Filling Gaps: Decision principles and structure in sentence comprehension*

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Abstract

The correct grammatical characterization of sentences containing filler-gap dependencies is a topic of considerable theoretical interest in linguistics. In some grammatical frameworks, these dependencies are represented in terms of conditions on the permissible indexing of structures (or alternative structure evaluation conditions) which a representation must adhere to in order to be well-formed. In other frameworks, constraints on permissible filler-gap dependencies are simply inherent in the set of phrase structure rules contained in the grammar of a language.

The processing of sentences with multiple (potential) filler-gap dependencies was investigated in two experiments. The first experiment provided evidence for three claims. First, the human sentence processor abides by a strategy of assigning the most recent potential filler to a gap. Hence, 'recent filler' sentences where this assignment proves to be correct takes less time to comprehend than 'distant filler' sentences where this decision turns out to be incorrect. Second, the recent filler strategy is itself just a special case of a more general strategy of assigning the most salient potential filler to a gap. Third, unambiguous sentences in which a filler-gap assignment is disambiguated by 'control' information specified by individual verbs gives rise to the same recent filler errors as ambiguous sentences. This suggests that tentative filler-gap assignments are made by the processor before all of the relevant constraints on permissible filler-gap dependencies are consulted by the processor.

The second experiment tested an alternative hypothesis that the more complex 'distant filler' sentences took longer to comprehend in the first experiment only because these sentences often contained verbs which license

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two adjacent gaps. The experiment showed that there was a significant recent filler effect in sentences that did not contain adjacent gaps and that this effect did not interact with verb class.

The finding that the processor delays use of verb-control information is extremely surprising. It may be explained by the fact that this information is only relevant to one type of gap ('equi-gaps') and what type of gap the processor is dealing with often can not be determined unambiguously at the time when it initially encounters a gap in its left-to-right processing of a sentence.

If our interpretation of these findings is correct, they argue for a considerable amount of structure in the sentence comprehension system. Further, they favor a view of sentence processing in which processing operations involving constraints on the permissible indexing (or evaluation) of structures lag behind the processor's structure building operations. Hence, the results favor those grammatical theories which preserve this distinction over grammatical theories which provide a uniform characterization of all syntactic well-formedness conditions.

1. Introduction

A theory of sentence comprehension should guide research concerning the central questions in the area, and ultimately provide insightful answers to them. In this paper, we focus upon the following questions:

(i) What distinct categories of grammatical and non-grammatical information are used during sentence comprehension? What constraints exist for representing, organizing and using information in each category?

(ii) When the information available to the comprehension mechanism at one point in time is insufficient to specify a unique analysis of a sentence, what decision principles does the comprehension mechanism use?

(iii) What are the functional and structural properties of the comprehension mechanism, and how do they constrain its use of different categories of information and determine its decision principles?

We will address these questions by working toward a theory which makes strong claims about the existence of structure in the human sentence comprehension mechanism, and about the constraints it must obey (cf., Forster, 1979).

We begin with a set of specific claims about the comprehension mechanism: it rapidly constructs a surface structure representation of a sentence, left to right, and essentially in real time; to construct this representation, it uses various types of information, among them, information about
lexical category and permissible phrase structure configurations; further, it makes on-line decisions on competing representations of a sentence when the information available up to that point is insufficient to specify a unique analysis, and does so despite the possibility that later information may force a change in its decision.

In justifying and articulating these claims, the present paper focuses on the processing of sentences with filler-gap dependencies. Data that we present from experiments with filler-gap sentences provide evidence about the decision principles and categories of linguistic information used by the processor, and the constraints on how this information is used. These data also allow us to consider the reasons for the processing constraints, based on the structural properties of the comprehension mechanism. As a point of departure, we introduce briefly the two major areas that our research addresses: decision principles and constraints on information use.

1.1 Decision principles

The decision principle problem concerns how the sentence comprehension mechanism copes with temporary ambiguity, a situation in which it does not have sufficient information to specify uniquely the correct analysis of some portion of an input sentence. The problem of temporary ambiguity is pervasive in natural language, as a language user can demonstrate by interrupting sentences at arbitrary points and considering the implications of all possible continuations for the analysis of already analyzed material. In principle, the sentence comprehension mechanism might cope with temporary ambiguity by projecting all possible analyses of the ambiguous string, by choosing just one analysis, or by delaying making any decision about the analysis. Each of these options has costly consequences in terms of processing or memory load. Computing all possible analyses entails substantial extra work. Choosing one analysis means that errors may have to be corrected. Delaying analysis will occasion a heavy memory load for unprocessed material.

Substantial evidence exists that the comprehension mechanism operates on a one-analysis-at-a-time basis. The clearest intuitive evidence lies in the existence of 'garden-path' sentences, such as, "The boat floated down the

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1 We leave open the possibility that it is actually an 'S-structure' (cf. Chomsky and Lasnik, 1977), in which the effects of stylistic and deletion rules have been 'undone', which is developed during sentence comprehension. This distinction may be crucial with respect to stating the grammatical constraints on the possible antecedents for a pronoun and thus to a processing account of pronoun resolution. The distinction is not crucial, however, to any of the arguments presented here and thus we remain neutral on the issue.
river..." when it ends "... sank". It seems clear that one commits oneself to an analysis of the initial part of the sentence which has to be revised later. Experimental evidence corroborates these intuitions, both in the domain of phrase structure parsing (Bever, 1970; Ford, Bresnan and Kaplan, 1981; Frazier, 1979; Frazier and Fodor, 1978; Frazier and Rayner, 1982; Kaplan, 1974; Kimball, 1973) and in the domain of the parsing of sentences with transformational dependencies among their elements (Fodor, 1978, 1979; Wanner and Maratsos, 1979).

1.2 Constraints on information use

The comprehension mechanism uses many distinct types of information: lexical, prosodic, syntactic, semantic, discourse-contextual, world knowledge, etc. Many current models of sentence comprehension, especially Marslen-Wilson's (1975) early work but including such models as Rumelhart's (1977), claim that the comprehension mechanism uses all types of information in a parallel, 'interactive', unstructured fashion. Contrary to the spirit of these models, we propose to argue strong claims for the existence of structure in the timing of information use, sharing as we do Forster's (1979) belief that progress in determining what structure exists in a system will best be made by theorizing about the presence of structure, not about its absence.

The problem of when information is consulted during comprehension can be attacked by noting that temporary 'ambiguities' can arise even when the left context of some item in a sentence is sufficient in principle to specify an analysis of the sentence to that point, but the processing of some of the information it contains lags behind presentation. Such cases can arise when, for instance, the comprehension mechanism does not initiate some principled class of operations until it has received all of the items in the domain over which the operations are defined (e.g., delays in computing some relations until the end of a syntactic clause; cf. Fodor, Bever and Garrett, 1974) or when the relevant information in left context belongs to an information type which is used relatively late in processing, or when heavy processing loads delay the processing of all information. We will refer to temporary ambiguities which arise from the incomplete use of information presented in left context as 'vertical ambiguities'; ambiguities that remain even after full use of all information in left context, we shall call 'horizontal ambiguities'. The experimental identification of a vertical ambiguity can often be considered evidence that some type of information is delayed in its use, a finding which points to a possible constraint upon the sequencing of information use.
2. Processing filler-gap sentences

Sentences with filler-gap dependencies, dependencies between a lexically specified phrase and a phonetically null position in the phrase marker, are the focus of intense theoretical activity in linguistics (Bach, 1982; Bresnan, 1978; Chomsky, 1980, 1981; Engdahl, 1980, 1981; Fodor, 1981a; Gazdar, 1981; Williams, 1980) and psycholinguistics (Ades and Steedman, in press; Bresnan and Kaplan, 1980; Engdahl, 1979; Fodor, 1978, 1979, 1981b; Marcus, 1980; Solan, ms.). However, relatively little experimental work of clear theoretical impact has been done on them. Filler-gap dependencies are frequently analyzed as arising from transformational operations. The very earliest modern psycholinguistic work focussed on the transformational component of the grammar, but with the intention of assessing the Derivational Theory of Complexity (see Fodor, Bever and Garrett, 1974, for an excellent review). When this early approach to sentence comprehension was abandoned, most psycholinguists turned their attention to other aspects of sentence processing, especially those concerning the base component (e.g., the representation and access of lexical information, the processing of phrase structure ambiguities, etc.) and the effects of context. The little work on transformational dependencies that continued to be carried out concentrated on the processing of relative clauses. Apart from some well-known work carried out in the ATN framework (Wanner and Maratsos, 1979; Kaplan 1974), the focus of these studies was primarily to determine whether (and, if so, why) all nested constructions are perceptually more complex than corresponding unnested structures (Bever, 1970; Chomsky and Miller, 1963; cf. Grosu, 1974; Kimball, 1973; Miller and Isard, 1964; Schlesinger, 1968; Stolz, 1967) and whether object relative clauses are more complex than subject relative clauses (Baird and Koslick, 1973; Cook, 1976; Hakes, Evans and Brannon, 1976; Holmes, 1979; Savin, reported in Bever, 1970). While these are interesting topics which may prove to bear critically upon evaluations of sentence processing models, their relevance to the questions with which we began this paper has not been developed.

