INTRODUCTION

A theory of parsing must explain how sentences are processed. Specifically, it must explain how a serially presented sentence string is parsed and how constituent attachment in the order of words imparts structure to it. Consequently, this representation is subject to constraints imposed by the serial order of the sentence string and by the constituency structure of the sentence. Constituent attachment constrains possible thematic roles that a constituent can fill. In the example, when clearly is attached to VP (VP), it modifies the verb phrase to the extent that it specifies the manner in which the writing was done (Jackendoff, 1972).

Consider the two parse trees shown in Figure 11.1. These trees consist of the same constituents, but they differ in how the constituents are organized into the tree. In the first case, clearly attaches to the verb phrase node (S), and in the second case, it attaches to the sentence node (S'). Does this have any consequences? Certainly. The point of syntax (VP) is to specify any constituent's thematic role. The thematic role that a constituent is to fill will determine what goes with what in a sentence and the semantic relations holding between them. We refer to this association of structural roles to thematic roles as thematic role assignment. This is in contrast to constituent attachment, which specifies how any constituent is configured with other constituents within a sentence (q). (q) specifies how any constituent is configured with other constituents within a sentence. View multiple-constraint comprehension: a theory of parsing as a theory of how sentences are processed. Specifically, it must explain how a serially presented sentence string is parsed and how constituent attachment in the order of words imparts structure to it. Consequently, this representation is subject to constraints imposed by the serial order of the sentence string and by the constituency structure of the sentence. Constituent attachment constrains possible thematic roles that a constituent can fill. In the example, when clearly is attached to VP (VP), it modifies the verb phrase to the extent that it specifies the manner in which the writing was done (Jackendoff, 1972).

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A termite the place where it attaches onto a parse tree. Thus, if one wanted to attach a parenthetical comment into a parse tree, it would get attached to S to provide sentential context rather than to VP to specify something about the verb; if one wanted to specify something about the action expressed by the verb, like the manner in which an action was performed or the instrument that was used, then the constituent would get attached to the VP node.

Clearly the letter John wrote John the letter clearly wrote.

**Figure 11.1.** Examples of parse trees.

This simple example exemplifies the major theoretical concern to be tackled in this chapter, which can be summarized thus: In reading, can factors associated with thematic roles—specifically, semantic factors— constrain the initial syntactic attachment of a constituent?

The reason this question is particularly important is because the initial constraints on sentence processing have often been viewed as originating in the syntactic processor. In this chapter we question this view. We do not intend to deny the possibility that syntactic considerations may play some role. Rather, we seek evidence for the influence of semantic factors in the context of a model in which syntactic and semantic factors jointly influence the course of constructing initial representations of sentences.

The relationship between syntax and semantics cannot be dealt with independently of a consideration of the cognitive architecture in which these factors are integrated. The reason is that the architecture places limits on the directionality of influence within a model. For example, given the configuration shown in Figure 11.2A, Processor B could never directly influence Processor A. Processor B could only use whatever output Processor A decided to send it. If Processor B could generate a feedback signal, as shown in Figure 11.2B, then it could affect Processor A, but only after Processor A had produced some initial output and Processor B had evaluated it. In principle, this information could be used to change the general constraints on initial attachment of a constituent in a way that would affect the orientation of the syntactic processor. This is because the architectural design of this model provides for the possibility of a constraint on the syntactic attachment of a constituent that is independent of the cognitive architecture in which it is embedded. The entailment between syntactic and semantic constraints cannot be dealt with independently of the architectural design of the parser.
If the preferences that these frames represent are strong, they could affect the syntactic processing even if the verb is initially encoded. The syntactic processor in these models incorporates into the syntax phrases into a parse tree largely through guidance from principles of syntactic attachment. According to syntax-based models, the constituents that are attached to a constituent are specified arguments and complements associated with verbs. These principles are used to guide the attachment of a constituent to a higher constituent in a parse tree. The syntactic processor, for example, uses information about the preferred grammatical functions associated with verbs in a sentence. For example, if the verb is "stirred" and the object is "the coffee," the syntactic processor would attach the phrase "the coffee" as the object of the verb "stirred." This is an example of how syntactic principles influence parsing. The syntactic processor considers the thematic roles that the verb requires and attaches the constituent that satisfies those roles to the verb. Multiple-constraint models include syntactic constraints on initial decisions about syntactic attachment, but semantic information could also guide parsing. In these models, the selectional features of the verb are considered alongside the syntactic constraints. This interaction between syntax and semantics is important for accurate parsing and comprehension. The syntactic processor, therefore, uses both syntactic and semantic information to construct a parse tree for the sentence. The parse tree represents the syntactic structure of the sentence, with branches and leaves corresponding to syntactic constituents.
The rigors of reading, the analysis of a sentence in a left-to-right serial fashion, is typical. Time and time again, the reader faces uncertainties about attachment and assignment because information is not yet available to force one or another decision. For instance, upon reaching clearly: John clearly wrote the letter, clearly could be interpreted in accord with another Figure 11a or 11b. The ambiguity could be lessened by content preceding the constituent—for example, as the handwriting expert himself has testified, John clearly wrote the letter, or it could be resolved by content following the ambiguity—John clearly wrote the letter and received an A for style. In some cases, the ambiguity encountered and resolved on a purely syntactic basis by simply reading the word. There is no question that readers are sensitive to the alternative constructions possible when faced with ambiguities, as discussed in the research on verb-complexity (Fodor, Garrett, & Bever, 1968; Holmes & Forster, 1972; Shapiro, Zurif, & Grimshaw, 1987). Further, readers appear biased in the initial syntactic attachment of constituents, as discussed in part in the research on verb preferences (Clifton, Frazier & Connine, 1984; Connine, Ferreira, Jones, Clifton, & Frazier, 1984; Holmes, 1984, 1987; Mitchell & Holmes, 1985). It was our view that readers were sensitive to what a sentence was about, and the content of a sentence suggested itself as a potential source of processing preferences. It was our goal to show that the ongoing process of constituent attachment and role assignment was influenced by prior content. This content set up expectations for further processing and provided an important source of guidance. Our studies centered on a particular syntactic ambiguity that has been the focus of previous studies that purported to find evidence for a "syntax-first model and, in particular, for the view that initial parsing decisions are guided by general syntactic principles. Our intuitions, however, suggested to us, in this particular construction, that syntactic preferences were in fact relatively weak and that attachment and role assignment seemed more susceptible to semantic guidance based on the specific content of the sentence. We chose to study this construction as a test case, not because we felt that syntactic influences on processing are necessarily weak in general, but because we felt that content-based influences on processing would be most easily observed in the absence of strong syntactic biases.
Minimal Attachment

