Chapter 8

Conceptual Knowledge, Modularity, and Discourse

Language exhibits simultaneous levels of structural representation. This raises an issue concerning the level at which the analysis-by-synthesis cycle occurs. The most salient levels are the word, phrase, clause, sentence, and discourse. We have focused on the clause and sentence levels for several reasons. Clauses and sentences are highly structured, which sets a crucial problem for models that assign structure directly. The clause and sentence levels are highly productive, which is a crucial problem for template and statistical models. The clause and sentence levels are the critical interface between form and compositional meaning, at which sufficient information is available to form complete propositions. As outlined in chapter 3, these levels are the minimal level for representation of fully productive recursion. By hypothesis, a specific sentence structure is not directly constrained by its meaning.

In this chapter, we first develop the idea that analysis by synthesis in fact may apply at each natural level of analysis. In each case, there is an initial pseudosyntactic component that assigns an approximate structure followed by a synthetic component that checks it for completeness. This provides a natural account for the strong intuition that comprehension builds up incrementally as we encounter sentences, rather than waiting until the end of each major unit. We then review recent evidence of the computational modularity of syntax processing independent of conceptual information. Finally, we review experimental evidence for how the sentence level of comprehension interacts with discourse-level structures and the relations between connected clauses.

8.1 Parallel Syntactic and Semantic Analyses

A strict interpretation of LAST for the sentence level would seem to require that the final analysis and interpretation occur only at the end of the sentence. This unlikely event is also a potential characteristic of many of the structural models that we reviewed in chapter 4, which assign structure independently of and prior to semantic analysis.

However, *all* models that give priority to the sentence level can accommodate the appearance of ongoing comprehension by postulating that meaning is computed "in parallel" with syntax. It is worth examining how this intuitively appealing notion cashes out in detail. It implies two parallel syntactic computations, the one that applies automatically to the incoming forms and one that provides the basis for semantic analysis of incomplete information. Thus, "parallel" assignment models have an inherent circularity at worst and a duplication of processes at best.

Consider our favorite example, as it appears word by word:

(1) The horse raced past the barn.

(2) a. The
    b. The horse
    c. The horse raced
    d. The horse raced past
    e. The horse raced past the
    f. The horse raced past the barn.

Let us assume a structural model in which syntactic and semantic analyses are pursued in parallel. A theoretically critical point is just after the first complete noun phrase *the horse*. In a structure-first model, this is assigned a phrase-level "noun phrase" as a function of fitting the pattern of "determiner noun." That phrase can then go to the parallel semantic analyzer, where several things happen. First, the conceptual analysis of *the horse* can be assigned. At the same time, a potential thematic role for the phrase is considered (but not assigned). In a structure-first model, assigning a potential thematic role can be done only if there is sufficient structure to determine what the range of possible thematic roles might be. What happens next depends on how much syntactic analysis the semantic processor performs.

An extreme view would be that the semantic processor directly triggers potential syntactic structure at each point. Thematic assignment in syntax-first models is dependent on prior and independent syntactic assignment. After the first noun phrase, there must be the postulation of a syntactic "dummy" analysis, with enough placeholders at least to arrive at a verb that can assign a thematic relation, as shown in figure 8.1.

With that information, *the horse* can be assigned the thematic role of "agent" of the (as yet unspecified) verb. However, this assignment and its associated structure cannot inform the ongoing syntactic analysis of the input form sequence, since in such models, the syntactic assignment is not informed by semantic analysis or plausibility. The dual assignment of syntactic structures allows such a model to meet the intuition that semantic and thematic information is assigned continuously and to maintain the claim that the "real" syntactic assignment occurs independently of semantic analysis.

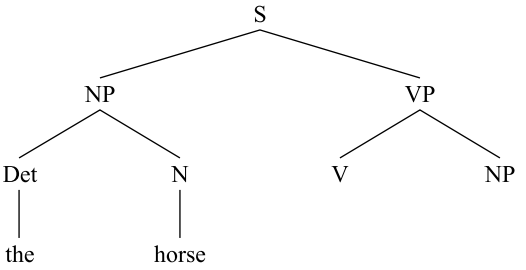

Figure 8.1
Dummy syntactic analysis for projected thematic assignment.

