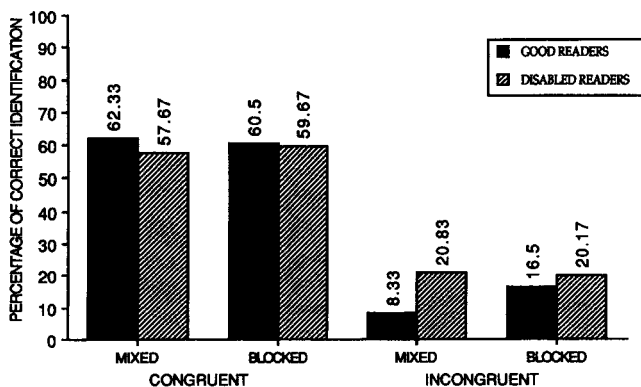


FIG. 1. Percentage of correct identification of syntactically congruent and incongruent targets in the blocked and mixed presentation modes.

by a two-factor analysis of variance. This analysis was performed in order to test our hypothesis that the unexpected difference between the two groups in overall identification performance in Experiment 1 was caused by excessive masking. The analysis revealed a significant interaction between reading level and congruity condition [ $F(1,58) = 18.93$ ,  $MS_e = 112$ ,  $p < .0001$ ]. Post-hoc comparisons showed that this interaction was caused by a significantly higher percentage of correct identification of incongruent targets by the reading-disabled than by the good readers (a difference of 12%), in contrast to the statistically insignificant difference between the groups (less than 5% difference) in the percentage of correct identification of congruent targets ( $MS_e = 112$ ,  $q(4,58) = 3.75$ ,  $HSD = 5.134$ ).

The possible influence of IQ level on the revealed pattern of results was examined as in Experiment 1. As evident in Tables 6 and 7, the pattern of results was apparently independent of IQ level.

The error distribution in the good and disabled readers is presented in Table 8. A three-way analysis of variance, with error type, reading level and presentation condition as main factors, was performed separately within each

TABLE 6  
Percentage of Correct Identification in Each Congruity Condition for Each Reading Group, Split by IQ Level, within the Mixed Presentation Mode

	Reading-disabled			Good readers		
	IQ	Congruent	Incongruent	IQ	Congruent	Incongruent
Whole group	105	58%	20%	116	62%	10%
IQ matched	106	57%	23%	103	62%	8%
Low IQ	92	57%	22%	103	62%	8%
High IQ	116	58%	21%	126	61%	6%

TABLE 7  
Percentage of Correct Identification in Each Congruity Condition for Each Reading Group,  
Split by IQ Level, within the Blocked Presentation Mode

	Reading-disabled			Good readers		
	IQ	Congruent	Incongruent	IQ	Congruent	Incongruent
Whole group	105	60%	20%	116	61%	17%
IQ matched	109	61%	23%	113	68%	21%
Low IQ	99	58%	26%	113	68%	21%
High IQ	109	61%	23%	128	59%	19%

congruity condition. This analysis revealed a significant main effect of error type in both conditions ( $F(2,232) = 97.49$ ,  $MS_e = 550$ ,  $p < .0001$  and  $F(2,348) = 170.07$ ,  $MS_e = 255$ ,  $p < .0001$  for the congruent and incongruent conditions, respectively). The second-order interaction of error type, reading group and presentation condition (blocked or mixed) was significant for the incongruent targets [ $F(3,348) = 8.47$ ,  $MS_e = 255$ ,  $p < .0001$ ] but not for the congruent targets [ $F(2,232) = 1.43$ ,  $MS_e = 550$ ,  $p > .2420$ ].

Examination of the distribution of error types in the incongruent condition across the two presentation conditions indicated that the percentage of substitution of another word for the target word ("logical substitution" or "nonsense") was much higher for the reading-disabled children than for the good readers. In contrast, the percentage of no response is much higher for the good readers than for the reading-disabled children. As was previously found with fluently reading adults, the percentage of no response was lower in the blocked condition than in the mixed condition for the good readers, while an opposite trend was observed for the reading-disabled.