We suggest that experimental work on sentences with filler-gap dependencies can be particularly informative with respect to the central questions of decision principles and constraints on information use. Temporary ambiguities which can be resolved locally in sentences without filler-gap dependencies may require the use of global information in filler-gap constructions. For instance, the decision about whether the verb ‘move’ is being used transitively can be made on the basis of local information in (1a) and (1b), while the comparable decision in the filler-gap sentences (2a) and (2b) cannot be made simply by checking the constituents that immediately
follow the verb. This is because the transitivity of the verb depends on whether there is any other position in the sentence for which the obligatory filler ‘the mansion’ is a legitimate filler. (We follow the convention of underlining fillers and indicating a gap by a ____.) The need to use such global information arises because many filler-gap dependencies are long-distance dependencies in which an arbitrary amount of lexical material can intervene between the filler and gap (cf., Ross, 1967). Dealing with such long-distance dependencies may be expected to occasion substantial memory and processing loads, which should be observable using available experimental techniques. Indeed, using a secondary load memory task, Wanner and Maratsos (1979) have shown that there is an increase in memory load in the region of a sentence when an obligatory filler must be held unassigned in memory.

In fact, filler-gap dependencies may be expected to be perceptually complex even when the filler and gap are not widely separated in the lexical string. This is because their correct processing requires the integration of many different types of information and because even the assignment of local filler-gap dependencies may directly interact with decisions concerning dependencies far removed from them in the lexical string (i.e. other potential filler-gap assignments).

Filler-gap sentences also provide a rich field for studying constraints on the use of distinct types of information. In addition to the information needed to establish the constituent structure of ‘untransformed’ sentences, the sentence comprehension mechanism needs information about the possible movement rules of the language (or possible binding relations; cf., Chomsky, 1980; or slashed categories; cf., Gazdar, 1981), special constraints on the relation between the fillers and gaps (e.g., conditions like subjacency, Chomsky, 1973, 1980), and information about the control properties of verbs (Chomsky, 1980; Chomsky and Lasnik, 1977; Jackendoff, 1972; Koster, 1981; Williams, 1980). Each of these types of information, if not used as soon as logically possible, could give rise to a vertical ambiguity whose existence and resolution could be studied. Consider, for instance, sentences (3c) and (3d), parallel to (3a) and (3b) except for the main verb of the relative clause:
(3a) Mary is one student who the teacher wanted ___ to talk to the principal about ____.
(3b) Mary is one student who the teacher wanted ___ to talk to the principal.
(3c) Mary is one student who the teacher decided ___ to talk to the principal about ____.
(3d) Mary is one student who the teacher forced ___ to talk to the principal.

If the control information contained in the lexical entries for 'decide' and 'force' is used immediately to constrain the subject of the verb 'to talk', the horizontal ambiguity present at this point in (3a) and (3b) is eliminated. If control information is delayed in its use, a vertical ambiguity will occur.

2.1 Theoretical analyses of filler-gap processing

Early studies of the comprehension of transformed sentences (often with filler-gap dependencies) were typically designed to test the Derivational Theory of Complexity. Apart from these, most accounts of the comprehension of filler-gap constructions have claimed that sentences containing filler-gap dependencies are analyzed like corresponding untransformed sentences (cf., Jackendoff and Culicover, 1971; Wanner, Kaplan and Shiner, ms.; Fodor, 1978, 1979). Fodor (1978) reviews these accounts, and explicitly notes that they assume that phrase structure rules are used to build up well-formed deep structures. Construction of a legitimate deep structure will be blocked if a phrase occurs in a position where it could not be base-generated or if there is no phrase in the correct position in the input sentence to be assigned to an obligatory position in the phrase marker.

A phrase structure model built along these lines could contend with transformed sentences containing dependencies between obligatory fillers and gaps. However, it would have to be elaborated to be able to recognize the presence of an optional filler, or an optional gap, or to assign dependencies between multiple fillers and gaps. Consider the problem of identifying a noun phrase as a filler. The head of the relative clause, the boy, is unambiguously marked as a filler in (4a) by the presence of the relative pronoun who, but cannot be identified as a doubtless filler in (4b) until the relative clause is identified as such. In (4c), the phrase the girl cannot be identified as a true filler until the final verb of the sentence is identified as being transitive.

(4a) Tom is the boy who the girl wanted ___ to die.
(4b) Tom is the boy the girl wanted ___ to die.
(4c) Tom is the boy the girl wanted ___ to kill ___
Existing theories have not gone far beyond appealing to the processor’s use of explicit markers, such as relative pronouns, in its attempts to identify fillers.

The topic of identifying gaps has received more attention. Fodor’s Lexical Expectation model claims that the probability of detecting an optional gap is a function of the ranking of alternative subcategorization frames for an item in untransformed sentences. In this model, the processor will not be garden-pathed as often as in a model which claims a gap is postulated only as a last resort, when there is no lexical phrase in an obligatory position in the phrase marker, and it will not engage in the excessive gap-detection activity of a model which claims that a potential gap is postulated at every point where one is possible. The model also accounts for intuitions concerning the equivalent ease of (5a) (whose verb is obligatorily transitive requiring an obligatory gap) and (5b) (whose verb is merely used more often in a transitive than an intransitive manner).

(5a) Which book did the teacher show ______ to the children?
(5b) Which book did the teacher read (______) to the children?

And it predicts that (6a) should be harder to process than (6b) or (6c) since the false gap after read would be detected, whereas the potential gap after sing will not, assuming that sing is typically used intransitively.

(6a) What did the teacher read (______) to the children about ______?  
(6b) What did the teacher talk to the children about ______?  
(6c) What did the teacher sing (______) to the children about ______?

In sentences where more than one filler and one gap have been detected, the processor must at some point decide which filler to assign to which gap. Various proposals predict that the most recently encountered filler will be assigned to the leftmost gap in a sentence. There is linguistic evidence for the existence of a strategy of assigning the most recent filler to a gap. The clearest evidence is the fact that many languages place special restrictions on intersecting filler-gap dependencies (illustrated in [7a]) but not on nested filler-gap dependencies (as in [7b]):

(7a) FILLER FILLER GAP GAP  
(7b) FILLER FILLER GAP GAP

Fodor (1978) argues that English is constrained by the following no-ambiguity principle:
Nested Dependency Constraint. If there are two or more filler-gap dependencies in the same sentence, their scopes may not intersect if either disjoint or nested dependencies are compatible with the well-formedness conditions of the language.

The principle is illustrated by the grammaticality of (8a), the ungrammaticality of (8b), and the availability of only the silly reading of (8c):

(8a) Which pot is this soup easy to cook in?
(8b) Which pot is this soup easy to cook in?
(8c) Which soup is this pot easy to cook in?

Developmental evidence exists for a strategy akin to the strategy of assigning the most recent filler to a gap. C. Chomsky (1969) has shown that young children systematically misinterpret (9a), taking Bill, the most recent lexical noun phrase, to be the subject of to grab, following the Minimum Distance Principle, in which the noun phrase nearest the complement verb is interpreted as its subject. (Such a principle does correctly characterize the control properties of most verbs in English; cf. [9b]).

(9a) John promised Bill to grab the jewels.
(9b) John told Bill to grab the jewels.

Various approaches to explaining the apparent strategy of assigning the most recent filler to a gap have been taken. One class of approaches assumes that the comprehension mechanism adopts a recent filler strategy simply to cope with the grammatical constraints on filler-gap dependencies. Fodor (personal communication) has suggested that the strategy might simply be the most effective way to guarantee that the processor will meet the grammatical constraint that all fillers must c-command (cf., Reinhart, 1976) their gaps. Solan (unpublished manuscript) also implies that the strategy may indirectly be attributed to the grammar. He suggests that \( S \) defines the domain for processing natural languages (presumably due to the role of \( S \) as a grammatical domain) and thus he formulates a 'Local Parsing Strategy' in which a recent filler assignment results from the processor attempting to identify a filler for a gap by searching through earlier processing domains beginning with the most recently processed domain.

Other approaches stress presumed real-time processing operations. Fodor (1978, 1979) suggests that the selection of the most recent filler is the result of the processor's attempt to construct uninterrupted stretches of well-formed deep structure which contain no intervening unassigned fillers or gaps. Other alternatives appeal to the operation of special memory buffers. In the ATN framework (Wanner and Maratsos, 1979; Kaplan, 1974), a filler is placed in a special push-down store, the 'HOLD' buffer. In the latter
framework, the topmost entry in HOLD, which will be the most recently encountered filler, is assigned to a gap when one is identified.

We propose another alternative, which explains the recent filler strategy in terms of the very general tendency for the human sentence processor to pursue the first analysis of a sentence available to it (cf., Fodor and Frazier, 1980). We assume that a variety of factors, including its recency, interact to determine how quickly a noun phrase can be retrieved from memory to be assigned as a filler to a gap. These factors collectively determine the ‘salience’ of a filler. We propose that the processor initially assigns the most salient filler to an identified gap. The empirical content of this ‘salience hypothesis’ consists in its claim that all factors which affect the availability in memory of a filler will contribute to the likelihood of initially assigning it to a gap. Such factors would, we presume, include the degree of sentential stress with which the potential filler was spoken, the presence of a special grammatical marker (e.g., a relative pronoun) which signals that a phrase is an obligatory filler, and, potentially, discourse factors including the communicative importance of a phrase.