This solution is forced and duplicative. The separation of the two ongoing syntactic assignments serves only the theoretical claim, and the duplication of syntactic assignment is odd, at best. At worst, it implies circularity because the syntactic tree with dummy elements certainly allows for semantic analysis of *them*. In the preceding example, not only might *horse* be assigned the "agent" of V, there can also be a projected semantic analysis of the V with the VP-internal argument as some kind of thematic object. The result would be that the semantic analysis of basic thematic relations can actually move ahead of the incoming syntactic analysis. This is not to say that a structural model of this type could not be proposed; but in doing so, there would be a theoretical corruption of syntactic autonomy in the "garden-path" model.

Fortunately, structure-first models typically take a less extreme view, which, however, still implies some duplication of syntactic processing. For example, Frazier and colleagues (Frazier 1987a; Rayner, Carlson, and Frazier 1983) propose that the semantic analyzer develops various alternative sets of thematic relations as argument-assigning words are received (e.g., *raced*). World knowledge points to the most plausible thematic relations, given the arguments provided by the syntactic processor. The semantic processor thus determines the phrases that carry arguments, and thematic roles. If the minimal syntactic structure provided by the syntactic processor does not match the most plausible thematic roles, the semantic processor "guides" the syntactic processor to reanalyze the input for an alternative structure that has the arguments for the most plausible thematic roles. Clearly, this architecture implies that the semantic processor is capable of some syntactic analysis. At the least, the semantic processor is able to determine the correspondence between syntactic phrases and thematic roles, to recognize when the proposed syntactic structure does not match its favored semantic analysis. Even more problematically, the semantic processor may "suggest" an alternative syntactic analysis that supports its favored set of thematic relations.

LAST accounts for the intuition that meaning is computed immediately by way of the pseudosyntactic assignment processes that map the surface sequence onto a

preliminary meaning. We have likened the mapping templates to automatic, statistically valid associative constructs, which are triggered differentially according to the strength of their input cues in the listener's experience. For example, the NVN template is triggered partially by the appearance of an initial noun phrase, *the horse*, on two grounds. First, it is a complete noun phrase at the beginning of the sequence. Second, the noun phrase is animate. Accordingly, to some extent, *the horse* will be assigned the thematic role of agent by the automatic initial activation of the NVN template.

Similar principles apply at lower and higher levels of representation to account for the intuition that processing is immediate, as opposed to delayed until the ends of the units. In chapter 5, we first outlined how LAST operates in isolating and recognizing words from a continuous speech stream. An initial phase involves mapping easily recognized features, morphemes, and words onto an hypothetical lexical sequence, which is then checked by internal regeneration of the sequence. The initial phase occurs immediately and explains the apparent immediacy of the recognition. The same sort of process can occur at the phrase level. Pseudosyntax consists of regularities such as

"det ... N" $\rightarrow$ [det N]$_{\text{phrase}}$

Because phrases with nouns are themselves potential arguments, they can be subject to a reconstitutive check of their structure. In this way, a cascade of analysis-by-synthesis modules can operate simultaneously to assign a lexical analysis, phrase structure hierarchy, and derivational sentence-level syntax.

The notion that lexical, phrasal, and sentential analyses proceed in parallel is relatively uncontroversial since all three have proper analysis as component parts of an autonomous "syntax." The next intuitive level of analysis is that above the single-clause sentence, namely, multiclause sentences and discourses. We consider the discourse level first, as the clearest case of a suprasentential level of representation. Then we return to the more complex case of multiclause sentences.

The most salient feature of discourses is that they have little language-specific structure, if any. In general, a multisentence narrative or essay in one language has an accurate, sentence-by-sentence translation in every other language (modulo sentence-internal constraints such as mechanisms for focus and topicalization). This intertranslatability suggests that the form of discourse representation is not syntactic but is more directly related to conceptual structures. In LAST, conceptual structures are themselves initially assigned by a set of low-level syntactic features and statistically valid templates. The initial conceptual analysis is then confirmed by its link to the syntactic reconstruction of the input. This means that the conceptual level associated with each sentence is never "generated" via some recursive processes, but is passively assembled and then checked via its implied syntactic infrastructure.