TABLE 8  
The Distribution of Errors among the Different Types in Each Congruity Condition in the  
Mixed and Blocked Presentation Mode for Good Readers and Reading-Disabled

Congruity condition	Reading ability	Mode of presentation	Error type			
			Spontaneous correction	Logical substitution	Nonsense	No response
Congruent	Good readers	Mixed	—	39.6%	3.2%	57.2%
		Blocked	—	51.6%	14.3%	33.5%
	Reading-disabled	Mixed	—	45.8%	2.4%	52.8%
		Blocked	—	46.1%	15.7%	37.1%
Incongruent	Good readers	Mixed	11.4%	17.7%	1.8%	69.1%
		Blocked	12.7%	25.1%	7.0%	55.0%
	Reading-disabled	Mixed	11.7%	31.2%	18.9%	35.3%
		Blocked	11.3%	27.4%	14.7%	46.7%

### Discussion

The most interesting result in Experiment 2 was that the effect of presenting the syntactically incongruent sentences in a separate block as opposed to mixing them with congruent sentences was different in good and disabled readers. Whereas for the good readers there was less interference of syntactic incongruity with target identification in the blocked presentation mode than in the mixed presentation mode, disabled readers were not affected by this manipulation. Moreover, the amount of inhibition in the mixed presentation mode was smaller for the reading-disabled than for the good readers. In contrast to incongruent targets, syntactically congruent targets were equally well identified by both reading groups, and this performance was not affected by the mode of presentation (blocked vs mixed).

The smaller inhibitory effect in the blocked than in the mixed presentation mode, and the absence of any effect of presentation mode on the facilitatory component of the syntactic context effect—both of which were observed among good readers—replicates a similar pattern found in fluently reading adults (Deutsch & Bentin, 1994). This pattern supports the hypothesis that the inhibitory component of the syntactic context effect is controlled by attention-mediated mechanisms while the facilitatory component of the syntactic context effect is more automatic.

The absence of any influence of presentation mode on the identification performance of disabled readers suggests that they were either less sensitive than good readers to the syntactic structure of the sentence (and therefore less disturbed by syntactic incongruity), or that they did not use that information to generate a performance strategy. The similar amount of facilitation in the syntactically congruent condition observed in the performance of disabled and good readers indicates that the second interpretation is more plausible than the first. We will elaborate this interpretation in the General Discussion.

The equally good performance of disabled and good readers with syntactically congruent targets is noteworthy also because it supports our account for the unexpectedly poorer performance of disabled relative to good readers found in Experiment 1 across all congruity conditions. We assumed that this inferiority was caused by too intense masking. Indeed, when the signal-to-noise ratio was increased in the present experiment in comparison to that in Experiment 1 (i.e., the amount of masking was reduced), the general pattern of differences between the two reading groups replicated the pattern found by Bentin *et al.* (1990): Disabled readers identified as many targets as good readers in the congruent condition, and more targets than good readers in the incongruent condition. Thus, assuming that intense auditory masking affected disabled readers more than good readers, the smaller difference between the two groups in the incongruent condition than in the congruent condition which was observed in Experiment 1 (despite the high-intensity masking) may have reflected the same underlying mechanism suggested by the results of Experiment 2, i.e., that the identification of target words is less inhibited by syntactic incongruity in disabled than in the good readers.

Additional support for our account of the differential effect of presentation mode on good and disabled readers was provided by the pattern of errors. As found in the analysis of incorrect responses, the second order interaction between the type of errors that subjects made, presentation mode and reading ability was significant only in the incongruent condition. These results revealed that although good readers produced significantly more no response responses than poor readers, this trend was influenced in both groups by the mode of presentation. However, the manipulation had a different effect in each reading group. In the blocked presentation condition good readers produced no response errors less often than in the mixed presentation, but they had an increased tendency to commit substitution errors of various kinds. In contrast to the case of good readers, mode of presentation had no effect on disabled readers. The types of the errors made by disabled readers in both conditions resembled the pattern found in good readers in the blocked presentation mode, i.e., there was a relatively high percentage of substitutions and a relatively low percentage of no response errors.

Recall that, as discussed in Experiment 1, no response may reflect the inhibition caused by the conflict between context based expectations and phonological input. Therefore, the fact that good readers produced a smaller proportion of no response errors in the blocked presentation condition than in the mixed presentation might have been the result of a strategic decision that the context is not very helpful in the target identification process, in the block of incongruent sentences and can therefore be ignored. Using the same logic, the finding that reading-disabled produced fewer no response among their errors than good readers may reflect the fact that they did not rely as much on context-based expectations in either presentation mode. Although less informative, the pattern of substitution errors can also be integrated into the above interpretation. It is possible that when conflict is reduced (in the blocked presentation), subjects can more easily adopt a less conservative strategy and release intuitive responses.