The research reported here has the initial goal of determining whether the strategy of assigning the most recent filler to a gap is an on-line strategy, executed during the comprehension of a sentence as the accounts described assume. It thus assesses the truth of the following:

**Most Recent Filler Strategy:** During language comprehension a detected gap is initially and quickly taken to be co-indexed with the most recent potential filler.\(^2\)

\(^2\)Further specification of the Most Recent Filler Strategy may be needed. As stated, the strategy claims that the most recent noun phrase that occurs in a potential filler position in the phrasemarker is assigned to a gap. For gaps in ‘cased’ positions (e.g., the post-prepositional gaps in example (3)), this turns out to be the most recent noun phrase in a complementizer position introducing a clause. For gaps in caseless positions (e.g., the gaps before the infinitive verbs in (3)), it is the most recent noun phrase in any position that may control a gap. However, the experiments to be reported here do not permit us to distinguish this statement of the strategy from a strategy which merely selected the most recently occurring noun phrase preceding the gap or one which selected any noun phrase in the next \(S\) domain above that which contains the gap (cf., Solan, ms.). It may even prove to be the case that readers prefer to fill a gap with a filler related to that gap by control rather than by wh-movement. These various possibilities would all be consistent with evidence for the processor’s initial adoption of the more recent potential filler in the constructions discussed here. Thus, additional investigation is needed to disentangle these alternatives.

Evidence that the Most Recent Filler Strategy is just a special case of a preference to initially assign the most salient potential filler to a gap would render some of the above alternatives less attractive than the Most Recent Filler Strategy to the extent that the alternatives could not explain the interaction of recency and other factors that influence the salience of a phrase. For example, if the preference for recent filler assignments is described as a preference for control dependencies over wh-dependencies, it is not obvious why placing heavy stress on a distant filler (e.g., on the head of the relative in (3b) in the text) should alter the preference; there is simply no reason to expect this type of interaction between stress and recency given that statement of the strategy.
The research also considers some implications of the salience strategy as the correct description and explanation of the Most Recent Filler Strategy. It goes on to test whether semantic control information constrains the application of the Most Recent Filler Strategy.

3. The current experiments

Our initial experiments tested an hypothesized decision principle for dealing with the temporary ambiguity posed by a variety of filler-gap constructions, and searched for the existence of constraints on the timing of the processor's use of theoretically distinct information types. The decision principle is the Most Recent Filler strategy just discussed. It claims that, when a likely gap is detected, the comprehension mechanism initially fills it with the most recently encountered potential filler. Thus, in sentence (10a), where the most recent filler is the correct filler for the first gap, following the most recent filler strategy directly will lead to a correct assignment of fillers to gaps. In sentence (10b), on the other hand, the initial assignment of 'the teacher' to the single gap will be incorrect (we assume a Chomskian, 1981, analysis of the sentence in which 'to talk' is a part of a complement sentence with an empty subject position). When the sentence ends without providing a second gap for 'the girl', which as the head of the relative clause must be assigned to some gap in that clause, the comprehension mechanism is obliged to revise its initial assignment, taking extra time and introducing the possibility of error. Thus, (10b) (which we will refer to as a Distant Filler Sentence) should be harder to comprehend than (10a) (a Recent Filler Sentence), and this difficulty in comprehension should occur only at the end of the sentence.

(10a) This is the girl the teacher wanted ____ to talk to ____.
(10b) This is the girl the teacher wanted ____ to talk.

The experiments are also concerned with the timing of information use in sentence comprehension. They focused upon control information, as contrasted with categorial and phrase structure information. In sentence like (11), control information carried by the verb dictates which filler must be assigned to the gap in subject position of the complement verb:

(11a) This is the girl the teacher decided ____ to talk to ____.
(11b) This is the girl the teacher forced ____ to talk.

If control information is used by the sentence comprehension mechanism in making initial filler-gap assignments, then the Most Recent Filler strategy
would be blocked in (11b), and the girl would initially and correctly be assigned as filler to the gap. Thus, unlike (10b), (11b) should not mislead the comprehension mechanism. On the other hand, if semantic control information is not consulted until some later stage in processing, after an initial filler-gap assignment has been made, then (11b) will be vertically ambiguous and open to the same incorrect recent filler analysis as (10b), and thus prove more difficult to comprehend than (11a).

3.1 The task

We used a very simple sentence comprehension task to determine whether sentences consistent with the Most Recent Filler Strategy (10a) and (11a) were easier to comprehend than sentences which violated it, (10b) and (11b), and to determine whether any such difference was reduced or eliminated by the control information in (11). The experimental sentences were presented on a computer-controlled video display at a rate comparable to normal rapid reading. Subjects were instructed to judge as quickly as possible after the end of a sentence whether or not they understood the sentence. Their decision time was measured.

This simple comprehension task has received limited but profitable use in psycholinguistic investigation (e.g., Clark and Haviland, 1974; Clark and Sengul, 1979; Schwartz, Sparkman and Deese, 1970). It seems appropriate for our purposes, since it is quite possible that readers can complete a rapid structural analysis of a sentence and judge it to be comprehensible before completing a deeper semantic analysis of the sentence. Consider, for example, one’s initial impression of understanding sentences like ‘Everyone said that someone left’ or ‘John didn’t deny that Sam left’. Introspection suggests that the sentences can be understood at some level before one has committed oneself to a decision about the scope of the quantifiers (in the first sentence) or the interaction of the negatives (in the second). Speeded grammaticality judgment tasks and meaningfulness classification tasks have been analyzed as tapping this early stage of completing an initial structural analysis (Frazier, 1978; Holmes, 1979; Moore and Biederman, 1979). If subjects can be induced to base their comprehension responses on the completion of the early structural analysis we assume to exist, then the speeded comprehension time task would be a useful tool for measuring early stages of sentence comprehension, unencumbered by the grammaticality judgment task’s somewhat unnatural requirement that grammaticality be judged, and by that task’s need to present a substantial number of ungrammatical foils.

The speeded comprehension task would be particularly appropriate for measuring the activities of interest in such filler-gap sentences as (10) and
(11). The Most Recent Filler strategy predicts that substantial structural revision will occur immediately after the end of the sentence in the (b) version of these sentences. This structural revision must be completed before a response is initiated, leading to longer comprehension times measured from the presentation of the last word of the sentence, as compared to the (a) version of these sentences. Further, subjects may be expected upon occasion to fail to make the necessary structural revision, resulting in an indicated failure to comprehend the (b) sentences. Thus, the end-of-sentence measure of speeded comprehension judgments can serve as an initial index of on-line processes of structure-building and structure-modification. It must, of course, eventually be supplemented by additional techniques which tap within-sentence processes more directly, but it should serve to provide initial data on complexity differences and the relative timing of different processing operations.

A second task, designed to assess later stages of processing, was also used. Each sentence could be followed by a question, to be answered out loud by the subject. While the comprehension time task was designed to assess an early stage of successful completion of an initial structural analysis, success in answering a question should indicate successful completion of deeper processing, closer to full understanding of the sentence. It may be that sources of information that are not used quickly in forming the initial structural representation are used in forming or holding in memory whatever representation underlies full comprehension. In this event, information which had no effect on the comprehension time measure could prove to have an effect on question-answering accuracy.

Experiment 1

Method

Subjects and Procedures

Fifty-nine college students were tested. Ten subjects were rejected because of equipment failure or experimenter error, and one for not being a native speaker of English. A subject saw a total of 96 sentences (after eight practice sentences) presented on a computer-controlled video display. Each word of each sentence was presented for 300 msec beginning at the same position of the display, with a 50 msec blank interval between words. A period was displayed with the last word of a sentence. Subjects were instructed to pull one trigger of a response console if they intuitively felt they understood a
sentence, and a different trigger if they failed to understand a sentence. They were instructed to make their comprehension decision as soon as possible after the end of a sentence, and were asked to make it on a quick, intuitive basis, without reviewing the sentence in their mind. They were instructed to indicate 'missed it' (failure to understand) if they would normally be inclined to go back and re-read a sentence, and 'got it' (understand) otherwise. The time from the onset of the sentence-final word to the trigger response was recorded.

On a randomly selected one-third of the trials on which a subject indicated understanding a sentence, a question about the sentence was presented. Subjects answered the question orally, and the experimenter recorded the answer.

Materials and design
Forty-eight sentences were constructed as experimental materials, in addition to forty-eight non-experimental sentences of varied forms but similar length, and eight practice sentences. The experimental sentences each contained a single main clause which ended with a noun phrase containing a relative clause which, in turn, contained a complement construction within its verb phrase. Half of the sentences were Recent Filler sentences, with a preposition at the end of the complement sentence; e.g. (12);

(12) The mayor is the crook who the police chief tried to leave town with.

the other half were Distant Filler sentences, without a preposition:

(13) The mayor is the crook who the police chief forced to leave town.

The verbs used in the complement sentences were of three types: those which are compatible only with the Recent Filler construction (e.g., *try, agree, start*) as in (12); those which are compatible only with the Distant Filler construction (e.g., *force, persuade, allow*) as in (13); and those which can appear with either (e.g., *want, expect, beg*) as in (14):

(14) Recent Filler:
    The mayor is the crook who the police wanted to leave town with.

    Distant Filler:
    The mayor is the crook who the police wanted to leave town.

