Attention Mechanisms Mediate the Syntactic Priming Effect in Auditory Word Identification*

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The effect of syntactic priming and the involvement of attention in that process was investigated testing identification of spoken Hebrew words presented in sentences. Target words were masked by white noise and were either congruent or incongruent with the syntactic structure of the sentence. In comparison to a neutral condition, the identification of congruent targets was facilitated and identification of incongruent targets was inhibited, equally. When congruent and incongruent sentences were presented in separate blocks the inhibition effect was attenuated whereas the facilitation was not affected. The introduction of 350 ms silent ISI between the context and the target increased the inhibition without affecting the facilitation. We suggest that the facilitation as well as the inhibition effects of syntactic priming are based on a veiled controlled process of generating expectations. The inhibition is caused by an additional controlled process of re-evaluation of the auditory input triggered by syntactic incoherence. The later process requires additional attentional resources.

There is much evidence in the research literature that syntactic context influences the process of word recognition (Carrello, Lukatela, & Turvey, 1988; Goodman, McClelland, & Gibbs, 1981; Gurjanov, Lukatela, Moskovljevic, & Turvey, 1985; Katz, Boyce, Goldstein, & Lukatela, 1987; Lukatela, Kostic, Feldman, & Turvey, 1983; Lukatela & Moraco, Stojonov, Savic, Katz, & Turvey, 1982; Marslen-Wilson, 1987; Seidenberg, Waters, Sanders, & Langer, 1984; Tanenhaus, Leiman, & Seidenberg, 1979; Tyler & Wessels, 1983; West & Stanovich, 1986; Wright & Garrett, 1984). The common finding is that performance is faster and more accurate if the target words are congruent with the syntactic structure into which they are integrated, than when they are incongruent. This differential performance was found mostly in tasks such as lexical decision and naming (Carrello et al., 1988; Goodman et al., 1981; Katz et al., 1987; Gurjanov et al., 1985; & Lukatela et al., 1982; 1983; Seidenberg et al., 1984; Tanenhaus et al., 1979; West & Stanovich, 1986; Wright & Garrett, 1984). In analogy with the effects of semantic context in similar tasks, the influence of the syntactic context has often been labeled grammatical or syntactic priming. However, because the term priming has been borrowed from the semantic domain, the use of the term "priming" in the syntactic domain needs specific consideration. In the semantic domain, priming refers primarily to a process that influences the identification of a particular lexical entry (Forster, 1981; Seidenberg, 1982). The syntactic context, on the other hand, refers primarily to a particular grammatical form of the word, which may or may not be independently represented in the lexicon. Therefore syntactic priming may affect the identification of a particular grammatical structure, without direct influence on accessing a particular lexical entry. It is in this sense that we will adopt here the term syntactic priming.

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Like other priming phenomena, syntactic priming might also reflect the combined or independent contribution of two basic components: One is the facilitation of processing syntactically congruent targets due to the agreement between the observed grammatical form and that predicted by the syntactic structure. The other is the inhibition of processing incongruent targets either because they do not conform with previous expectation, or because they may require additional processing aimed at resolving the amorphic input, or both. Several studies have interpreted syntactic priming in terms of facilitation (Katz et al., 1987; Lukatela et al., 1982; 1983; Marslen-Wilson, 1987; Tyler & Wessels, 1983), while others have emphasized the inhibitory aspect (Tanenhaus et al., 1979; West & Stanovich, 1986; Carello et al., 1988). However, the question of whether facilitation or inhibition, or both are operative is unsettled because, with the exception of one study in which only inhibition was found (West & Stanovich, 1986), the syntactic priming effect has not been assessed relative to a neutral condition.

The distinction between facilitation and inhibition is important because each of these two processes might reflect a different cognitive mechanism. In particular, current models of priming suggest that facilitation and inhibition differ in their attentional requirements. In normal language communication syntactic congruity is expected. Therefore, it might be expected that syntactically congruent targets are automatically integrated into the sentence structure. In contrast, syntactically incongruent targets cannot be automatically integrated into the syntactic context. Therefore, they may require some re-evaluation of the sensory input as well as of the context. In the semantic domain it is assumed that these activities which inhibit word identification are actively controlled and require the allocation of attention resources (Neely, 1977; Posner & Snyder, 1975).

The role of attention in syntactic priming has been approached indirectly in earlier studies. For example, dealing with inflectional morphology, Katz et al. (1987), suggested a modular syntactic processor whose involvement in word recognition is mandatory and informational encapsulated (Fodor, 1983). This interpretation implies that syntactic priming, particularly as it relates to facilitatory processes, should not require attentional resources. Indeed, several authors have proposed that syntactic priming is automatic (Carello et al., 1988; Gurjanov et al., 1985; Lukatela et al., 1982; See also Seidenberg et al., 1984)). Note, however, that in the studies just cited, the automaticity of the syntactic priming effect was suggested primarily by inflectional processing in pairs of words presented in the highly-inflected Serbo-Croatian language. Testing English-speaking subjects with word-pairs materials, Goodman et al. (1981) found evidence that syntactic priming may be strategy-controlled and modulated by attention. A role for attention in syntactic priming can be inferred indirectly from the assumption that attention is involved primarily during lexical (or post-lexical) processes which are involved in lexical decision more than in naming. Indeed, several studies using single-word context in English (Seidenberg et al., 1984) as well as in Serbo-Croatian (Carello et al., 1988) reported that syntactic priming in naming, was significantly smaller than in lexical decision or inexistent. In addition, using sentential context West and Stanovich (1986) found significant inhibition for incongruent targets without facilitation of congruent targets.