BY GENERAL SYNTACTICAL PRINCIPLES
IS PROCESSING GUIDED ONLY

1. The spy saw the cop with a revolver, but the cop didn't see him.

2. The spy saw the cop with a revolver, but the cop didn't see him.

3. The cop admired the house with a garden, but knew that it was overpriced.

4. The cop admired the house with a friend, but knew that it was overpriced.

5. The cop admired the house with a friend, but knew that it was overpriced.

6. The cop admired the house with a friend, but knew that it was overpriced.

Although results in Rayner et al. (1983) for sentences like (1) inferred from Experiments 3 and 4 are used in Experiments 3 and 4, phrases produced subjected to non-minimal attachment in the so-called general syntactic constraints and phrase-partICLE constraints often affect the same experimental results of second-order attachment, we are interested in the second-order attachment to phrases produced subjected to non-minimal attachment in the so-called general syntactic constraints and phrase-partICLE constraints. The experiments were designed to explore these differences and to determine whether the second-order attachment can be manipulated by the so-called general syntactic constraints and phrase-partICLE constraints.
The expectation ratings and doze task showed that one set of sentence frames set subjects' expectations to favor VP attachment of the prepositional phrase, whereas another set of sentence frames set expectations to favor Object-NP attachment. The reading times showed that these expectations were not epiphenomenal with respect to reading; rather, they produced significant differences in reading time. When attachment expectations fit the attachment required by the content of the sentence, reading times were faster compared to cases in which expectations did not fit. To determine whether these were factors related to content or the syntactic constituents, we simply compared the performance with these stimuli on sentences in which the attachment of the prepositional phrase was opaque. The results showed that when the expectations were based on the content of the sentence, the reading times were faster compared to cases in which the expectations were based on the syntactic constituents. Thus, an important factor in the online processing of sentences is the degree to which the ultimate attachment of constituents in the sentence actually matches the subject's expectations for these constituents. When these expectations are violated, subjects experience difficulty relative to cases in which expectations are fulfilled. It should be noted that the particular interaction between expectations, attachment, and reading difficulty that we have reported here cannot be accounted for by any general syntactic principle of which we are aware; that is, by any principle that does not consider the content of the sentence - as the expectation effects occurred in sentences that differed in the content, and not the syntactic constituents, of the sentence. The expectation effects observed in our experiment were found in experiments in which we varied the content of the sentence, but not the syntactic structure of the sentence. Thus, the expectation effects are not simply due to differences in the syntactic structure of the sentence, but reflect the influence of the content of the sentence on the subject's expectations for attachment.
count for a lot.