A sentence-final adverbial phrase (*next week, after the scandal, for MGM*) was written for each sentence. The phrase could be used with both Recent
and Distant Filler versions, and appeared in 50% of the sentence presentations of each type. This variable was included to allow us to check whether differences between Recent and Distant Filler sentences could be due to the fact that the Recent Filler sentences ended with a preposition while the Distant Filler sentences typically ended with a noun or verb. The adverbials used were of a particular type: they would not be fully grammatical in Distant Filler sentences if they occurred before the prepositional phrase containing the gap; they would have to follow these phrases. Thus, sentence (15a) seems to be odd, if not ungrammatical; (15b) is well-formed.

(15a) The mayor is the crook who the police chief wanted to leave town after the scandal with.
(15b) The mayor is the crook who the police chief wanted to leave town with after the scandal.

Given this choice of adverbial types, a reader who had made a misassignment in a Distant Filler sentence by using the Most Recent Filler strategy could, in principle, be given an indirect clue to this error before the end of the sentence in sentences containing adverbial phrases. He would know, as soon as he had identified the adverbial phrase, that no prepositional phrase gap could subsequently appear to which the unassigned filler could be assigned. At this point, he could begin to revise his initial assignment. If it turned out that the adverbial phrases were used in this way, then in those presentations which include these final adverbial phrases, there should be a smaller difference in comprehensibility between Recent and Distant Filler sentences.

The final variable was the presence or absence of the relative pronoun which is, in all cases, optional:

(16) Recent Filler:
The mayor is the crook (who) the police chief tried to leave town with.

Distant Filler:
The mayor is the crook (who) the police chief forced to leave town.

Half of the sentences were presented with the pronoun; half without. This contrast was included to test the possibility that the presence of an overt relative pronoun would make the preceding noun phrase more salient as a filler, thereby increasing the likelihood that it would be assigned to the first gap detected.

Given the four variables, each experimental sentence could appear in sixteen different forms, illustrated in Table 1. The forms are defined by the factorial combination of (1) presence or absence of a relative pronoun, (2)
presence or absence of a sentence-final adverbial phrase, (3) consistency or inconsistency with the Most Recent Filler Strategy, or, equivalently, presence or absence of a preposition in the complement verb phrase of the relative clause, and (4) ambiguity or nonambiguity of the semantic control properties of the matrix verb of the relative clause. We will refer to these variables as (1) Relative pronoun versus No Relative pronoun; (2) Final phrase versus No Final phrase; (3) Recent Filler versus Distant Filler; and (4) Ambiguity versus No Ambiguity. We tried to maintain semantic plausibility for all sixteen forms of each experimental sentence.

A single question was constructed for each sentence. It queried either the subject of the complement verb (e.g., Who expected to leave town? Who would take the blame?) or some other randomly chosen aspect of the sentence.

Sentences were presented in blocks of eight sentences each, with brief rest periods between blocks. On each block, four experimental and four distractor sentences were presented, in individually-randomized orders. A counterbalancing scheme met the following design features: (1) Each subject received three experimental sentences in each of the 16 sentence forms; (2) Each sentence form was presented once in each group of 4 blocks of 8 sentences, (3) Each sentence was tested in each form for three different subjects; and (4) No subject saw more than one version of any sentence.

Results

The data are presented in Tables 2 through 4. The mean reaction times were computed for all 'got it' responses (responses indicating a feeling of successful comprehension), after eliminating the 2% of all responses that were longer than 3500 msec or more than four standard deviations greater than the mean reaction time for a subject. The percentage 'got it' responses considered all responses, regardless of their reaction times.

Two analyses of variance were performed on the reaction time data, one treating subjects as the random variable, and the other treating sentences as the random variable. Similar analyses of variance were performed on the percentage 'got it' responses. The fixed effects factors in these analyses were the four factors that defined the sixteen sentence forms. Missing comprehension time data occurred when a subject failed to report understanding all three sentences of a given form (or, in the analysis allowing generalization to other sentences, when all three subjects who received a particular experimental sentence in a particular form failed to indicate understanding it). They were replaced using an iterative technique described by Myers (1972),
Table 1. **Illustration of the sixteen sentence forms**

<table>
<thead>
<tr>
<th>Sentence Structure</th>
<th>Example Sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs for.</td>
</tr>
<tr>
<td>Rel, Recent Filler, Ambig</td>
<td>Everyone liked the woman who the little child started to sing those stupid French songs for.</td>
</tr>
<tr>
<td>2. No final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs.</td>
</tr>
<tr>
<td>Rel, Recent Filler, Unambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs.</td>
</tr>
<tr>
<td>3. No final phrase</td>
<td>Everyone liked the woman the little child begged to sing those stupid French songs for.</td>
</tr>
<tr>
<td>Rel, Distant Filler, Ambig</td>
<td>Everyone liked the woman the little child started to sing those stupid French songs for.</td>
</tr>
<tr>
<td>4. No final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs.</td>
</tr>
<tr>
<td>Rel, Distant Filler, Unambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs.</td>
</tr>
<tr>
<td>5. No final phrase</td>
<td>Everyone liked the woman the little child begged to sing those stupid French songs.</td>
</tr>
<tr>
<td>No-Rel, Recent Filler, Ambig</td>
<td>Everyone liked the woman the little child forced to sing those stupid French songs.</td>
</tr>
<tr>
<td>6. No final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs.</td>
</tr>
<tr>
<td>No-Rel, Recent Filler, Unambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs.</td>
</tr>
<tr>
<td>7. No final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs.</td>
</tr>
<tr>
<td>No-Rel, Distant Filler, Ambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs.</td>
</tr>
<tr>
<td>8. No final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs.</td>
</tr>
<tr>
<td>No-Rel, Distant Filler, Unambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs.</td>
</tr>
<tr>
<td>9. Final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>Rel, Recent Filler, Ambig</td>
<td>Everyone liked the woman who the little child started to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>10. Final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>Rel, Recent Filler, Unambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>11. Final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>Rel, Distant Filler, Ambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>12. Final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>Rel, Distant Filler, Unambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>13. Final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>No-Rel, Recent Filler, Ambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>14. Final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>No-Rel, Recent Filler, Unambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>15. Final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>No-Rel, Distant Filler, Ambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>16. Final phrase</td>
<td>Everyone liked the woman who the little child begged to sing those stupid French songs for last Christmas.</td>
</tr>
<tr>
<td>No-Rel, Distant Filler, Unambig</td>
<td>Everyone liked the woman who the little child forced to sing those stupid French songs for last Christmas.</td>
</tr>
</tbody>
</table>

in which they are estimated as a combination of the mean reaction times for other sentences of that form and the mean reaction time to other sentences by the subject for which data were missing (or, in the sentences analysis, the mean reaction time to the other forms of the sentence for which data were missing).

The main finding was very simple: subjects more quickly indicated successful understanding of Recent Filler sentences than of Distant Filler sentences, 1071 versus 1165 msec, min $F'(1, 74) = 4.07, p < 0.05$. Subjects also indicated successful understanding of more Recent Filler than Distant Filler sentences, 78% versus 66%, min $F'(1,94) = 14.21, p < 0.01$. These results are consistent with the prediction of the Most Recent Filler Strategy.

The theoretically critical interaction between Recent versus Distant Filler and Ambiguous versus Non-Ambiguous verb was thoroughly nonsignificant in both reaction time analyses ($F_1(1,47) = 0.72$ and $F_2(1,47) = 0.17$ for the
Table 2.  

*Mean reaction times, 'Got it' responses (with percentage 'got it' responses in parentheses)*

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Present</th>
<th>Absent</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ambiguous verbs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recent Filler</td>
<td>1069 (75)</td>
<td>1077 (79)</td>
<td>1073 (77)</td>
</tr>
<tr>
<td>Distant Filler</td>
<td>1120 (68)</td>
<td>1228 (38)</td>
<td>1174 (63)</td>
</tr>
<tr>
<td>Mean</td>
<td>1095 (72)</td>
<td>1153 (69)</td>
<td>1124 (70)</td>
</tr>
<tr>
<td><strong>Unambiguous verbs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recent Filler</td>
<td>1094 (80)</td>
<td>1042 (78)</td>
<td>1068 (78)</td>
</tr>
<tr>
<td>Distant Filler</td>
<td>1141 (75)</td>
<td>1170 (63)</td>
<td>1155 (69)</td>
</tr>
<tr>
<td>Mean</td>
<td>1118 (78)</td>
<td>1106 (70)</td>
<td>1112 (74)</td>
</tr>
<tr>
<td><strong>Pooled over verbs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recent Filler</td>
<td>1081 (78)</td>
<td>1059 (77)</td>
<td>1071 (78)</td>
</tr>
<tr>
<td>Distant Filler</td>
<td>1130 (72)</td>
<td>1199 (61)</td>
<td>1165 (66)</td>
</tr>
<tr>
<td>Mean</td>
<td>1106 (75)</td>
<td>1129 (69)</td>
<td>1118 (72)</td>
</tr>
</tbody>
</table>

Table 3.  