The involvement of attention may be especially conspicuous in the case of incongruent targets, when re-evaluation of the target/sentence relationship, although possibly unavoidable, necessarily requires attentional resources. Such an interpretation of the syntactic priming effect was suggested by Tanenhaus et al. (1979). Examining the process of selecting the contextually appropriate readings of noun-verb ambiguities in sentences, these authors suggested that the syntactic selection process is characterized by veiled controlled mechanism which makes use of context to suppress the inappropriate meaning (see Shiffrin & Snyder, 1977). Applied to syntactic priming, Tanenhaus et al. (1979), suggest that the inhibition of incongruent targets is caused by a controlled, yet unavoidable (therefore “veiled”) process of matching the incongruent sensory input with the expected syntactic structure.

To summarize, the present evidence for a role of attention in syntactic processing is not conclusive. Indeed, most authors suggest that the application of syntactic rules is mandatory and does not require much attention. However, the empirical basis for this conclusion is weak. First, attention was not directly manipulated in any of those studies. Second, the conclusions were based mostly on studies of syntactic priming by single word context. Finally, the absence of neutral conditions in most studies prevents any distinction between the facilitatory and inhibitory
components of the syntactic priming effect. The present study is a systematic investigation of the syntactic priming effect in spoken sentences. We sought to determine the relative contribution of facilitatory and inhibitory mechanisms to syntactic priming and to examine the attention requirements of each of these mechanisms.

Methodological Considerations

In the present study, we manipulated the Hebrew agreement rule between subject and predicate regarding gender and number, and a morpho-syntactic rule that involves the decomposition of the conjunctive form of pronoun-plus-preposition. These rules were chosen for two reasons. First, we aimed at isolating the influence of the syntactic context from the influence of the semantic context. Both agreement between subject and predicate, and the morpho-syntactic rule that we employed are simple and essential in Hebrew grammar. The essential role of an agreement rule in Hebrew is to specify the syntactic relation between the constituents of a sentence, and has no effect on the semantic information. For example: The predicate agrees with the subject in person, gender and number but, because the specification of the gender and number is already available in the subject, violation of one or more of these types of agreement does not affect the meaning of the sentence. Moreover, because the agreement rule is at the level of inflectional morphology, violation of it does not cause changes in word class (changes, that may have semantic implications, Carello, 1988).

Second, the particular agreement rule that we chose operates between sentential elements, like the subject and the predicate, and not at the phrase level as, for example, the agreement between subject and attribute. Therefore, we were not constrained to present the subject and the predicate in succession, thus emphasizing the sentence rather than the phrase level. Because of the minimal involvement of semantic factors, and the possibility to deal with syntactic rules beyond the phrase level, we believed the rules that we used, were appropriate for exploring syntactic priming effect. In addition it should be emphasized that none of the targets used represented a high cloze of the sentence. Therefore, subjects could not simply predict the target and use semantically-induced word-guessing strategy.

Most of the previous studies of the effect of syntactic context (with the exception of Katz et al., 1987; Marslen-Wilson, 1987 and Tyler & Wessels, 1983) used visually presented stimuli. In the present study, we have examined syntactic priming in speech perception rather than reading because speech is more basic than reading in human language and is perhaps less affected by learned strategies.

Previous studies of semantic or associative priming in the visual modality suggested that the degradation of stimulus intelligibility magnifies the effect of contextual influence on word recognition (Becker & Killion, 1977; Meyer, Schvaneveldt, & Ruddy, 1975; Neely, 1991; Stanovich & West, 1983). Therefore, in attempt to focus our investigation on the nature of the syntactic context effect, our basic task required the identification of target words masked by white noise.

EXPERIMENT 1

The purpose of the present experiment was to assess the relative contribution of facilitatory and inhibitory processes to syntactic priming. In a previous study (Bentin, Deutsch, & Liberman, 1990) we observed a large syntactic context effect on the identification of words masked white noise. The identification of target words was four times as accurate when they were syntactically congruent than when they were incongruent with the context sentence. In the present experiment we replicated and extended our former study by adding a neutral condition. The addition of the neutral condition enabled us to disentangle the facilitatory effect of syntactic congruity and the inhibitory effect of syntactic incongruity that were confounded in our previous study (see also West & Stanovich, 1986, Neely, 1976).

The neutral context that we used with all targets was “the next word is...,” as was originally suggested by McClelland and O’Regan (1981) and applied to an investigation of syntactic priming in reading by West and Stanovich (1986). We chose this neutral condition because, it probably involves no syntactic bias toward specific syntactic structures or word classes (West & Stanovich, 1986).

We assumed that the facilitatory and inhibitory components which may contribute to the syntactic priming effect, should be differentially reflected in comparison to the neutral condition. Facilitation was measured by the difference between the percentage of correct target identification in the congruent and the neutral context, whereas the difference between the correct identification in the neutral and the incongruent context conditions was the measure of inhibition.
Method

Subjects. The subjects were 30 undergraduate students who participated in the experiment for course credit or for payment. They were all native speakers of Hebrew, without any known hearing problems.

Test Materials. The auditory identification test included 44 target words. Targets were the last word in a three- or four-word sentence. Each target was embedded in three different sentences, which defined three different conditions of the syntactic context: 1. "Congruent"—the target word fitted the syntactic structure of the sentence. 2. "Incongruent"—the target word did not fit the syntactic structure of the sentence, that is, caused a violation of a syntactic rule. 3. A "Neutral" condition as explained above.

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

Type 1: Violation of the agreement in gender between subject and predicate. 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 vice-versa (in the other 6 sentences), that is, a feminine subject presented with a masculine predicate.

Type 2: Violation of the agreement in number between subject and predicate. Twelve target words (other than in Type 1) were repeated across the three conditions forming 36 sentences. In the incongruent condition a singular predicate followed a subject in a plural form (in 6 of the sentences) or vice-versa (in the other 6 sentences).

Type 3: Violation of the agreement in both gender and number between subject and predicate. This category also included 12 target words (different than in type 1 and 2) and repeated across conditions to form 36 sentences. In the incongruent condition the compatibility of gender and number between the subject and predicate was altered in each sentence. For example: A masculine singular subject was followed by a feminine plural predicate. (We constructed all the 4 possible combinations, 3 sentences for each).