Count for a Lot

Expectations for Thematic Roles and for Thematic Role Fillers

holding everything else constant, the effects of each of these factors vary widely according to the cost of the other factor. The expectations for each of these influences vary widely. In fact, the effects of violations are different. The data from Experiment 1, in mind...
The attachment and role assignment of the prepositional phrase also requires the attachment of the word to which it is prepositional, and disambiguation of the word's role. But for now, the crucial aspect is that the role of the prepositional phrase can vary depending on the sentence structure, and can be disambiguated by the prepositional phrase itself. Again, the attachment and role assignment of many words can be predicted by the expectations for thematic role assignment.

The evidence so far is consistent with the view that the guidance that was important for the thematic role was not in accord with those expectations. The effect of/theme was produced in sentences that were con-

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Semantic Violations

was not (less-expectation role), because of (many). The manager because of many.

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**Experiment 3**

In order to make sense of the world around them, people use language to express their thoughts and ideas. A sentence is not always that simple, as the following experiment demonstrates.

**MULTIPLE-CONSTRAINT MODELS**

The strong predictions of constraint models...
TARABAN AND MCCLELLAND

(VP-expectation) and a separate analysis using the sets of consistent and inconsistent sentences for which subjects are expecting noun phrase attachment (NP-expectation). After all, the change in the object is posited to modulate expectations for attachment regardless of the site of attachment. The VP-expectation and NP-expectation sets each provide for a test of consistency over frames that use the same verb, and could show whether there is actually only one consistent cell or whether there are truly two consistent cells, as required for a clear test of the hypothesis at hand.

Eighteen stimulus quadruples like Examples 6 and 7 were used for this experiment. In pointing out that the object noun phrase is a source of influence on attachment and role assignment, we definitely do not want to suggest that it has this influence on its own. Although the other constituents in a frame were held constant for purposes of this demonstration, it is we believe, partly clear that the particular object has its influence. The consequence of expectation over the condition of consistency or noun phrase attachment was found, and can reasonably be attributed to the consistent cell. In the analysis of expectation over frames with consistent sentence, where the consistent sentence could define a single specific attachment, the consistent condition crossed a single specific attachment, whereas the consistent condition crossed a single specific attachment, this condition was not dependent on a single specific attachment. In the overall analysis, faster reading times could not be dependent on a single specific attachment, because the consistent conditions cross attachments. In the analysis by type of attachment expectation (VP- or NP-expectation), the advantage of consistent sentences could not depend exclusively on a particular verb frame, since the verb was held constant across the VP- and NP-expectation sets. In fact, minimal attachment and verb-based lexical models would both predict null effects for Consistency. For these reasons, faster reading times for the consistent conditions were found though and can reasonably be attributed to the consistent cell. In pointing out that the object noun phrase is a source of influence on attachment and role assignment, we definitely do not want to suggest that it has this influence on its own. Although the other constituents in a frame were held constant for purposes of this demonstration, it is we believe, partly clear that the particular object has its influence.

In the overall analysis, the effect of the object noun phrase on reading times could not be dependent on a single specific attachment, because the consistent conditions cross attachments. In the analysis of expectation over frames with consistent sentence, where the consistent sentence could define a single specific attachment, this condition was not dependent on a single specific attachment. In the overall analysis, faster reading times could not be dependent on a single specific attachment, because the consistent conditions cross attachments. In the analysis by type of attachment expectation (VP- or NP-expectation), the advantage of consistent sentences could not depend exclusively on a particular verb frame, since the verb was held constant across the VP- and NP-expectation sets. In fact, minimal attachment and verb-based lexical models would both predict null effects for Consistency. For these reasons, faster reading times for the consistent conditions were found though and can reasonably be attributed to the consistent cell. In pointing out that the object noun phrase is a source of influence on attachment and role assignment, we definitely do not want to suggest that it has this influence on its own. Although the other constituents in a frame were held constant for purposes of this demonstration, it is we believe, partly clear that the particular object has its influence. The consequence of expectation over the condition of consistency or noun phrase attachment was found, and can reasonably be attributed to the consistent cell. In the analysis of expectation over frames with consistent sentence, where the consistent sentence could define a single specific attachment, this condition was not dependent on a single specific attachment, because the consistent conditions cross attachments. In the overall analysis, faster reading times could not be dependent on a single specific attachment, because the consistent conditions cross attachments. In the analysis by type of attachment expectation (VP- or NP-expectation), the advantage of consistent sentences could not depend exclusively on a particular verb frame, since the verb was held constant across the VP- and NP-expectation sets. In fact, minimal attachment and verb-based lexical models would both predict null effects for Consistency. For these reasons, faster reading times for the consistent conditions were found though and can reasonably be attributed to the consistent cell.
The data that we collected do not help to distinguish between these two possibilities. In fact, like the subject, another and all the data are consistent with the claim that the force of the argument made in this chapter is that the finding here is that the sentence content preceding a constituent evokes expectations for its influence. We consider two distinct ways of construing the data in a sentence without first considering what it means to have an expectation. In the latent model, expectancies about attachment and role assignment are activated immediately after the sentence is passed. In the active model, we noted the operation of a priority ordering of promising subcategorization frames that the main verb in a sentence must be questioned as a sole source of influence by the experimental results at hand. Thus the finding here does not, as suggested in verb-argument and role assignment of a constituent? Did Subjects Predict the Initial Attachment?