*Mean reaction times, 'Got it' responses (with percentage 'got it' responses in parentheses)*

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Present</th>
<th>Absent</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Recent Filler</strong></td>
<td>1055 (72)</td>
<td>1085 (83)</td>
<td>1070 (78)</td>
</tr>
<tr>
<td><strong>Distant Filler</strong></td>
<td>1129 (65)</td>
<td>1200 (67)</td>
<td>1165 (66)</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>1092 (69)</td>
<td>1142 (75)</td>
<td>1117 (72)</td>
</tr>
</tbody>
</table>

subjects and sentences analyses, respectively). The mean reaction times appear in Table 2. The difference in comprehension time between Recent and Distant Filler sentences was 101 msec for sentences whose complement verb could countenance either form, while it was 87 msec for sentences whose complement verb forced one reading or the other. An analysis of the percent 'got it' responses also revealed the inferiority of Distant Filler sentences for both ambiguous and unambiguous verbs; the interaction between ambiguity and sentence form was nonsignificant in both analyses.
Decision principles and structure in sentence comprehension

(\(F_1(1,47) = 1\); \(F_2(1,47) = 1.78\)). (The main effect of verb ambiguity approached significance, \(F_1(1,47) = 2.73\); \(F_2(1,47) = 2.61\); \(p < 0.10\); 70% indicated comprehension for ambiguous verbs, 74% for unambiguous verbs.) These findings invite the conclusion that readers use control information only after they have applied the Most Recent Filler strategy.\(^3\)

The effect of presence versus absence of a sentence-final adverbial phrase is shown in Table 3. There was a nonsignificant tendency for comprehension times to be faster when the final phrase was present than when it was absent, \(F_1(1,47) = 3.84\), \(p = 0.06\); \(F_2(1,47), p < 1\). The fact that presence of a sentence-final adverbial phrase decreased the percentage of indicated comprehension responses (min \(F'(1,92) = 4.55, p < 0.05\), possibly more for Recent Filler than Distant Filler sentences (min \(F'(1,93) = 2.75, 0.10 > p > 0.05\)) complicates the interpretation of the effect of adding a final adverbial phrase. The clearest conclusion to draw from Table 3 is that the effect of Recent versus Distant Filler was clearly, and significantly, present, regardless of presence or absence of the adverbial phrase, indicating that the effect was not trivially due to the final preposition being easier to read than other sentence-final words.

While presence of a relative pronoun only marginally facilitated sentence comprehension in general (\(F_1\) and \(F_2 < 1.0\) in the reaction time analysis; min \(F'(1,87) = 3.14, 0.10 > p > 0.05\) in the percentage comprehension analysis), the relative pronoun appeared to enter into a most interesting interaction with sentence form. Presence of a relative pronoun reduced the effect of Recent versus Distant Filler (\(F_1(1,47) = 6.05, p < 0.02\), but \(F_2(1,47) = 1.36, p > 0.10\), in the reaction time analysis; min \(F' = 5.61, p < 0.05\), in the percentage indicated comprehension analysis; see Table 2). The effect of Recent versus Distant Filler was 49 msec (still significant at the 0.05 level) when the sentence contained a relative pronoun, but 140 msec when it did not (and 6% versus 16% in the analysis of percentage indicated comprehension). The apparent interaction held true whether or not the verb was

\(^3\)Kaplan (1974) used a visual monitoring technique to measure the difficulty of processing sentences similar to our unambiguous sentences. His results could be interpreted either as showing increasing processing difficulty late in Distant Filler sentences, or increased processing difficulty early in the processing of Recent Filler sentences. The former interpretation is consistent with our claim that reanalysis of an incorrect filler-gap assignment takes place late in Distant Filler sentences, while the former is consistent with Kaplan's interpretation in terms of memory load produced by keeping an item in the HOLD cell. However, interpretation of the results is made very difficult by Kaplan's use of such a slow presentation (as slow as one word per second) that his subjects may have been able to use semantic control information to constrain their initial interpretation of the sentence. Similarly, Wanner and Maratsos (1978) tested the comprehension of sentences similar to our unambiguous experimental sentences. But again a comparison of results is difficult because in that study the presentation of a sentence was interrupted for a 5 second period (for presentation of a memory task), perhaps facilitating or permitting early use of control information.
ambiguous or unambiguous (top two panels of Table 2). The effect of the relative pronoun can be understood in terms of the salience interpretation of the Most Recent Filler strategy, under which the sentence processing mechanism first assigns the most salient and easily retrieved potential filler to the gap. The relative pronoun could make the noun phrase immediately before it, the head of the relative clause, more salient as a filler, and thus more likely to be assigned to the first-encountered gap.

Table 4. Percentage of correct answers to questions (considering only within sentence responses)

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Verb</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ambiguous</td>
<td>Unambiguous</td>
</tr>
<tr>
<td>Recent Filler</td>
<td>72</td>
<td>83</td>
</tr>
<tr>
<td>Distant Filler</td>
<td>71</td>
<td>84</td>
</tr>
<tr>
<td>Mean</td>
<td>72</td>
<td>84</td>
</tr>
</tbody>
</table>

The final data to be discussed concern the answers subjects made to the questions asked of 1/3 of the comprehended sentences. Table 4 presents the percentage of all answers to these questions which were correct, after eliminating those trials on which subjects made no response, or gave an answer which used words not in the sentence questioned. Two points may be noted about the data in Table 4. First, accuracy was as high on the presumably harder Distant Filler sentences as on the Recent Filler sentences. Recall, though, that questions were asked only when subjects indicated successful comprehension of a sentence, a more frequent event for Recent Filler than for Distant Filler sentences. Second, accuracy was higher for sentences with unambiguous verbs than for sentences with ambiguous verbs, 84 versus 72% \((t(23) = 2.73, p < 0.01, \text{ in an analysis allowing generalization to other sentences})\). This pattern of results implied that the initial 'got it' response does indicate successful structural analysis of a sentence, but that other factors, presumably associated with verb control information, operate in allowing full understanding and retention of a questioned sentence.

Discussion of Experiment 1

The basic findings of the experiment confirm the predictions of the Recent Filler Strategy. Distant Filler sentences were more difficult to comprehend
than Recent Filler sentences, as indicated both by the response time measure and by the percentage of comprehension ('got it') responses. This 'recent filler effect' held equally for verbs whose control properties were ambiguous and those whose control properties were unambiguous, indicating that control information does not constrain initial filler-gap assignment. However, control information did facilitate some stage of comprehension, as indicated by the question accuracy data. Subjects were more often correct in their answers to questions containing unambiguous verbs.

The question accuracy data could indicate that it takes subjects more time to arrive at or process a deeper semantic representation for the sentences with ambiguous verbs than for sentences with unambiguous verbs. Alternatively, this result might simply indicate that at times subjects had problems remembering a sentence that was questioned. Under this circumstance, we would expect questions about sentences with unambiguous verbs to be answered more accurately than sentences with ambiguous verbs simply because of the stronger constraints imposed by the unambiguous verbs (just as we would expect more consistency for these verbs in an anagram task).

Before discussing the implications of these findings for the questions with which we began, we will consider an alternative to the interpretation we have given the data, and report an experiment which bears upon it.

It is possible that the Recent Filler effect occurred for one reason in the case of sentences with ambiguous verbs but for a different one in the case of sentences with unambiguous verbs. If this were the case, then we could not argue that the use of control information was delayed. There are reasons to claim that the basis of the effect was, in fact, the same for ambiguous and unambiguous verbs. First, the size of the effects in the two cases was closely comparable. Second, the presence of a relative pronoun had the effect of facilitating comprehension of Distant Filler but not Recent Filler sentences, and this effect did not differ between ambiguous and unambiguous verbs. We interpret the relative pronoun effect in terms of 'salience', as suggested earlier. Presence of the relative pronoun makes the head of the relative clause more available as a filler, and it is the filler that must be assigned to the first gap in Distant Filler sentences. It seems unlikely that the effect of the relative pronoun

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4 Following a suggestion by Marilyn Ford (personal communication) we examined those sentences which could be considered to focus upon the head of the relative clause (the distant filler) either by introducing it with a demonstrative there-phrase ("There goes the police chief who...") or with an equative copula ("The mayor is the crook who..."). Such sentences might make the distant filler relatively salient, compared to sentences in which the head of the relative was not focused ("Everyone liked the woman who..."), and thus reduce the Recent Filler effect. In fact, Recent Filler effects closely comparable in size, and not significantly different from each other, were found for both focus and non-focus sentences.
upon the size of the distant filler effect would be the same for ambiguous and unambiguous verbs if the distant filler effect occurred for different reasons in the two cases.\(^5\)

A third argument concerns one plausible reason for the existence of a difference between the comprehensibility of Recent Filler and Distant Filler sentences for unambiguous verbs, but requires additional data to assess. Consider the possibility that the Distant Filler sentences with ambiguous verbs are difficult for the reasons we have suggested, but that, when the verb is unambiguous in its control properties, the proper filler-gap assignment is made initially. However, unambiguous Distant Filler sentences are more difficult than unambiguous Recent Filler sentences because the former have two postverbal gaps to fill, while the latter have only one. This suggestion rests upon an analysis in which the unambiguous Distant Filler verbs used in the experiment have obligatory objects, phonetically null in the sentences used, while the unambiguous Recent Filler verbs do not:

\[(17a) \text{This is the girl who the teacher decided } \underline{\text{to talk to}} \underline{\text{.}} \]
\[(17b) \text{This is the girl who the teacher forced } \underline{\text{to talk.}} \]

(The two adjacent gaps in the Distant Filler sentence are filled with the same filler.\(^6\)) Identifying and filling two adjacent gaps might be harder than identifying and filling a single gap (plus the gap after the preposition).