Type 4: Decomposition of the conjunctive form of pronoun and preposition. This category included 8 target pronouns, each of which was combined with a different preposition, forming 24 sentences. In Hebrew, the pronoun and the preposition 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 were formed of three words in the following order: Subject, attribute and predicate. The masked target was always the predicate. The predicate was either a verb or an adjective (participle form in nominal clauses). Type 4 sentences were formed of a subject, a predicate and a verbal completion (the conjunctive pronoun). The masked targets were the verbal completions in their normal conjunctive form (congruent and neutral conditions) or decomposed (the incongruent condition).

The sentences were organized in 3 lists of 60 sentences, 20 in each congruity condition. Each group of 20 included 12 manipulations of the agreement rule (Types 1 to 3) and 8 manipulations of the morpho-syntactic rule (Type 4). The targets in 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 the pronouns is limited, 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 the repetition of priming as much as possible a different context was used in each condition. Moreover, the contexts were counterbalanced across the three lists.

All the sentences were recorded on tape by a female who was a professional speaker of Hebrew. 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. The white noise was digitally added to the target, starting slightly before onset with a signal-to-noise ratio of 1:3.4. This ratio was determined on the basis of pilot tests, so that correct target identification level was about 50%.

The sentences in each list were randomized and output to tape at a 2 second inter-sentence interval at a comfortable loudness.

Procedure. Subjects were randomly assigned to one of the three stimuli lists. Each subject was tested individually. The experimenter and the subject listened to the stimuli simultaneously, both using earphones (HD-420).

The subject was instructed to listen to the sentence and to repeat the last (masked) word
during the silence interval at the end of each sentence. No time constraints were imposed; in a few instances when the subject's response was delayed relative to the inter-sentence interval, the experimenter stopped the tape-recorder. The responses were recorded manually by the experimenter.

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 (accurate identification of the inflected word) or error. The errors made in the incongruent condition were further categorized into four types: 1) “Self correction” (a correction of the syntactic violation using the same root); 2) “Random completion” (a totally different root forming a semantically and syntactically congruent sentence); 3) “Nonsense” (any completion which was semantically meaningless or syntactically incongruent, including nonwords); 4) “No response” (“I don't know”). In the neutral and congruent conditions only the last three categories were possible.

Because in our previous study (Bentin et al., 1990) the congruity effect on the four types of syntactic rules was similar, we collapsed our analysis over the sentence types.

Across subjects or stimuli, the percentages of correct identification were 74.8%, 50.2%, and 27.3% for the congruent, neutral, and incongruent syntactic conditions, respectively (Figure 1).

The statistical significance of the congruity effect was examined by one-factor analyses for subjects (F1) and stimuli (F2). The main effect of syntactic context was significant \( F_1(2,58)=110.5, \ MSe=153, \ p<.0001 \) and \( F_2(2,118)=49.8, \ MSe=661, \ p<.0001 \).

The distribution of errors is presented in Table 1. Statistical evaluation of the distributions (ANOVA followed by Tukey-A post-hoc comparison) showed that within each congruity condition, all differences were reliable at the \( p<.05 \) level.

![Figure 1. The percentage of correctly identified congruent, neutral and incongruent targets.](image-url)
### Table 1. Mean percentage of errors (SEM) of each type in each congruity condition.

<table>
<thead>
<tr>
<th>CONGRUITY CONDITION</th>
<th>SELF CORRECTION</th>
<th>RANDOM COMPLETION</th>
<th>NONSENSE</th>
<th>NO RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONGRUENT</td>
<td>-</td>
<td>62.0% (4.1)</td>
<td>2.9% (1.9)</td>
<td>33.4% (4.3)</td>
</tr>
<tr>
<td>NEUTRAL</td>
<td>-</td>
<td>54.6% (4.0)</td>
<td>0.5% (0.5)</td>
<td>42.8% (3.9)</td>
</tr>
<tr>
<td>INCONGRUENT</td>
<td>12.1% (1.2)</td>
<td>19.3% (2.1)</td>
<td>3.5% (1.2)</td>
<td>62.2% (3.2)</td>
</tr>
</tbody>
</table>

### Discussion

The results of Experiment 1 demonstrated that the syntactic priming effect, as it is revealed in our auditory word identification paradigm, consists of two components, facilitation and inhibition. The relative contribution of each component to the global context effect is approximately equal: Congruent context improved identification of white-noise masked words by about 23% while incongruous context reduced identification by the same amount, from a neutral baseline of about 50% correct.

Before discussing these results any further, a trivial interpretation should be considered. Because only verbatim accurate responses were considered correct, it could have been the case that the pattern of facilitation and inhibition simply reflected that, facing uncertainty, subjects identified the word-root and completed the inflection using an intelligent-guessing strategy. Along with this interpretation, the difference in the percentage of correct identification of inflected targets in the congruent and incongruent conditions, would reflect the correspondence or disagreement between the subject's intuition about how the identified root should have been inflected and what was actually presented. Such a strategy, however, implies that a) targets' roots were identified better than their inflected forms and b) that in the incongruent condition there would have been a high percentage of Type 1 errors (i.e., errors reflecting the inadequate use of the correct syntactic form). The first implication could not hold in the present experiment because, as mentioned in the methodological considerations, there was no strong semantic constrain which could have facilitated an independent identification of roots on semantic basis. The second was rejected by the analysis of errors.

As revealed in Table 1, the percentage of self correction in the incongruent condition was very small, by far smaller than the percentage of no responses. Note also that the percentage of random completions (i.e., substituting the target with an incorrect but semantically and syntactically congruent word) was also relatively low in this condition. This pattern does not support the "intelligent-guessing strategy" while suggesting that the low percentage of correct identification in this condition reflected a general process of inhibition caused by syntactic incongruence.