In conclusion, the results of the present experiment supported our previous findings that syntactic incongruity disturbs reading-disabled children less than good readers, and revealed that one source of this difference is a reduction in the efficiency of an attention-based inhibitory component in the syntactic context effect. We will elaborate this mechanism and its possible implications for understanding reading disability in the next section.

## GENERAL DISCUSSION

The present study was aimed at further investigating the basis of the difference in the ability of reading-disabled and good readers to use the syntactic information conveyed by a sentence context in word identification (Bentin *et al.*, 1990). More specifically we examined how attention-related mechanisms may be a source of this difference. To achieve this goal, we have tested the interaction between reading ability and attentional mechanisms that mediate the syntactic-context effect on word identifica-

tion. Auditory masked target words were embedded in an unmasked sentential context, and were either congruent or incongruent with the syntactic structure of the sentence. The results revealed that, as compared to a neutral condition, word identification was facilitated by syntactic congruence and inhibited by syntactic incongruence in both good readers and the reading-disabled children and that, as was predicted, the effect of inhibition was smaller in the latter than in the former group.

Before discussing the possible interpretations of these results it is worth mentioning that the absence of any relationship between general intelligence level and the word identification performance in any of the reading groups studied, supports previous claims that reading skills and intelligence are not closely related (Baddeley, Logie & Allis, 1988; Brady, Shankweiler & Mann, 1983; Fowler, 1988; Shankweiler, Crain, Brady & Macaruso, 1992; Siegel, 1988; Stanovich, 1991; Stanovich, Cunningham & Feeman, 1984). Discussing this issue Stanovich and his colleagues also showed that the correlation between reading and intelligence is limited to reading comprehension. On the basis of extensive research they concluded that intelligence scores may account for the performance of garden-variety type of poor readers, but it is less informative in accounting for the inferior linguistic performance of children with severe reading disorders which are based on specific phonological handicap. Although, this also seems to be the case in the present research, it should be noted, that the intelligence assessment for the reading disabled groups was based on one of two scores derived from different non-verbal intelligence tests, whereas for the good readers groups all intelligence scores were derived from the same intelligence test. Therefore, the possibility that differences observed between the good and disabled readers in the syntactic tasks were confounded by differences in intelligence is not unequivocally excluded.

The manipulation of attention-related strategies, by presenting congruent and incongruent sentences in separate blocks, had a differential effect on the two reading groups. For good readers, this manipulation affected the magnitude of the inhibition but had no effect on facilitation. These results replicated our previous findings with fluent adult readers (Deutsch & Bentin, 1994), suggesting that attention mechanisms mediate mainly the inhibitory component of the syntactic context effect. In contrast to the performance of good readers, the performance of the reading-disabled children was not affected by the blocked/mixed manipulation in the identification of either congruent or incongruent targets. Moreover, the percentage of correct identification of incongruent targets was relatively high in the mixed as well in the blocked condition, resembling the performance of good readers in the blocked condition.

Our interpretation of the differences in performance between good readers and reading-disabled is based on a conceptualization of the mechanism of the syntactic-context effect that we elaborated in a previous study (Deutsch & Bentin, 1994). In analogy to a commonly held account of attention-mediated factors in semantic priming (Fischler, 1977; Fischler & Bloom, 1979; Neely,

1977; Stanovich & West, 1981; 1983), we suggested that the involvement of attention in the syntactic-context effect is related to a process of elaborating context-based expectations. In an attempt to explain the nature of these expectations, we borrowed a concept put forward to account for the role of attention in the construction of expectations in the semantic domain, and extended it to the syntactic domain. This concept is the assumption of coherence formulated by de Groot, Thomassen, and Hudson (1982). According to the coherence assumption, the reader (or the listener) covertly assumes that every linguistic message must be coherent. Consequently, he/she expects each word in the linguistic message to be congruent with the context in which it is embedded. This expectation induces a process of verification that this coherence indeed exists. According to de Groot *et al.*'s (1982) analysis, this verification is performed at a post-lexical level, after a phonological unit has been provisionally identified. This process delays the final identification of the word until the coherence has been verified, and thus its effect on word identification is always inhibitory. However, the effect should be particularly strong when the coherence assumption is not satisfied.