This suggestion for the relative difficulty of unambiguous Distant Filler sentences can be tested by comparing different ambiguous verbs. Some of the ambiguous verbs we used are commonly analyzed as having two gaps after the main verb of the relative clause, when used in Distant Filler sentences, while others are commonly analyzed as having only one (Rosenbaum, 1967). In particular, the ambiguous verbs ‘choose’ and ‘ask’ substituted for ‘forced’

\(^5\)An alternative explanation, that the distant filler effect simply is smaller in easier sentences, and the relative pronoun made sentences easier, seems to be ruled out by the data. While relative pronouns did make sentences easier, at least in the ‘\% got it’ analysis, it was not the case that easier sentences in general showed a smaller distant filler effect. The correlation between a measure of sentence comprehensibility (the percentage ‘got it’ responses over all forms of a sentence) and the size of the recent filler effect (the average RT difference between Distant Filler and Recent Filler forms of the sentence) was \(+0.18\), showing a nonsignificantly larger recent filler effect for the easier sentences.

\(^6\)There are various situations in which the same filler (i.e. a single lexically-specified phrase) must be assigned to more than one gap, including the Across-the-Board extractions discussed in Williams (1978) and the parasitic gaps discussed by Engdahl (1982), in addition to the adjacent gap constructions discussed in the text. Though any proposal about the assignment of filler-gap dependencies must eventually say something special about these situations, we are not currently in a position to tease apart various possibilities which differ significantly in their details. However, we must emphasize that this inexplicitness in our account does not undermine any of the arguments presented in this paper, since the only claim crucial to our arguments is that one or both of the adjacent gaps will incorrectly be assigned to the most recent potential filler.
in sentence (17b) seem to have an object gap as well as the gap in subject position of the complement clause, while 'want' and (ambiguously) 'expect' seem not to (as indicated, for example, by the ability of these words to be followed by existential there, which occurs only in subject position). None have double gaps in Recent Filler sentences. If filling two adjacent gaps is harder than filling one, and if this source of difficulty adds to the effect of the Most Recent Filler Strategy, then the difference between Distant Filler and Recent Filler sentences should be greater for 'ask' and 'choose' than for 'want' and 'expect'. Experiment 1 was not designed to detect such an effect, since different sentences were used for each verb. Experiment 2 was conducted to determine whether such an effect existed, as well as to replicate some parts of Experiment 1. Failure to find a difference between the different verbs in the size of the recent filler effect would constitute evidence against the alternative interpretation of the effect offered for unambiguous verbs.

Experiment 2

Method

Seventy-two college students were tested in a procedure substantially identical to the one used in Experiment 1. Twenty-four of the 96 experimental sentences they received were chosen from the experimental sentences of Experiment 1, with the criterion that they would be semantically plausible with any of the verbs want, expect, ask, and choose. Two of these 24 sentences were presented on each of 12 blocks of eight sentences each, together with four of the distractor sentences from Experiment 1, and two sentences with other types of verb phrase complements included as a distinct experiment. Counterbalancing and randomizing procedures were used to ensure that each subject received equal numbers of the four critical verbs, and that each of the 24 sentences was presented with each of these verbs to 18 different subjects.

Results

Table 5 presents the data for both the comprehension reaction time and percentage indicated comprehension measures. Recent Filler sentences were comprehended more easily than Distant Filler sentences, both in the reaction
Table 5. Mean reaction time, "got-it" responses (with percentage "got-it" responses), Experiment 2

<table>
<thead>
<tr>
<th>Verb</th>
<th>Recent Filler</th>
<th>Distant Filler</th>
</tr>
</thead>
<tbody>
<tr>
<td>want</td>
<td>980 (83)</td>
<td>1168 (59)</td>
</tr>
<tr>
<td>expect</td>
<td>997 (82)</td>
<td>1082 (67)</td>
</tr>
<tr>
<td>ask</td>
<td>969 (81)</td>
<td>1132 (72)</td>
</tr>
<tr>
<td>choose</td>
<td>915 (84)</td>
<td>1050 (66)</td>
</tr>
</tbody>
</table>

Time analysis (a 142 msec effect; min $F'(1,185) = 11.69$) and in the percentage indicating comprehension analysis (an effect of 16 percentage points; min $F'(1,62) = 3.208$). Both these differences were significant for each individual verb. The interaction between sentence form and particular verb was thoroughly nonsignificant in the reaction time analysis ($F_1(3,213) = 1.16$; $F_2(3,69) < 1$) although there was a possible main effect of verbs; $F_1(3,213) = 3.16$, $p < 0.05$, but $F_2(3,69) = 1.36$, $p < 0.25$). A marginal interaction appeared in the analysis of percentage indicated comprehension, $F_1(3.213) = 2.83$ and $F_2(3,69) = 2.84$, $p < 0.05$; but min $F'(3,208) = 1.41$, $p > 0.10$. Inspection of Table 5 indicates that the differences among the different verbs are hardly systematic, differing substantially between the two measures. The verbs which should have shown a larger difference between Recent and Distant Filler sentences, ask and choose, did show a marginally larger difference than the other verbs, want and expect, 150 versus 137 msec. However, the difference reversed in the percentage comprehension measure, 13.2 versus 19.0 percentage points. One must conclude that there is no evidence to support the hypothesis that some, or all, of the effect of Recent versus Distant Filler sentences is due to the requirement of filling two gaps rather than one in some Distant Filler sentences.

The question accuracy data paralleled those of Experiment 1. Questions of Distant Filler sentences and of Recent Filler sentences, were answered with equal accuracy, 60% versus 64%, $t(50) = 0.43$.

4. Discussion

We will assume that our experiments have demonstrated that readers follow a simple and immediate decision procedure for assigning fillers to gaps, and that they do not consult verb control information in making their initial assignment. We have characterized the decision principle as the Most Recent Filler Strategy, and suggested that this strategy may be reduced to a general
salience principle, thereby accounting for the experimental evidence concerning the differential effect of the presence of a relative pronoun on the Distant Filler versus Recent Filler sentences and also for the intuitive evidence concerning the effect of stress on filler-gap assignments.

The most surprising result of the experiments is the failure to find a difference in the processing of sentences with ambiguous versus unambiguous verbs. We have interpreted this finding to mean that the semantic control information which disambiguates the unambiguous sentences is not consulted when an initial filler-gap assignment is made. To explain the recent filler effect one way for ambiguous sentences, and another way for unambiguous sentences (which would be required by a claim that subjects did use the verb control information immediately) would force one to claim that the substantial similarities we have noted between these types of sentences are totally accidental. We believe that the simplest, and most justifiable, assumption is that the unambiguous sentences act as if they are ambiguous because they are effectively ambiguous due to the delayed use of semantic control information.

Notice that this interpretation does not entail that no lexical information is used by the processor prior to the construction of its syntactic representation of these sentences. Rather, what it implies is that semantic control information may be used or checked separately from information about, say, the lexical category of an item. This could be true regardless of whether semantic control information is computed by rule from the thematic structure of a lexical item (or from the structural configuration it occurs in) or whether the control properties of a verb are listed as an arbitrary property of the lexical item. We will now examine the implications of this finding.

4.1. Explanations for delayed use of information

We briefly review two types of answers that have been considered in the past to the question of why the language processor would delay using helpful information that could prevent an initial erroneous analysis of some sentences. We will then introduce a third type of answer.

The first possibility is that the basic architecture of the processing system simply makes it impossible for the processor to use certain types of information at early stages in the processing of a sentence. If we assume that control information is listed as semantic information in the lexical entries for individual verbs, this possibility would support the very strongest interpretation of the autonomy principle proposed by Forster (1979). On this interpretation, absolutely no semantic information can influence the initial syntactic processing of sentences, regardless of whether the semantic in-
formation is listed in the lexicon or is the result of semantic or 'message' level processing.

A second possibility is that the use of certain information types is delayed not because of external constraints imposed by the architecture of the processing system but only because of inherent differences in the time needed to perform various computations. Apparent structure in the use of different information types might arise only because two computations, even when begun at the same time, are completed at different times. Under such circumstances, the execution of some relatively quick processing operation would not be constrained by the output of a slower computation, unless the quicker operation were logically dependent on the outcome of the slower. Conceivably, use of control information is delayed merely because it takes the processor a long time to look the information up in the lexicon, or perhaps to compute the default control structure prior to looking up exceptions (cf., Williams, 1980), relative to the time needed to apply the Most Recent Filler strategy.

We suggest a third possibility which we believe has intriguing implications both for the processing mechanism and for theories of grammar. Note that determining the grammatical status of a phonetically null noun phrase (a gap) is not trivial. It requires integrating a large number of different facts about the particular lexical items in the sentence, about possible phrase structure configurations, about binding relations, etc. Depending upon what the grammatical status of a gap is, different conditions constrain the appropriate assignment of a filler to it. Consider (18a) through (18f):

(18a) Who does Susan want ____ to marry a rich man?
(18b) Susan always seems ____ to marry rich men.
(18c) Susan wants ____ to marry a rich man.
(18d) Susan wants a rich man ____ to impress her friends with ____.
(18e) Susan wants a rich man ____ to impress her friends.
(---) (------)
(18f) Susan bought some strawberries ____ to put ____ on the shortcake.
(---)
(note, someone else may put the strawberries on the shortcake.)