Additional support to our interpretation is provided by comparing the pattern of random completions and no responses in the incongruent condition with those observed in the neutral and congruent conditions. It is evident that the tendency to substitute a different but logical word for the misidentified target (random completions) is higher in the neutral than in the incongruent condition and even higher in the congruent condition. On the other hand, the tendency to say "I don't know" (no response) is lower in the congruent and neutral conditions than in the incongruent condition. This tendency can be explained assuming that syntactic incongruence inhibited identification and enhanced uncertainty. The absence of syntactic incongruence in the congruent condition eliminated inhibition, and reduced uncertainty even when targets were misidentified. As a result, the percentage of random completions in the congruent condition was twice as large as the percentage of no responses.

The present results diverge from those reported by West and Stanovich (1986) who, using a similar neutral condition, found only inhibition. However, in addition to differences in task (West and Stanovich used a visual lexical decision task), the two studies differ in several other meaningful ways and, therefore, cannot be straightforwardly compared. First, we presented auditory masked-words whereas West and Stanovich (1986) used visually presented unobstructed stimuli. Although we have no evidence for a differential effect of
context in speech perception and reading, we cannot ignore this possibility. Moreover empirical findings on associative and semantic priming in reading, suggest that context effects are larger for degraded than for undegraded words (Stanovich & West, 1983). It is also possible that the divergence between the two studies is partly accounted for by differences between the material used in the two studies. In contrast to the semantically anomalous sentences used by West & Stanovich (1986), our sentences were always semantically sound.

Since we have no direct evidence about the influence of the above-mentioned factors on context effects and how they interact with syntactic priming, our ability to draw general conclusions is limited. Therefore inferences regarding the existence of facilitatory and inhibitory components to syntactic priming, and especially the finding of the equal contribution of the two components, may be restricted to the specific condition of the present demonstration. Despite this limitation, we can continue our general course and investigate the involvement of attention mechanisms with each of these two components.

**EXPERIMENT 2**

In the present experiment we examined the influence of presenting congruent and incongruent sentences in separate or mixed blocks on the inhibitory and facilitatory components of the syntactic priming effect.

Studies of semantic priming in visual word perception generally showed that lowering the proportion of related targets in the list reduced the amount of inhibition (Fischler & Bloom, 1979; Stanovich & West, 1981; but see Stanovich & West, 1983, Experiment 4). Within the framework of the two-process theory of Posner & Snyder (1975), most authors have assumed that the influence of the ratio of related and unrelated targets is mediated by attention mechanisms (e.g., Fischler & Bloom, 1985; Stanovich & West, 1983; Tweedy, Lapinski, & Schvaneveldt, 1977). Specifically it has been assumed that lowering the proportion of related targets discourages word perception strategies based on context-related expectations.

A similar manipulation was used to compare semantic vs. syntactic priming effects in visual word perception (Goodman et al., 1981 and Seidenberg et al., 1984). These studies suggested that the syntactic priming effect is mediated primarily by post-lexical, strategic mechanisms. In these studies, however, no attempt was made to examine the effect of separately manipulating strategies design to operate selectively on the facilitatory and inhibitory components of the syntactic priming effect. We applied the blocked vs. mixed presentation technique to disentangle the effect of attention mechanisms on each of these two components.

The blocked condition is an extreme case of manipulating the ratio between incongruent and congruent sentences, where the proportion of incongruent stimuli is either 1:0 or 0:1. This proportion was contrasted with a 1:1 ratio of incongruent and congruent stimuli used in the mixed condition. Therefore, the comparison between the blocked and mixed modes of presentation should maximize the effect of attentional processes that may mediate syntactic priming. A differential effect of the presentation mode on the percentage of correctly identified words in congruent and incongruent sentences should suggest that attention mechanisms are differentially involved in the mediation of the facilitatory and inhibitory components of the syntactic priming effect. Particularly, the involvement of attention mechanisms should reduce interference in the blocked presentation, leading to a higher percentage of identification of incongruent targets. On the other hand, the absence of an interaction between the modes of presentation and the congruity of the sentence should indicate that attention mediates the two components to a similar extent.

**Method**

*Subjects.* The subjects were 60 undergraduate students who did not take part in the first experiment. They participated in this experiment for course credit or for payment. They were all native speakers of Hebrew, without any known hearing problems.

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

A target appeared only once in each list (with the exception of sentences of Type 4, see above). Across lists, each target appeared equally in the congruent and incongruent conditions.
Procedure. Different 30 subjects were tested with each presentation mode. Subjects were randomly assigned to one of the lists, so that each subject was exposed equally to syntactically congruous and incongruous sentences.

The mixed presentation followed the same experimental procedures as in Experiment 1. The experimental list was preceded by a mixed list of 12 practice sentences (6 congruent and 6 incongruent).

In the blocked presentation, 15 subjects began with the congruent block, and 15 with the incongruent block. Each block was preceded by 8 practice sentences in the respective congruity condition. No special instruction were given before the incongruous block, but the “peculiar” structure of the sentences was not denied in reply to queries raised by the subjects following practice with incongruous sentences (as was true for the mixed condition as well).

Results

The percentage of correct identification of targets was averaged for each subject and target in each congruity condition. Separate means were computed for each presentation group. The percentages of correct identification of syntactically congruent targets was almost identical in the blocked and the mixed presentation groups. In contrast, more incongruent targets were identified in blocked than in mixed presentation (Figure 2).

The statistical significance of the observed differences was tested by two-factor analyses for subjects (F1) and for stimuli (F2). The factors were Congruity condition (congruent, incongruent) and Mode of presentation (mixed, blocked). Both main effects were significant \[ F(1,58)=486.7, MSe=123, p<.0001, \] \[ F(1,59)=128.7, MSe=937.3, p<.0001, \] and \[ F(1,58)=18.1, MSe=192, p<.0001, \] \[ F(1,59)=21.6, MSe=296, p<.0001, \] for the Congruity and Mode of presentation effects, respectively. The most interesting result, however, was the significant interaction between the two factors, revealing that the presenting incongruent and incongruent sentences in separate blocks improved the identification of incongruent targets, but had no effect on congruent targets \[ F(1,58)=25.6, MSe=123 p<.0001, \] \[ F(2,1,59)=21.9, MSe=256, p<.0001. \]

Errors in Experiment 2 were categorized and analyzed using the same types as elaborated in Experiment 1 (Table 2).