In light of the fact that the syntactic system is more constrained than the semantic system, and supported by the residual inhibition observed in the incongruent block despite its obvious structure, we suggested that the same covert assumption of coherence, which was used in the semantic domain to account only for the inhibition process, may underlie both the inhibition and the facilitation processes in the syntactic domain (for a detailed elaboration of this claim see Deutsch & Bentin, 1994). It was shown that in incongruent contexts the process of inhibition is unavoidable (de Groot *et al.*, 1982). Therefore the mere tendency to generate grammatical expectations and the triggering of the coherence verification cannot easily be controlled. Hence, we suggested that at the sentence level these expectations are probably generated by a veiled controlled (quasi-automatic) process which uses only minimal attention resources (Schneider & Shiffrin, 1977). The term "veiled controlled processes" is used to describe an intermediate stage of attentional processing which is carried out like an automatic process: It is characterized by low demands on attentional resources and is generally carried out without intention (Shiffrin & Schneider, 1977). Congruent targets are facilitated in comparison with a neutral condition because their morphological structure may have been previously activated while generating the expectations, and/or because they may be integrated more easily into a previously activated syntactic structure. On the other hand, when the same expectations are violated by incoherent input, attention is mobilized to control an additional process of re-evaluating the basis of the syntactic expectations and/or reexamining the phonological input. The re-evaluation may be the attention-mediated factor in the process of inhibition. This account for the syntactic-context effect accommodates the finding that strategic changes induced by the blocking manipulation influenced the magnitude of the inhibition effect without affecting the quasi-automatic facilitation. Moreover, because the generation of expectations is not under



strategic control, residual inhibition may also exist when experimental circumstances discourage the initiation of the re-evaluation process. This mechanism may account for the inhibition found in the blocked presentation mode.

In the present study we found that the performance of the reading-disabled was facilitated by syntactic congruence as much as that of good readers. This finding precludes the possibility that the reading-disabled children were simply insensitive to the syntactic structures. Alternatively, this finding may suggest that the coherence assumption, and the uncontrolled generation of context-based expectations, function in reading-disabled children as well as in good readers.

In contrast to the equal facilitation, the inhibition process was different in the two groups. Good readers were inhibited more than the reading-disabled when the congruence conditions were mixed, whereas in the blocked presentation word identification was similarly inhibited in the two groups. The equal amount of inhibition found in the reading-disabled group across presentation conditions suggests that the natural manifestation of the inhibition process in reading-disabled children is similar to its manifestation in good readers when influenced by the artificial conditions created by blocking the incongruent sentences, i.e., when the validity of the coherence assumption was reduced. In our interpretation this residual inhibition is accounted for by the uncontrolled generation of syntactic expectations, while the attention demanding process of re-evaluating the syntactic structure is reduced in the reading-disabled.

In accordance with the above analysis, we propose that reading-disabled children are as competent as good readers in assembling appropriate syntactic structures and generating morpho-syntactic expectations while identifying words in context. They are, however, inferior to good readers in using this system for the attention-based process of re-evaluating the generated structure and/or the phonologic input when their expectations are not fulfilled. Note that similar suggestions have been made in the semantic domain (Gernsbacher, 1993; Gernsbacher & Faust, 1991). These authors found that, while poor readers do not differ from good readers in generating context based expectations, they are inferior in suppression inappropriate contextual information.

The distinction between the attention-based and quasi-automatic mechanisms of the syntactic-context effect is similar to the distinction between the ability to comprehend and produce language, on the one hand, and the ability to reflect on this linguistic knowledge and use it intentionally, on the other hand. The latter skills comprise the concept of "linguistic awareness" (Hakes, 1980). Using this concept to interpret our present results, we suggest that, at least in regard to morpho-syntactic rules as manipulated in the present study, the syntactic knowledge of reading-disabled children may be intact, but that they are less competent than good readers in using this knowledge intentionally. Assuming that linguistic awareness develops on the basis of the accumulated knowledge in a particular linguistic domain and on the organization of this knowledge (cf. Hakes, 1980), the absence of syntactic awareness in these children may reflect deficiencies in the nature, quality and organization of

the syntactic knowledge they possess. This deficiency should not impair the automatic processes of understanding and producing language, but it is evident in more complex linguistic tasks, such as reading, or in artificial tasks (such as those in the present study). The more complex tasks require the intentional activation of attention-based operations on the basis of this knowledge (for a similar conceptualization see Cupples & Holmes, 1992).