The distinction between conceptual and syntactic representations gives rise to a central concept in the cognitive sciences, the modularity of certain processes. Up to now, we have not mentioned this major issue, but consideration of the interface between conceptual and syntactic processes forces us to confront it directly. There are two main ideas associated with the notion of modularity:

1. Certain perceptual processes are modular. This means they characteristically are
a. Rapid and automatic.
b. Architecturally (e.g., "neurologically") segregated in such a way that they resist outside influence. In particular, their operations proceed independently of information from a "central processor."
2. Modular processes are computational, symbolic, and highly constrained. In contrast, the "central processor" operates associatively, can connect widely different kinds of information, and is largely unconstrained.

The first notion was discussed by Forster and associates (Forster 1970; Forster and Olbrei 1974), then elaborated by Marshall (1980) and, most articulately, by Fodor (1983). Fodor also clarified the second kind of distinction, between modular and central processes.

A great deal of recent psycholinguistic research has the credit or discredit of modularity as its underlying agenda. Indeed, much of the research on sentence comprehension we have reviewed in previous chapters was actually motivated by this controversy. In those chapters, we were concerned to show how the data support LAST, rather than whether they do or do not support the modularity hypotheses. In general, it is easy to see that evidence supporting the role of conceptually associative information in online comprehension is prima facie evidence against both premises of modularity. Evidence for the autonomy of syntactic parsing is evidence in favor of modularity. Put crudely for language comprehension, if meaning influences initial syntactic assignment processes, modularity is false; if it does not, modularity is true.

We are about to review research that bears more directly on the modularity hypothesis for language comprehension because it deals with the interaction of discourse and sentences, which necessarily forces a confrontation between the role of conceptual and syntactic processes. But our presentation will satisfy neither modular adherents nor opponents of modularity. The reason for this is that in fact, modularity of the sort described above is not an issue, for at least the following reasons:

1. *Scientific method.* The first premise of modularity is fundamental to accepted scientific method (see, e.g., Forster and Olbrei 1974). Therefore, modularity often appears to be substantively true when it is actually a methodological foundation of research (Marr 1976; Simon 1962; Spearman 1937). It is scientifically trite that we divide nature at her joints and study the properties of distinct "modular" processes free of outside influences.

2. *Unfalsifiability*. It is virtually impossible with today's methods to prove modularity, if it were true. We noted at the beginning of this chapter that it is intuitively obvious that comprehension appears to move word by word, or even in smaller increments. But the ability of the system to project ahead of the immediate input means that meaning can appear to be computed immediately. This point does not depend on whether the projections are via multiple incomplete analyses (which we do not advocate), or via overlapping pattern completion and synthesis mechanisms (which we do advocate). The "whole person" can understand a whole proposition in advance of the complete input regardless of the architectural independence of the component processes. This is not to say that it is impossible in principle to titrate out evidence for distinct internal processes when meaning is neutralized. But it is very hard to show that apparent evidence for the impact of meaning on syntax is *not* via direct interaction between conceptual and syntactic processes. Perhaps sufficiently sensitive measures will emerge in the future.

3. *The whole iguana*. Architectural modularity is the proposal that, for example, semantic information cannot inform ongoing syntactic processes because of architectural segregation of semantic and syntactic processes. But, even if this were false, it might appear to be true because of what we have called *informational independence* (Townsend and Bever 1991, 1982; see also Frazier 1985, 1990; Jackendoff 1990).

It is a point of logic underlying the necessity of modularity when different kinds of representational systems are concerned. If the computational language of two systems differ, one cannot affect the internal operation of the other. This does not necessarily demonstrate an architectural boundary between them, because their mutual computational opacity would lead to such discontinuities of influence anyway.