![Figure 2](https://example.com/figure2.png)

*Figure 2.* The percentage of correctly identified congruent and incongruent targets in the mixed and blocked presentation conditions.
Table 2. Mean percentage of errors (SEm) of each type in each congruity condition in the mixed and blocked presentation modes.

<table>
<thead>
<tr>
<th>CONGRUITY CONDITION</th>
<th>ERROR TYPE</th>
<th>SELF CORRECTION</th>
<th>RANDOM COMPLETION</th>
<th>NONSENSE</th>
<th>NO RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONGRUENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIXED</td>
<td></td>
<td></td>
<td>63.7% (5.7)</td>
<td>0.4% (0.4)</td>
<td>33.9%</td>
</tr>
<tr>
<td>BLOCKED</td>
<td></td>
<td></td>
<td>56.6% (4.5)</td>
<td>2.9% (1.4)</td>
<td>(5.2)</td>
</tr>
<tr>
<td>MIXED</td>
<td></td>
<td>17.5% (1.8)</td>
<td>22.2% (2.5)</td>
<td>4.0% (1.2)</td>
<td>56.4%</td>
</tr>
<tr>
<td>INCONGRUENT</td>
<td>BLOCKED</td>
<td></td>
<td>30.2% (3.6)</td>
<td>11.8% (2.1)</td>
<td>43.4%</td>
</tr>
</tbody>
</table>

In the congruent condition the distribution of errors was similar for mixed and blocked presentation modes (the interaction was not significant F(2,116)<1.0). Errors were unevenly distributed among types [F(2,116)=70.9 MSE=729, p<0.001]. The pattern of this distribution was similar to Experiment 1: There were significantly more random completion than no response errors (p<.01). In the incongruent condition, on the other hand, there was a significant interaction between the distribution of errors among the types and the mode of presentation [F(3,174)=5.2, MSE=1532, p<.01]. Post hoc analysis (Tukey-A) revealed that, although significantly less correction than no response errors were made in both presentation modes (p<.01), the difference was larger in the mixed than in the blocked presentation.

Discussion

The present results revealed that manipulating the proportion of congruent and incongruent sentences in the experimental list affects only the inhibitory component of the syntactic priming effect. In comparison to a mixed presentation (1:1 proportion), the presentation of incongruent and congruent sentences in separate blocks reduced the amount of inhibition without altering the amount of facilitation. Assuming that this manipulation influences primarily strategic components, the present results suggest that syntactic priming includes attention-mediated mechanisms that are reflected more in its inhibitory than its facilitatory effects.

An attention mechanism that might have been affected by our manipulation is the strategic process of generating context-based expectations about the target's syntactic form. The application of this strategy should probably be encouraged by a high proportion of congruent sentences in a mixed list and discouraged by frequent syntactic incongruence. Hence, the tendency to generate expectations (leading to less identification of incongruent targets) should decrease in parallel to the reduction of the percentage of congruent sentences in the list. Informal study of the percentage of correctly identified incongruent targets across Experiments 1 and 2, conformed to this prediction: Incongruent targets were identified least (14.3%) in the mixed condition of Experiment 2 where 50% of the sentences were congruent, more in Experiment 1 (27.3%), where, due to the neutral condition only 33% of the sentences were congruent, and most in the blocked condition of Experiment 2 (35.3), where there were no congruent sentences. In contrast, the proportion of congruent sentences did not affect the percentage of correctly identified congruous words significantly (69.3%, 74.8%, 69.8% in the mixed presentation of Experiment 2, Experiment 1, and the congruent block of Experiment 2, respectively). This suggests that the facilitatory component of the syntactic priming effect is less sensitive to strategic mediated processes.

Additional support to our interpretation is provided by the distribution of errors among the
different types. A comparison between the mixed and blocked presentation modes revealed that the percentage of random and nonsense errors (those that reflected less concern about the priming sentence) was higher in the blocked than in the mixed presentation modes, whereas the opposite trend was observed for no response and self correction errors (that reflect the influence of the priming effect induced by the syntactic structure of the sentence). Hence, it appears the syntactic context influence on word identification was reduced in the blocked relatively to the mixed presentation mode. The singularity of this interaction to the incongruent condition is in agreement to our hypothesis that the generation of expectations is one of the factors involved in producing the syntactic priming effect on word identification.

It is worth noting that the present results diverge from the results of Stanovich & West (1983), who found that the pattern of contextual (semantic) effects was not altered by increasing the proportion of congruent targets. This divergence may either suggest a fundamental difference between the involvement of attention in semantic and syntactic context effects, or that our manipulation of blocking congruity condition was more powerful than changing proportion of congruent and incongruent targets within a mixed block.

In Experiment 3 we used a different method to manipulate the subjects’ tendency to generate expectations as a strategy of word identification, in an attempt to corroborate the differential involvement of attention with the facilitatory and inhibitory components of the syntactic priming effect.

**EXPERIMENT 3**

In contrast to Experiment 2, where our manipulation was meant to discourage the generation of expectations for specific syntactic forms, in the present experiment we sought to encourage this strategy.

Studies of semantic priming revealed that the length of the inter-stimulus interval (ISI) [or the stimulus onset asynchrony (SOA)] between the context and the target, influences the relative weight of the attention-based component of the priming effect with single-word (Antos, 1979; Neely, 1977) and sentence contexts (Stanovich & West, 1979). Different ISIs were used in different studies and the general consensus among authors is that, within a limited range of times, the tendency to use context-based expectations increases with longer ISIs. Possibly, at longer ISIs the subject has more time to process the context and generate such expectations.