The relatively low percentage of spontaneous syntactic corrections of the incongruent targets in good readers, and the fact that the percentage of these error-types was similar across groups require additional consideration. Because corrections may draw on attentional resources (de Villiers & de Villiers, 1974; Fowler, 1988), this pattern of errors could be interpreted as evidence against our suggestion that good readers are more aware of their syntactic knowledge than poor readers. However, a different interpretation of correction errors is possible in the present context—namely, that spontaneous corrections may not necessarily reflect syntactic awareness but may be sporadic responses characterizing children's performance in many linguistic tasks even at a developmental stage when linguistic awareness is still absent (Hakes 1980). This pattern is particularly relevant to the present experiment, in which the task was not to correct the sentence grammar (cf. Fowler, 1988) but rather to identify the target words. Thus, the low percentage of "spontaneous correction" errors, which was similar in all reading groups and in both the mixed and the blocked presentation modes, may reflect an unintentional process which differs fundamentally from the processes we are interested in—the ability to intentionally allocate attention to the syntactic structure.

The deficiency in the attention mechanism which according to our interpretation, underlies the impaired use of syntactic context by reading-disabled children is not necessarily a general attention deficit. In our present conceptualization we are considering attention only in its limited role as a vehicle for linguistic awareness. Hakes (1980) described the development of linguistic awareness on the basis of practice and repeated experience with existing knowledge. According to this model, linguistic awareness enables the perceiver of language to gain control of processes which may be triggered automatically. For example, the coherence assumption posits that the generation of the syntactic structure and of the expectations which are based on this analysis are automatic. However, without linguistic awareness and without the ability to direct a minimal amount of attention resources to these expectations, the perceiver would not be aware of their content and would not be able to respond to their violation. As we suggested above, this activity is the source of the attention-based interference caused by syntactic incongruence. This is not to say, however, that the perceiver is necessarily conscious of the process. The control may be veiled, as suggested by Shiffrin and Schneider (1977). For example, while using the syntactic context normally in the perception of congruent sentences, the subject may not be conscious of the expectations developed during the process of word recognition. Furthermore, attention-based control is not an all-or-none ability, and the amount of attention

resources it requires may vary according with the complexity of the linguistic message and the subject's linguistic sophistication. For example, Jou and Harris (1992) showed that, while incorrectly inflected verbs embedded in a text interfered with reading speed, the performance was improved by increasing the inflection error rate to 100%. This pattern suggests that, although the process of syntactic analysis is motivated by a covert automatized involuntary process based on prior knowledge, this process can be controlled and modulated by attention in novel situations (see also MacLeod & Dunbar, 1988).

The full development of attention-based elaboration of context-based expectations, as well as an accomplished linguistic awareness, probably require the integrity of the linguistic system. Consequently, the reduced syntactic awareness in the reading-disabled may suggest an impairment in the consolidation and integrity of syntactic knowledge in this population. In the final section of this discussion we consider the role that syntactic awareness might have in reading.

Most reading-related studies of syntactic ability difficulties in the syntactic domain were related to advanced levels of reading comprehension (Bowey, 1986; Willows & Ryan, 1986). On the basis of the present results and our interpretation of them, we suggest that difficulties in syntactic awareness may also be related to primary stages of the reading process, namely the process of word identification (for a similar argumentation see Tunmer, Herriman, & Nesdale, 1988). In the process of word identification, whether spoken or written, syntactic context may play a particularly role in resolving categorical ambiguity (e.g., deciding whether RUN is a noun or a verb). Syntactic information may be more important in reading than in speech because of the lack of prosodic cues which facilitate disambiguation in spoken but not in written language, and because there is additional ambiguity in print in the case of heterophonic homographs such as "WIND."

In Hebrew, the language in which the present study was carried out, there is a large incidence of heterophonic ambiguity. In Hebrew orthography most vowels are represented by diacritical marks which are usually omitted from print. This aspect of the orthography creates a situation in which the same sequence of consonants may be read in many ways, each with a different vowel pattern. Consequently, heterophonic homographs and categorical ambiguity are more frequent in Hebrew than in many other languages. In fact even words that have only one meaningful phonological structure cannot be read entirely through the assembled phonology. (For a detailed description of Hebrew orthography and its consequences for reading, see Frost & Bentin, 1992.) Given this specific orthographic structure, it is conceivable that the importance of context-based expectations in word identification is amplified in Hebrew. Nonetheless, we believe that our findings are not language-specific. This claim is based on existing evidence which was reviewed in the Introduction, but undoubtedly the particular relationship between attention-based mechanisms of syntactic processing and reading disability require additional research.

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