As an extreme, consider a cross-modal example such as the matching of pictures to words. At first, this appears to be an obvious example of two distinct modules at work, separated architecturally. Operationally speaking, to demonstrate their modular independence one would want to show that if a picture facilitates the perception of a corresponding word, it is only after the word is initially sensed. That is, a picture of an iguana cannot directly facilitate perception of the isolated letter sequences *i* or *ig*, or *igu*, or *igua*, but only of a representation of the word *iguana*. Such facts, if true, would support the assumption that picture processing and word finding are distinct modules. But in fact, the results show something weaker. It is empirically reasonable that the computational language of object recognition is not directly mapped onto phoneme sequences. It follows logically that object recognition cannot inform word recognition. That is, the picture of the iguana cannot constrain the word-finding process to search for words beginning with *i*, or *ig*, or *igu*, or even *iguana*. It can only constrain the word-finding process to find words with semantic structure related to that of iguanas. Of course, the word-finding process itself may quickly provide the information that the most important word that is semantically related to iguanas is

iguana and thereby constrain its visual expectation for that word. But that constraint does not interact with letter recognition directly, only via conceptual and lexical levels of representation (see Schwartz and Schwartz 1984).

This logical point makes it necessary to be cautious about any evidence for architectural modularity between different sources of information relevant to language behavior. Because there are empirical reasons to believe that the internal computational languages of nonlinguistic knowledge, semantics, syntax, and phonology all differ, we must expect on those grounds alone to find discontinuities in the apparent influence of information from one system to another.

4. *Having it both ways.* Finally, LAST assumes an interaction between associative and syntactic information, of a specific kind, that resolves many apparent conflicts in research data that were initially touted by their discoverers as definitively proving or disproving modularity. LAST assumes the immediate projection of a conceptual representation, based in part on associatively accumulated information that can immediately interact with longer-term and current expectations. At the same time, the model assumes that, once launched from the initial analysis, the syntactic assignment operates autonomously from conceptual impact. Thus, LAST is both modular and nonmodular, depending on which aspect one emphasizes.

We can summarize four points as follows. We accept the idea that the modularity of different kinds of information involved in comprehension is a good working hypothesis, following the standard methodological stance (point 1). It is difficult to find unambiguous evidence for any kind of syntactic modularity (point 2), or crucial experimental evidence uniquely for architectural modularity (point 3). LAST offers a specific model to test against the kinds of experimental facts that the modularity hypothesis stimulated (point 4). We maintain that LAST fits the facts well, and thereby *replaces* the general claims about modularity with a specific and experimentally supported model.

Thus, we doubt that modularity is the constant primary question of cognitive science. But we also do not despair over the last decades of research on modularity in language comprehension. Just because it has focused on the relative roles of associative and computational language processes, it has turned up a great deal of data that we have organized and shown to favor LAST. We now turn to some of the classic investigations of modularity, having to do with discourse and multiclause relations.

LAST provides unique explanatory opportunities for considering the relation between context, meaning, and ongoing structural assignment. First, the most significant unit of the meaning-form relationship is at the clause/sentence level. This follows from the fact that the output of the pseudosyntax must be rich enough to trigger a syntactic sentence-level derivation, and that the output of the syntactic component will tend to be sentences (see the discussion of the grain problem in section 5.4.2). Thus, while there can be a modular cascade of analysis-by-synthesis

loops, as suggested above, computational priority will naturally be given to the clause-level meaning-form relations. This leads to the natural prediction that the unit of interaction between context, meaning, and sentence-structure assignment will tend to be at the clause/sentence level.

A second feature of LAST is that its internal mechanisms require the formation of two sound-meaning pairs at each level during comprehension. First, pseudosyntax creates an initial meaning-form hypothesis related to the physical input. Then the syntactic component creates another meaning-form derivation, whose output is compared to the physical input. This computational architecture requires a memory store for the entire physical input of an utterance, at least a sentence in length. At the same time, the initial meaning-form hypothesis is also stored as part of the syntactic derivation. Thus, the analysis-by-synthesis model intrinsically requires a clause/sentence-level store for both an entire meaning and the entire physical sequence. This feature allows us to explain various phenomena in which one or the other kind of representation is accessed, depending on natural or experimental circumstances.