The empty noun phrase in the subject position of the infinitival clause may be the trace of a wh-dependency as in (18a); it may be the trace of an NP movement rule as in (18b); it may be a phonetically null pronoun (PRO) which is obligatorily coindexed with a particular noun phrase in the sentence.
as in (18c) or may be a PRO whose interpretation is pragmatically controlled as in (18d), (18e) and (18f). 7

The comprehension mechanism could be constructed to consider all available information at the point of a gap in determining the proper filler, or it could be constructed to make an initial assignment on the basis of a lesser amount of information. (We maintain our assumption that it is constructed to make some single assignment quickly.) If it were constructed in the former way, it would be faced with the need to integrate a substantial amount of information quickly, but, nonetheless, would still run the risk of making an incorrect assignment. The various types of filler-gap dependencies are in many cases distinguished only by information which comes after the gap, resulting in a temporary horizontal ambiguity concerning the proper filler assignment. The comprehension mechanism might be designed to delay the use of certain types of information until they could be interpreted unambiguously (perhaps at the end of certain structural domains), and to rely on a 'quick and dirty' strategy for making initial filler-gap assignments. Such a design could reduce total processing load, at the cost of introducing some additional temporary vertical ambiguities.

Note that this alternative does not claim inherent ordering of information use merely due to the time taken to perform some computation. Rather, it implies that an overall simplification in the processing of sentences is obtained by delaying certain computations, computations concerning control information in the present case. The general principle this alternative suggests is that certain complex computations occur later in the processing

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7 The precise grammatical constraints governing non-obligatory controlled gaps are just being worked out now. Recent studies suggest that the classification of the dependencies in (18) especially (18d)--(18e) must be refined considerably. Williams (1980) argues that all verbs which permit either a lexical subject or a controlled (phonetically null) subject to occur in their complement (e.g., (18c) in text) should be considered cases of nonobligatory control and thus contrasted with verbs like try which only permit null subjects to appear in their complement. Nishigauchi (1981) argues that the class of nonobligatory controlled gaps must be subdivided into thematically-controlled and pragmatically-controlled cases. In cases of thematic control, there must be a single (non-split) unique antecedent within the sentence (if one is available) which is determined by the thematic role of the phrase. By contrast, in cases of pragmatic control, the antecedent is not thematically determined and need not occur in the same sentence as the gap, as illustrated by the contrast between (i), a case of pragmatic control, and (ii), a case of thematic control (these examples are taken from Nishigauchi); further, a split antecedent is possible in cases of pragmatic control.

(i) John believes that it would not be advisable ______ to serve one's husband that way.
(ii) *John wonders how ____ to entertain one's husband.

See Koster (1981) for further discussion of these issues; see Faraci (1974) and Bach (1982) for discussion of purpose clauses and in-order-to clauses; see Jackendoff (1972), Roeppe (1981) and Wright (1980) for discussion of control in nominals and compounds. Also, see Fodor (ms.) for an attempt to explain the particular control properties associated with individual verbs in terms of maximizing the expressive power of the language.
of a sentence than is logically necessary because the results of the computations may have to be revised when subsequent context is processed. Performing simpler computations first may result in an overall optimization of processing effort because the outcome of the simpler computations may facilitate the execution of the more complex ones, or render them unnecessary. (See Bien, 1980, for a similar principle concerning resource allocation in natural language processing.)

Some reasons for the efficiency of a heuristic filler-gap assignment strategy are suggested by comparing filler-gap assignment processes with the resolution of temporary ambiguities involving the phrase structure relations between lexically specified items. In applying heuristics to guide its analysis of items in temporarily-ambiguous constituent structure relations, the processor seems not to postulate ungrammatical analyses (Frazier, 1978; Frazier and Fodor, 1978; Kimball, 1974). A chosen analysis may prove to be ungrammatical for the sentence being analyzed, but it will at least be a grammatical analysis for some sentences with the same initial string of words. In the case of phrase structure dependencies involving lexically present items, the processor at least knows what kinds of dependencies are involved and what kinds of constraints are applicable, namely, those contained in the phrase structure rules of the language. By contrast, filler-gap dependencies can be of a variety of different types. Determining what constraints are applicable may involve checking all of the different types of

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8 As usual, there are questions about the level at which a functional explanation such as this one holds. Efficiency considerations might apply during the course of evolution to shape the fundamental characteristics of a child's processing mechanism. Alternatively, they might operate as an evaluation metric during the language acquisition process itself, leading a child to discard less efficient processing routines for a more efficient set of routines wherever there is leeway in the developing language comprehension system. We will not attempt to distinguish between these two possibilities here.

9 One possible exception to this claim derives from intuitions about the processing of sentences in which a very short constituent follows a long constituent that separates the short constituent from its legitimate attachment site. For example, intuitions suggest that the word *down* in (i) is initially (ungrammatically) analyzed as a constituent of the noun phrase "the sweater, the bat, the ball and the glove down", rather than being correctly attached as a sister of the verb *throw* (see discussion in Frazier and Fodor (1978), especially note 19.

(i) The little girl angrily threw her sweater, the bat, the ball and the glove down.

To our knowledge, the only examples of this type where there is any conscious awareness of having constructed an ungrammatical phrase marker occur with short items that tend to be unstressed and thus perhaps the phonetic confusability of such items is partially responsible for this anomaly. (Consider the role of the phonetically similar phrase *[years in n years out]* in the processing of the final phrase in "Julia threw the clippings that she'd been saving for years and years out", to be contrasted with "Julia threw the food that she'd been eating for hours and hours up.")

10 Even in the case of constituent structure relations between lexically specified phrases the situation is not totally straightforward because of their interaction with filler-gap dependencies. In fact we believe that this interaction may be the underlying reason for why any initial filler-gap assignments are made during the early phrase-structure parsing of a sentence, as discussed below in the text.
constraints (e.g., constraints on movement rules, constraints on control relations, etc.) to see which would (a) countenance the postulated dependency as a grammatical dependency and (b) lead to a well-formed analysis of the entire sentence.

We think this fact may underlie the computational savings achieved by the processor's reliance on a superficial filler-gap assignment strategy. The frequency facts and locality constraints of English will insure that a recent (or salient) filler assignment will often turn out to be reasonable and grammatically permissible. In some sentences where it is not, superficial information will become available later in the sentence to rule out an incorrect recent filler assignment, namely, the fact that an obligatory filler has not been assigned to a gap. Thus, frequently, the detailed constraints on filler-gap dependencies will prove to be satisfied, even though initial filler-gap assignments are made on the basis of more superficially available information.

Two potential further advantages of the superficial strategy approach may be seen if some additional assumptions are made. First, if it is assumed that pragmatic plausibility information concerning some phrase is available only late in processing, then in the case of pragmatically controlled dependencies (e.g., (18e) and (18f)), a delay in consulting grammatical constraints on filler-gap dependencies will permit an incorrect recent filler assignment to be corrected at a stage when information relevant to the appropriate (pragmatically-controlled) assignment is available. Similarly, for thematically-controlled dependencies (see footnote 7), the processor will not have information concerning the appropriate filler-gap assignment until it has received sufficient information from the complement of a verb to determine which of the thematic structures associated with the verb is relevant to the particular sentence under analysis. (Typically, one or more of the arguments of a verb is optional, examples like put being the exception rather than the rule in English.)

Second, it might be inefficient to apply the grammatical constraints relevant to filler-gap dependencies early in the processing of a sentence if it turns out that these same constraints may have to be checked again later in the processing of the sentence anyway. Whether this will be necessary depends crucially on the precise statement of the constraints and whether the constraints apply to other grammatical relations in addition to filler-gap dependencies or refer to properties of representations not available in a surface structure that has been annotated with indices. For example, appeal to Logical Form may be necessary to capture the coreference possibilities between the variable of a wh-phrase (which is available only after wh-interpretation has taken place) and a pronoun which the wh-phrase has
‘crossed-over’ (to account for the fact that coreference is possible in (19a) but not in (19b); see the discussion of ‘crossover’ in Freidin and Lasnik, 1981).

(19a) Who read his book?
(19b) Whose book did he read?

If the coreference possibilities are stated in terms of the legitimate coin dexing of a phrase marker (e.g., the removal under certain circumstances of The referential index of all c-commanding phrases), it is arguably more efficient to build up a representation that is legitimate according to the phrase structure rules of the language and includes some set of indices and then later check the indexing of that representation to insure that it conforms to a well-formed logical form, than to consult some grammatical constraint every time a processing decision relevant to the constraint is made.