The influence of the ISI between context and target on syntactic context effects is not as clear. For example, using a lexical decision task with printed Serbo-Croatian stimulus-pairs, Lukatela et al., (1982) found significantly larger syntactic priming effects when the SOA was 800 ms than when it was 300 ms. However, with auditory presented stimuli (in Serbo-Croatian), Katz et al. (1987) did not find a reliable interaction between the length of the ISI (0 vs. 800 ms) and the magnitude of the syntactic priming on lexical decision. Despite the apparent divergent results, both groups of authors suggested that the syntactic context effect reflects the operation of an autonomous automatic module rather than an attention mediated mechanism. However, as Katz et al. (1987) pointed out, it is possible that this conclusion holds only for the particular case of inflectional morphology characteristic to Serbo-Croatian. Indeed, indirect evidence for non-automatic aspects of syntactic priming has been found in English (Tanenhaus, et al., 1979). Using a naming task, these authors reported that at 0 ms SOA, subjects were insensitive to the specific syntactic (and semantic) form of the prime, whereas at 200 ms, the targets were facilitated only by appropriate forms. Concluding these results Tanenhaus et al. (1979) suggested that at longer SOAs, syntactically inappropriate forms are inhibited by veiled controlled process (i.e., Shiffrin & Schneider, 1977). The time course of the controlled process, however, was obscured by the finding that at 600 ms SOA, it’s effect was not as evident as at 200 ms SOA. Together, the previous studies cannot unequivocally support or reject the existence of attention-mediated components of the syntactic priming effect. An additional step towards the clarification of the role of attention in syntactic priming can be made by distinguishing between effect of ISI manipulation on the inhibitory and facilitatory components of syntactic priming.

In the present experiment we used two ISIs. One was set at the normal speech rate, and the other was 350 ms. On the basis of the results of Experiment 2, we anticipated that the ISI manipulation should affect primarily the inhibitory component. More specifically we predicted that the at the longer ISI, syntactic incongruity should have a more deleterious effect on the identification of targets than at normal speech rate whereas the facilitatory effect will not change.
Method

Subjects. Sixty subjects participated in this experiment. Thirty were the mixed presentation group from Experiment 2. The other 30 were naive undergraduates who did not take part in the previous experiments, and participated in this experiment for course credit or for payment. All the subjects were native speakers of Hebrew, without any known hearing problems.

Stimuli and Design. The stimuli lists were those used in the mixed presentation condition of Experiment 2. The only alteration was the introduction of a silence period of 350 ms between the offset of the last unmasked word in the context and the onset of the masked target. The 30 naive subjects were tested with these lists. Their performance was compared to the performance of the mixed presentation group in Experiment 2, who heard the same lists at a normal speech rate. Each subject was exposed equally to syntactically congruous and incongruous sentences. Thus, the subject analysis was a mixed model ANOVA. The ISI effect was tested between groups and the syntactic congruity effect within subjects.

Across subjects, each target appeared equally in the congruent or incongruent conditions, and at each ISI. Thus the stimulus analysis was completely within stimulus.

Procedure. The experimental procedure of the present experiment in which we tested only the longer ISI condition was the same as that followed in the mixed presentation condition of Experiment 2. The test list was preceded by 12 practice sentences that included the silence interval.

Except of being informed about the brief silence period preceding the masked target word, the subjects were instructed identically as in the mixed presentation condition of Experiment 2.

Results

The percentage of correct identification of targets was averaged for each subject and each target in each congruity condition. These results were compared to the percentage of correct identification of congruent and incongruent targets at normal speech rate in the mixed presentation condition of Experiment 2 (Figure 3). Congruent targets were identified almost identically in the two ISI conditions. In contrast, the percentage of incongruent targets identification was smaller in the 350 ms ISI condition than at normal speech rate.

The statistical significance of the observed differences was tested by two-factor analyses (mixed model for subjects (F1) and repeated measures for stimuli (F2)). Both the congruity and ISI main effects were reliable (F1(1,58)=848.1, Mse=123, p<.0001, F2(1,59)=232.7, Mse=880, p<.0001, for the congruity effect and F1(1,58)= 5.2, Mse=159, P<.0264, F2(1,59)=4.4, Mse=268, p<.0411 for the ISI effect). The most important result, however, was the reliable interaction between the two factors, revealing that the 350 ms silence interval reduced the identification of incongruent targets, but had no effect on congruent targets (F1(1,58)=4.1, Mse=123 p<.0488, F2(1,59)=4.4, Mse=211, p<.0411).

The distribution of errors in the different ISI conditions is presented in Table 3.
Table 3. Mean percentage of errors (SEm) of each type in each congruity condition with normal speech rate and with 350 ms ISI between context and target.

<table>
<thead>
<tr>
<th>CONGRUITY CONDITION</th>
<th>SELF CORRECTION</th>
<th>RANDOM COMPLETION</th>
<th>NONSENSE RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONGRUENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NORMAL</td>
<td>-</td>
<td>63.7% (5.7)</td>
<td>0.4% (0.4)</td>
</tr>
<tr>
<td>350 ms</td>
<td>-</td>
<td>53.1% (5.2)</td>
<td>1.8% (1.2)</td>
</tr>
<tr>
<td>INCONGRUENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NORMAL</td>
<td>17.5% (1.8)</td>
<td>22.2% (2.5)</td>
<td>4.0% (1.2)</td>
</tr>
<tr>
<td>350 ms</td>
<td>15.2% (1.5)</td>
<td>17.9% (2.5)</td>
<td>1.9% (0.9)</td>
</tr>
</tbody>
</table>

The ISI manipulation influenced the distribution of errors in the incongruent condition \( [F(3, 174) = 2.72, \text{MSe} = 209, p < .05] \), but not in the congruent condition \( [F(2, 116) = 2.15, \text{MSe} = 833, p > .12] \). Across conditions the distribution of errors was similar to that observed in the former two experiments and significant \( [F(3, 174) = 179.3, \text{MSe} = 209, p < 0.0001] \) and \( [F(2, 116) = 61.2, \text{MSe} = 833, p < 0.0001] \), in the incongruent and congruent conditions, respectively. Post hoc analysis (Tukey-A) of the interaction revealed that, while no response type errors were more abundant in the 350 ms ISI condition than with normal speech rate, the percentage of all other three error types was reduced in the latter than in the former condition.