8.2 Intersentential Contexts

The influence of prior discourse information on sentence processing is a critical test for sentence-level syntactic modularity. On the strict interpretation of structure-first theories, structure is assigned independently of both generic and recent semantic in formation. This applies most strongly to information from prior sentences in a discourse. In LAST, the strategies of pseudosyntax apply directly and without inhibition from prior context. However, since the strategies arrive instantly at an initially hypothesized meaning, there is the possibility of certain kinds of behavioral interactions as a function of prior context.

8.2.1 Passive in Context

The assignment of pseudosyntax and an initial meaning relies predominantly on habits. The habit that NVN corresponds to agent-action-patient is so strong that the comprehension system follows it even when context suggests that it is not appropriate in a particular situation. Davison and Lutz (1985) demonstrated the resistance of the NVN template to context. They investigated whether a context sentence that focuses attention on a particular element could eliminate the processing complexity of a target sentence. They compared reading times for untransformed sentences that follow the NVN template versus transformed sentences that do not. The target sentences were preceded by context sentences that were neutral, supportive of the transformed version, or supportive of the untransformed version. Among the sentence types that Davison and Lutz investigated were passive, *there*-insertion, adverb preposing, raising to subject, and raising to object. We focus here on passive.

A specific example of the passive violation of the NVN template from Davison and Lutz (1985:35–41) is:

(3) *Passive target sentence*
A six-year-old girl was abducted by a man in California.

(4) *Active target sentence*
A man in California abducted a six-year-old girl.

The first sentence above does not conform to the NVN template, while the second does. Examples of context sentences for the active-passive pair are:

(5) *Neutral context*
Police reported the details of a recent kidnapping.

(6) *Active-supporting context*
Strange men have been on the prowl lately.

(7) *Passive-supporting context*
Children should never be allowed to walk alone.

The passive-supporting context focuses on *children* by placing it in the initial position, while the active-supporting context focuses on *men*. If focus influences immediate reliance on the NVN pattern, a passive sentence will be easier to read in a passive-supporting context than in an active-supporting context. Average reading times for active versus passive target sentences appear in table 8.1.

Davison and Lutz found that overall reading times were 163 ms shorter for active sentences than for passive sentences. Compared to neutral contexts, the active-supporting contexts increased the advantage in reading time for active target sentences, but passive-supporting contexts had little effect on the reading time difference between active and passive target sentences. If passive-supporting contexts reduced the processing complexity of passive sentences, these contexts should at least have reduced the advantage in reading time for active sentences, compared to neutral contexts. Assuming that the notion of focus constitutes a reasonable model of dis-

Table 8.1
Mean reading times (ms) for active and passive target sentences

	Target sentence		
Context	Active	Passive	Difference
Neutral	2356	2455	99
Active-supporting	2264	2526	262
Passive-supporting	2319	2448	129

Source: Adapted from Davison and Lutz 1985, fig. 1.1

course, these results suggest that the pattern of NVN = agent-action-patient is so strong that the initial phase of comprehension reacts to this pattern even in passive-supporting contexts.

Liversedge et al. (1998) obtained similar results with more online measures. They used an eye-tracking methodology to examine how context influences the interpretation of a *by*-phrase in passive sentences. The *by*-phrase may be interpreted as identifying an optional agentive argument in passives, as in

(8) *Agentive interpretation*
The shrubs were planted by the apprentice that morning.

or as a locative adjunct, as in

(9) *Locative interpretation*
The shrubs were planted by the greenhouse that morning.

The optionality of the agent argument in a passive is shown by the fact that the following sentence is consistent with the meaning of the agentive interpretation:

(10) *Patient-only passive*
The shrubs were planted.

Liversedge et al. (1998) found that an off-line measure showed a strong bias toward interpreting the *by*-phrase as agentive: 96 percent of sentence fragments like *the shrubs were planted by the* ... were completed as agentive, according to participants' judgments about their own completions. The materials included verbs that were predominantly transitive only.