The superficial-assignment-with-filtering view we have proposed does seem to suffer one serious logical drawback. If it is true that the comprehension mechanism resorts to a superficial heuristic because of the uncertainty and complexity of determining the type of filler-gap dependency it is dealing with, then why should it make any initial filler-gap assignment at all early in processing? Why shouldn’t it delay making an assignment until it checks the relevant grammatical constraints? We believe this concern is addressed by noting that filler-gap assignments interact with the phrase structure parsing of a sentence (see discussion in Fodor, 1981a, for example). The analysis of lexically present phrases is affected by the presence or absence of gaps. Gaps which occur in obligatory positions in a sentence (‘doubtless’ gaps) do not pose any particular problem because they will automatically be discovered by a phrase structure analysis of the sentence (cf., Fodor, 1978, 1979). However, ‘doubtful’ gaps, those which occur where optional material may occur, also affect the analysis of lexically present phrases. Determining whether a doubtful gap is a true gap depends on whether there is a filler available to assign to it. The processor must at least check for the presence of a phrase that could serve as a legitimate filler for that doubtful gap under some type of filler-gap dependency if it is to determine whether a gap could exist. In principle, this might be accomplished without actually making the filler-gap assignment. However, it seems plausible that very little additional effort is required to go ahead with making the filler-gap assignment (i.e., coindexing the filler and the gap). In fact, it would seem inefficient to delay making the assignment, since the assignment must be made eventually, and a very simple superficial strategy is available which will often result in the correct assignment.
4.2 Potential relevance to grammatical theory

We have suggested a view of sentence processing in which a phrase structure representation for some portion of a sentence is built up quickly, using conventional phrase structure rules (cf., Frazier and Fodor, 1980) and a superficial heuristic strategy to coindex fillers and gaps. The legitimacy of the indices on the representation is checked later, over some domain the size of which is an open question.

This view of sentence processing is consistent in interesting ways with some major developments in linguistic theory over the past fifteen years, namely, the move to replace constraints on the derivation of a sentence (cf., Chomsky, 1965, 1975; Ross, 1967) with constraints on representations (Chomsky, 1980, 1981), and the concommitant development of a clear ‘modularity’ in the grammar. The change from constraints on derivations to constraints on representations is important to the development of a model of processing because it allows constraints to be stated in terms of a single level of representation, an elaborated surface structure, which there is good reason to believe is a representation the human sentence processor must compute. Constraints no longer need be stated in terms of how rules map one abstract representation of a sentence onto another. Thus, the constraints are stated in a form more easily adapted to the needs of a processing model.

The modularity of recent Chomskian grammars consists in the fact that there are distinct sets of principles and constraints to which a representation must conform in order to be well-formed. Principles concerning the generation of phrase markers, for instance, are distinct in their properties from constraints concerning coindexing. The existence of distinct sets of principles and constraints gives rise to the possibility of certain natural organizations of the processing system. The claim that there are distinct components in our linguistic knowledge permits (though it does not dictate) the claim that there are corresponding components in our language comprehension mechanism, and that these components operate at different points in time in the comprehension of a sentence. For example, some contemporary grammars have phrase structure rules, limited transformational rules, and index-assignment conventions which overgenerate. These are distinct from one or more types of structure-evaluating constraints which reject or accept as well-formed the products of the structure-building rules. This distinction in type of linguistic knowledge permits and encourages the postulation of a parallel distinction in a processing model, a distinction which we believe our evidence requires.

The view of sentence comprehension we have advanced contrasts with a view that all grammatical constraints are checked at each step in the parsing...
of a sentence (i.e., that each parsing decision is immediately checked against every constraint). This latter view is itself consistent with some current linguistic theories other than Chomsky's. Fodor (1981) has argued that the true advantage of a Generalized Phrase Structure Grammar of the sort proposed by Gazdar (1981) stems precisely from the fact that no filters or independent set of syntactic constraints need be laid over the phrase structure rules of the language. In such a system, the constraints on filler-gap dependencies are inherent in the set of phrase structure rules available in the language, at the cost of an increase in the number of nonterminal symbols in the grammar. The 'nonmodularity' of the syntax of such a grammar discourages the development of a parsing model in which there are distinct categories of syntactic information, some of which are consulted before others. In the type of parsing model which seems to fit naturally with this homogeneous syntax, the processor would simultaneously consider dominance relations of lexically present phrases and filler-gap dependencies, so that all the well-formedness conditions constrain the initially-constructed representation of the sentence. We note that this view seems to complicate the comprehension of very simple sentences, since, to apply the filler-gap constraints as one builds a phrase structure representation, one must detect all optional fillers and keep track of the constraints on positions of potential gaps, even in sentences where no gap occurs, e.g., 'Mary wanted a cookie'. We also note that a parsing model constructed from this perspective would have to provide totally independent explanations for the recent filler effect found in the ambiguous sentences and the recent filler effect found in the unambiguous sentences. The former could arise as a result of garden-pathing, much as we have suggested, since the ambiguous verb would permit a reader to initially construct a recent filler analysis for a distant filler sentence. The latter could not, because by hypothesis the parser would use the information that the unambiguous verb permits only certain filler-gap assignments when it made its initial assignments, and thus would not consider a recent filler analysis for a sentence with an unambiguous distant filler verb, such as 'forced'. The inferiority of unambiguous distant filler verbs would have to be attributed to some other characteristic of unambiguous distant filler sentences. We have argued against separate accounts of the recent filler effect for ambiguous and unambiguous sentences and, in Experiment 2, presented data which weigh against one particular version of such an account.

5. Conclusion

We have provided experimental evidence for a Most Recent Filler strategy as the guiding heuristic covering the assignment of dependencies between
lexically specified phrases and phonetically null positions, and suggested that the strategy might be generalized slightly to a 'salience' strategy, where recency is simply the most powerful variable affecting salience. Evidence for the strategy was obtained in sentences containing two types of verbs, some ambiguous, others unambiguous in their control properties, suggesting that control information does not constrain initial filler-gap assignments.

We presented three alternative explanations concerning why the use of this and other potentially helpful types of information might be delayed during sentence comprehension. According to one explanation, the delay is the result of the basic architecture of the sentence comprehension mechanism and constraints on the passing of information between different processors. A second explanation attributed the delay to an inherent ordering arising from the time it takes the processor to perform different computations. We focused on a third explanation, which claimed that delaying certain types of complex operations results in an overall simplification in processing when the results of those operations are in any case subject to later revision due to the temporary confusability of different types of dependencies.

This final alternative encouraged a contrast between two fundamentally different views of the language comprehension process. On one view, which fits naturally with a Chomskian style grammar (but is not entailed by it) phrase structure rules and superficial strategies (such as the Most Recent Filler strategy) are used to make initial analyses of sentences, which are later checked against other (structure-evaluating) grammatical constraints of the language. The alternative view, which would fit most naturally with a Generalized Phrase Structure Grammar (or any grammar which directly defines all of the syntactic structures of a language with a single set of rules or principles) claims that all relevant grammatical constraints are checked as the phrase structure representation of a sentence is constructed. Our evidence favors the former view.

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Résumé

L'intérêt théorique d'une caractérisation grammaticale correct des phrases où se trouvent des dépendances entre un syntagme lexicalement spécifié et une position phonétiquement nulle dans l'indicateur syntagmatique (filler-gap dependencies) est considérable en linguistique. Dans certains schémas grammaticaux ces dépendances sont représentées en termes de conditions sur l'indexation permise des structures (ou sur les conditions d'évaluation de différentes structures) auxquelles une représentation doit adhérer pour être bien formée. Dans d'autres schémas, les contraintes sur les dépendances 'filler-gap' permises sont simplement inhérentes aux règles de structure syntagmatiques dans la grammaire d'une langue.

Deux expériences ont permis l'étude du traitement des phrases avec des dépendances 'filler-gap' multiples (potentielles). La première expérience permet trois affirmations. Premièrement, le processeur de phrases utilise une stratégie qui consiste à assigner le "filler" recent potential à la position nulle la plus récente. Les phrases 'recent-filler' où cette attribution est correcte sont comprises plus rapidement que les phrases 'distant filler' où cette attribution se révèle incorrecte. Deuxièmement, la stratégie 'recent filler' n'est elle-même qu'un cas spécial d'une stratégie plus générale qui consiste à attribuer le 'filler' potentiel le plus puissant à la position nulle. Troisièmement, les phrases non-ambiguës où l'attribution 'filler-gap' est désambiguëe par l'information 'contrôle' fournie par des verbes particuliers donnent lieu au même type d'erreurs que les phrases ambiguës. Cela suggère que les essais d'attribution 'filler-gap' sont effectués par le processeur avant qu'il ait consulté toutes les contraintes pertinentes sur les dépendances filler-gap permises.

Dans la seconde expérience on a testé l'hypothèse différente selon laquelle les phrases plus complexes 'distant filler' seraient plus longues à comprendre car leurs verbes permettent souvent deux positions nulles adjacentes. L'expérience montre un effet du 'filler-gap récent' dans des phrases ne contenant pas de nuls adjacents; cet effet n'interfère pas avec la clause du verbe.

Il est surprenant que le processeur retarde l'utilisation-contrôle du verbe. On peut expliquer cela par le fait que cette information n'est pertinente que pour un type de nul ('equi-gaps') et que le type de 'gap' traité par les processeurs ne peut souvent pas être déterminé de façon non-ambiguë au moment où il est rencontré dans le traitement de gauche à droite d'une phrase.

Si l'interprétation des résultats est correcte, ceux-ci révèlent que le système de compréhension des phrases est très structuré. Ces résultats favorisent un traitement des phrases où les opérations de traitement impliquent des contraintes sur l'indexation (ou l'évaluation) permise des structures postérieure aux opérations du processeur pour construire la structure.

Ces résultats favorisent donc les théories grammaticales qui préserver cette distinction aux dépens des théories qui donnent une caractérisation uniforme des conditions syntaxiques de bonne formation.