**Discussion**

Increasing the ISI from a normal speech rate to 350 ms between the context phrases and the targets, reduced the percentage of correct identification of incongruent targets but had no influence on the identification of congruent targets. These results confirmed our previous observations that the facilitatory and inhibitory components of the syntactic priming effect are differentially sensitive to the manipulation of attention-based strategies of word identification.

In Experiments 3, as well as in Experiment 2, our manipulation affected only the inhibitory priming component albeit, in each experiment in an opposite direction. Therefore, these results suggest that in both experiments we manipulated the same attention-mediated priming process. Assuming that this process involves the generation of context-based expectations, the results of both experiments support our distinction between an inhibitory component of syntactic priming, which reflects an attentional process of generating expectations, and a facilitatory component, that is less reliant on attentional mediation.

The distribution of errors is in complete agreement with the above interpretation. Again, the ISI manipulation influenced the distribution of errors only in the incongruent condition. However, the trend of this interaction was opposite to that found in Experiment 2. Whereas discouraging the generation of context-based expectations in the blocked, relatively to the mixed presentation mode increased the percentage of random and nonsense error-types, encouraging such a strategy by introducing a longer ISI lead to a decrease of such errors while increasing the percentage of no response errors.

Despite the correspondence between the results of the two experiments and the coherence of the emerging picture, the ISI manipulation should be considered with caution. Previous studies of the time course of sentence-context effects on word perception are not conclusive. For example, Fischler and Bloom (1979; 1980) presented written sentences word by word, manipulating the presentation rate. Contrary to our results, they found almost no facilitation of lexical decision for expected target words while the inhibition of incongruous targets was evident at all presentation rates. Their conclusion was that the effect of the sentence semantic context on word recognition is limited to an inhibitory postlexical process. This inhibition is probably related to the sentences' semantic incongruity and is not sensitive to the manipulation of ISI. A closer look at their data, however, reveals that, in agreement to our results, the magnitude of the inhibition effect on lexical decision (speed and accuracy), was twice as large at the slower rates (4 and 12 words per second), than at the higher presentation rates (20 and 28 words per second).
One problem in analyzing the ISI effect is that different studies manipulated different time intervals. It is possible that the ISI influence is not monotonic, and that it differs with factors such as task, presentation modality, and the linguistic context that it is investigated. It is, therefore, possible that relatively small differences in the particular ISIs compared in different studies, account for the variation of the results. The results of two pilot experiments that preceded the present study support this possibility. In these pilot experiments we explored the effect of 500 and 1000 ms ISI compared to normal speech rate. The effect of syntactic priming at these ISIs were not reliably different than at normal speech rate. An interesting trend emerged however across the ISIs. At 1000 ms, the increase in the inhibition was accompanied by a decrease in the facilitation. Relative to 1000 ms, 500 ms ISI caused a smaller decrease on the magnitude of the facilitation and an even bigger increase in the inhibition effect. Finally as reported in the present experiment, 350 ms ISI had no effect on the magnitude of the facilitatory component while significantly increasing the magnitude of the inhibition. Thus, it appears that the interaction between the ISI and the syntactic context effect is limited to a specific range. This limit might also account for the absence of a difference between the syntactic congruity effect at 0 and at 800 ms ISI in Katz et al., (1987) study. Despite the caution, however, the present results suggest that ISI manipulation, when carefully applied, may reveal interesting aspects of the context effects.

The inherent problems of ISI manipulation are not essential, however, to our conclusions regarding the involvement of attention in mediating syntactic priming effects. Therefore, we may resume our discussion of the relation between attention mechanisms and the syntactic context effects as revealed in the present study.

GENERAL DISCUSSION

In the present study we examined the inhibitory and the facilitatory aspects of syntactic priming as it is reflected in the identification of auditory masked targets that were presented as last words in clearly displayed sentences. In Experiment 1, we found evidence for both components. In addition, the data indicated that, at least for the present experimental conditions, facilitation and inhibition contribute equally to the syntactic priming effect. In Experiments 2 and 3 we found that manipulation of attention-related factors affected the magnitude of the inhibition but had no effect on facilitation. The presentation of congruent and incongruent sentences in separate blocks attenuated inhibition relative to a mixed condition. On the other hand, Experiment 3 suggests that the insertion of 350 ms of silence between the target and the context amplified the inhibition relative to normal speech rate.

Across experiments, the scarcity of self-corrections and the abundance of no-response errors relatively to random completions in the incongruent condition, on one hand, and the increased percentage of random completion errors at the expense of no-response errors in the congruent condition on the other hand, discarded the possibility that the variation in the percentage of correct identification between the different congruency conditions simply reflected a strategy of intelligent guessing on the basis of partially identified information. Taken together our results indicate that the syntactic context effects observed in the present study were probably related to a post-lexical syntactic analysis of the input, whose possible nature is discussed below.

In accord with the commonly-held account for attention-mediated factors in semantic priming (Fischler, 1977; Fischler & Bloom, 1979; Neely, 1977; Stanovich & West, 1981, 1983), we suggest that our manipulations influenced an attention-based mechanism that mediates the generation of expectations. However, the concept of generating expectations in the syntactic domain can not simply be an extension of the models suggested to account for attention mediation in semantic priming.