In the online measure of eye tracking, Liversedge et al. found that fixation times on the second noun were longer for *greenhouse* than for *apprentice*, even though the target nouns were matched for frequency and plausibility. These results were interpreted to show that comprehenders prefer to interpret noun phrases as filling argument roles, consistent with their preferences in the off-line task.

Liversedge et al. then examined whether a discourse context could modify this preference. Participants first read either an agent-supporting context sentence or a location-supporting context:

(11) *Agent-supporting context*
The gardener wondered who would plant the shrubs.

(12) *Location-supporting context*
The gardener wondered where to plant the shrubs.

followed by either an agentive target sentence or a locative target sentence. The results appear in table 8.2.

Fixation times on the noun were longer for agentive context-locative target pairs than for the other three pairings of context and target. This result suggests that both

Table 8.2
Mean fixation times for the noun in the *By*-phrase (ms/character) depending on context and target

	Target sentence	
Context	Agentive	Locative
Agentive	31	36
Locative	32	31

Source: Adapted from Liversedge et al. 1998, fig. 3

context and the verb argument requirements can "prime" an agent role. Processing is disrupted when discourse context leads to the expectation of an agent that is not fulfilled by the noun in the *by*-phrase. In contrast, processing a passive with an agentive *by*-phrase is disrupted very little when discourse context leads to the expectation of a locative phrase.

The Liversedge et al. study shows that the initial assignment process is sensitive to verb-argument preferences. The initial processes assign noun phrases to the argument roles that a verb takes. The study also shows a strong tendency to assign to the noun in a *by*-phrase the role of agent. This fact helps explain why studies of relative clauses as discussed in chapter 7 sometimes have shown that good patients eliminate the reading-time effect on the Verb + *by* region. The word *by* together with a good patient and a transitive-only verb strongly suggests a relative clause structure.

The studies by Davison and Lutz (1985) and Liversedge et al. (1998) indicate that the basic mechanisms of comprehension are similar in and out of context. The pseudosyntax develops a quick rough approximation to meaning based on familiar sentence patterns and information that follows from the argument requirements of verbs.

8.2.2 The Grammar Generates a Syntax from Primed Concepts

In chapter 6 we saw that the initial assignment processes can project slots or dummy elements based on the thematic requirements of verbs. The comprehension system then looks for noun phrases that can fill these slots. For example, in

(13) Sam put ...

the initial projection is that there will be a patient and a location. All other factors being equal, a hypothesis about sentence meaning triggers the sentence synthetic component primarily when all required slots are filled.

The initial assignment processes may also project units that are of broader gauge than arguments. "Scripts" activate expectations of a particular proposition or event. A *script* is a stereotypical sequence of events such as eating in a restaurant or visiting

a doctor (Bower, Black, and Turner 1979; Schank and Abelson 1977; Sharkey and Mitchell 1985). An activated event may function as an initial hypothesis about meaning, and allow the grammar to generate a candidate syntax. As before, the comprehension system then compares this candidate syntax with the input. If the candidate syntax matches the input, there is integration with the conceptual representation and loss of surface form. If the candidate syntax does not match, another hypothesis about meaning is formed and another candidate syntax generated.

We (Townsend and Bever 1988, 1989) obtained evidence for projection of a candidate sentence-level syntax from expected events. Subjects read stories based on scripts as in the following two examples:

(14) *Supportive story*
Johnny woke up very hungry for breakfast.
He found a bowl and a spoon in the kitchen.
He got a pitcher of milk from the refrigerator.
When he took down a box of cereal from the shelf . . .

(15) *Neutral story*
Johnny was watching his favorite programs on TV.
He started to get hungry for a snack.
He waited for a commercial to go into the kitchen.
When he took down a box of cereal from the shelf . . .

The first story was written from the events that college students listed when they were asked to describe what happens when one eats breakfast (see Bower, Black, and Turner 1979). One of the events that these students frequently listed for eating breakfast is that one takes out a box of cereal from the cupboard. Thus, the sentence

(16) He took down a box of cereal from the shelf.

expresses a typical event in eating breakfast. The first story strongly supports this sentence.