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on-line reading by simply looking at the main verb. There are indications that, when the propositional phrase requires a different attachment and role than the sentence, there is a tendency to predict which particular attachment and role the subject expects based on the prior content of the sentence, and the subject's expectations for the role of the object are specific only to that sentence. If the subject were to expect the role of the object in another sentence, the subject would more readily accept a propositional phrase that fits the role of the object in the sentence.

The hypothesis that the subject expected based on the prior content of the sentence was tested by comparing the reading times for the sentence where the subject's expectations were consistent with the attachment and role of the object to the reading times for the sentence where the subject's expectations were inconsistent with the attachment and role of the object. The results showed that the reading times were significantly longer for the sentence where the subject's expectations were inconsistent with the attachment and role of the object.

In summary, the results of Experiments 1 and 2 are consistent with the hypothesis that the subject's expectations for the role of the object are specific only to that sentence. The subject's expectations are used to guide the processing of the object, and the subject's expectations are generated based on the prior content of the sentence. These results support the hypothesis that the subject's expectations are specific only to that sentence.
The notion of thematic role assignments (or thematic roles) is central to Chomsky's theory of syntax. These roles are semantic slots that are assigned to various elements in a sentence, such as arguments and objects of verbs, and are used to constrain the possible syntactic and semantic interpretations of the sentence. The specific thematic roles assigned to an element depend on the semantics of the verb or other syntactic category that the element is associated with.

For example, consider the sentence "The man beat the woman." In this sentence, the man is assigned the thematic role of "agent," and the woman is assigned the thematic role of "theme." These roles are assigned in order to constrain the possible syntactic and semantic interpretations of the sentence. For instance, the thematic role of "agent" indicates that the man is responsible for the action of "beating," while the thematic role of "theme" indicates that the woman is the recipient of the action.

The assignment of thematic roles is a complex process that involves both syntactic and semantic constraints. Syntactically, thematic roles are assigned based on the syntactic structure of the sentence, while semantically, they are assigned based on the meaning of the words in the sentence. The assignment of thematic roles is also influenced by other factors, such as the discourse context and the speaker's knowledge of the world.

One way out of this might be to posit a multiple constraint satisfaction model. This model allows for the simultaneous consideration of both syntactic and semantic constraints, and is able to provide a unified account of the thematic role assignments in a sentence. In this model, the thematic role assignments are determined by a process that balances the competing constraints, and is able to provide a consistent and coherent account of the thematic role assignments in a sentence.

We argue here that although possible, this is not a good instrument of cleaning in light of the world knowledge into sub-regions for the verbs. Although we will not totally reject this, the notion of a thematic role assignment is consistent with our data and that is more attractive in the context of the sentence. We therefore propose a model that uses this information to sort out the possible thematic role assignments for the verbs in a sentence. This model is able to provide a unified account of the thematic role assignments in a sentence, and is able to provide a consistent and coherent account of the thematic role assignments in a sentence.
The stone broke the window.

The wind opened the door.

Christ died in order to save us from our sins.

The cook put the roast on the table in the kitchen.

...
There are encouraging signs both on experimental and computational models. The rules governing processing in the St. John and McClelland (1973) model are more autonomous than other models, and Forster considered it more promising for amalgamating evidence from various sources of information. McClelland et al. (1971) noted that, in this model, the process of finding (through learning) a set of factors that might have been discovered, and the implications of thematic role information in on-line processing. In such cases, the network eventually distinguishes between the thematic role structure for the sentence. In Sentence 17, 2013, the adverb plays a critical role in determining the effect of a preceding event on the sentence. In Sentence 18, it proves to be incorrect based on subsequent interpretation of the sentence. The network is able to instantiate vague words and elaborate the implications. As an example, the St. John and McClelland model does not allow the model to account for the thematic role information in on-line processing. In such cases, the model is unable to instantiate certain words, and the implications of thematic role information in on-line processing. In such cases, the model is unable to instantiate certain words, and the implications of thematic role information in on-line processing. In such cases, the model is unable to instantiate certain words,
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CONCLUSION: A THEORY OF PARISING NEEDS
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11. PARSING AND COMPREHENSION


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