When analyzing discourse the subject naturally expects that the input will be coherent with his/her existent linguistic knowledge (deGroot, Thomassen & Hudson, 1982; Fischler & Bloom, 1980). We assume that this strategy is applied in the syntactic as well as in the semantic domain. Specifically, we assume that when a particular syntactic structure is alluded by the context, the perceiver expects grammatical forms that can be integrated into that structure. The observed inhibition of incongruent targets in the present study might have been caused by the violation of those expectations. Possibly, incompatible input induces a second pass analysis of the target and/or context. This additional process may delay or, when the target is degraded, may suppress its identification.

In contrast to previous studies of syntactic priming (e.g., West & Stanovich, 1986), we found that the identification of congruent targets was
facilitated relative to a neutral condition. Regardless of the particular reasons for this discrepancy (that have been discussed in Experiment 1), we may speculate on possible sources of this facilitation. In the semantic priming domain facilitation is assumed to reflect two different processes: One is an automatic spreading of activation among nodes related in the semantic network (Collins & Loftus, 1975). The second is the confirmation of an explicit prediction regarding target identity (Becker, 1980). Because the existence of a syntactical organized network is supported neither by empirical evidence nor by theoretical considerations, the mechanism of spreading activation is an improbable source of facilitation in syntactic priming. Therefore the facilitation of syntactically congruent targets is better explained by a process that relates on ad hoc generated syntactic structures. The mechanism of explicit prediction suggested by Becker (1980) cannot be directly applied to syntactic priming because, in our study, the identity of the target could not be predicted by the context (for similar claims see also Oden & Spira, 1983; Tanenhaus et al., 1979; Tyler & Wessels, 1983). Therefore, we are lead to believe that the mechanism of facilitation by syntactic priming is based on the same form of expectations as postulated to account for the inhibition of incongruent targets. Thus, we propose that the same expectations may be used by different mechanisms to exert both facilitation and inhibition on the identification of the target. The first, which was postulated above, causes the inhibition of incongruent targets. The second, may facilitate the identification of congruent targets either because expected structures may assist the integration of the sentence, or because they reduce the amount of sensory input needed for the identification of a word.

The above proposal that, in syntactic priming, both the facilitation and the inhibition are based on a similar process of generating expectations, apparently contradicts with the results of Experiments 2 and 3 that showed that manipulating the tendency to generate expectations affects only the inhibition. This contradiction can be resolved assuming that the generation of expectations at the sentence level is motivated by the natural assumption of syntactic coherence (similar claims related to the processing of sentences at the semantic level were made deGroot (1982) and by Fischler & Bloom, 1980). It is conceivable that the tendency to generate expectations is not under strategic control. This view is compatible with the residual inhibition observed in the incongruent block, which suggests that despite the clear incongruent structure of all sentences, the initial expectations could not be completely avoided. Hence, at the sentence level, the expectations are probably generated by a veiled controlled process which uses only minimal attention resources (Schneider & Shiffrin, 1977). Such a process probably stands at the basis of the facilitatory mechanism of syntactic priming. On the other hand, as discussed above, when the same expectations are violated by incoherent input, attention is mobilized to trigger and control the additional, post-lexical process of re-evaluation, which we suggest that it is the main mechanism of the inhibition. Consequently, strategic changes should influence the magnitude of the inhibition, but have only minimal effect on the facilitation. Indeed, the interaction between the distribution of errors and the presentation procedure found in Experiments 2 and 3 only in the incongruent condition supports this view. Attenuating the tendency for re-evaluation of context-based expectations (in Experiment 2) reduced no-response and self-correction errors and increased the percentage of random and nonsense responses. On the other hand, facilitating the generation of context-based expectations (in Experiment 3) increased subjects' uncertainty as manifested by the increase in the no-response type errors. Should this process influence lexical access rather than post-lexical re-evaluation, the opposite manipulations on subjects' strategies in Experiments 2 and 3 should have had an effect on the overall percentage of correct identification in the incongruent condition but not on the distribution of errors. Our hypothesis that a similar attention mechanism is the basis of both the facilitation and the inhibition of performance in the syntactic priming task, also implies that the allocation of attention, at least in language processing is not an all-or-none phenomenon. Rather, based on data-driven or pre-determined strategies different amounts of attentional resources are directed to the different aspects of language perception processes.

A caveat of the above discussion is that the task used in the present study required the identification of degraded stimuli. Therefore is possible that the magnitude of the syntactic priming was largely dependent upon these conditions. In particular, the inhibition might have been much smaller if the auditory input was clear. The need for the re-evaluation could have been less conspicuous in the absence of auditory
uncertainty. However, we believe that using degraded stimuli we were able to tap mechanisms of top-down processing of syntax that are available to the language speaker.

REFERENCES


FOOTNOTES

*Cognition*, in press.

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Take, for example the sentence “A nice boy eats” which translated into Hebrew would sound “Yeled yafah ochel”. The morphological unit “yeled” (boy) contains information about gender (masculine) and number (singular). The same root with different affixes is used to form the word “Yaldah” (girl) or “Yeled” (boy) change the number. The agreement rule requires that the attributes and predicate will agree with the subject in gender and number. “yafeh” (nice) is a singular masculine form as is “ochel” (eats). The sentence “Yaldah yafah ochel” is a possible syntactic violation of that sentence because the predicate is in
masculine form while both the subject and attribute are in feminine form.

2This particular ISI was chosen on the basis of pilot studies. In the present study we were concerned to demonstrate the ISI effect on the two components of the syntactic priming effect and not to examine its precise time course of the putative controlled component. Therefore we examined different ISIs (1000 ms, 500 ms, and 350 ms), but completely analyzed only the later that had the most conspicuous effect.

3A similar model was proposed within the frame of the cohort theory (Marslen-Wilson, 1980). According to this model the syntactic context may facilitate word identification by limiting the size of an initial cohort to those members which belong to a single form-class category (Tyler & Wessels, 1983).