The second story was based on the events that college students listed for getting a TV snack, except that they never mentioned taking out a box of cereal as an event that occurs when one gets a TV snack. Thus, the target sentence is plausible in the neutral story, but it is not strongly supported by it.

In Townsend and Bever 1988, the target event appeared in either active or passive form. The stories were presented either one clause at a time or one word at a time in a self-paced reading task. We compared these reading paradigms because they appear to place different emphasis on conceptual and superficial representations.

We expected the whole-clause task to encourage the formation of conceptual representations so that the conceptually supportive contexts would decrease reading time, especially for the more complex passive construction. Since the initial analysis

in the pseudosyntax may access semantic context, the conceptual representation of the underlying script of eating breakfast will prime the subject, verb, and object concepts of the target event, but in an unordered conceptual representation:

Johnny = agent
get = action
cereal = patient

Thus, the conceptual representation of an anticipated event could neutralize the fact that the passive expression of the anticipated event is not in the canonical SVO order. Since both agent and patient concepts are primed, both noun phrases will be read more quickly, even though they are presented in the passive form.

But reading in the word-by-word paradigm should exert a different kind of pressure that encourages a more superficial representation of the anticipated event. Since the words disappear as subjects read through the sentence word by word, they must assign a structure to each word in sequence, and build up an ordered representation. Since the word-by-word reading format focuses attention on the superficial, ordered level, we expected less facilitation from conceptually supportive contexts. If the focus of attention is on the superficial level, subjects should represent predictions of upcoming events in a more superficial manner as well. That is, they should assign the anticipated event a syntactic form. Since the canonical form in English is agent-action-patient, we expected that that subjects would represent predicted events in a manner such as

(17) Johnny gets the cereal.

Thus, supportive contexts should facilitate word-by-word reading of active sentences. However, because the ordered prediction does not match the form of a passive sentence,

(18) The cereal was taken down from the shelf by Johnny.

we expected that supportive contexts would slow down word-by-word reading of passive sentences.

Overall, the subjects read active sentences more quickly than passives (375 ms/word vs. 432 ms/word; see table 8.3). Overall, they read target sentences faster in supportive contexts than in neutral contexts (382 ms/word vs. 425 ms/word). Reading times were faster in the clause format than in the word format (342 ms/word vs. 465 ms/word). Supportive contexts overall had larger effects for passives than for actives (a 50 ms/word facilitation vs. 27 ms/word facilitation).

The interactions between presentation format, context, and sentence structure were particularly revealing. In the clause format, supportive contexts reduced reading time more for the passive target sentence than for the active target sentence (by a factor of

Table 8.3
Mean reading times per word (ms) in target sentences depending on form, context, and presentation format

	Clause format		Word format	
Context	Active	Passive	Active	Passive
Neutral	322	436	465	477
Supportive	294	316	419	497
Facilitation	28	120	26	−20

Source: Adapted from Townsend and Bever 1988

4, 120 ms/word vs. 28 ms/word). In the word format, supportive contexts reduced reading time for active sentence (by 46 ms/word), but it significantly *increased* reading time for passive sentences (by 20 ms/word). Townsend and Bever (1988) found that this increase in reading time for the passive in supportive contexts occurred on both the initial noun phrase and the final noun phrase.

Knowledge of stereotyped scripts primes particular events, so that when these events actually appear, a projected initial meaning-form hypothesis may already be available. The grammar may use the initial hypothesis to generate and anticipate aspects of a particular surface syntactic form. All other things being equal, the form will be a canonical NVN. Thus, an actual sentence that does not match the canonical form may be harder to process, even though the context primes its meaning.

8.2.3 Contextual Integration at the Propositional Boundary

LAST proposes that semantic context can prime an initial hypothesis about meaning. Whichever meaning is most strongly primed from whatever source, that meaning is the basis for the grammar to generate a syntax, which is then checked against the input string stored in a temporary memory. If the generated syntax matches the input string, the corresponding meaning becomes integrated with conceptual information.

In this model, discourse context has two kinds of behavioral effects. As we just noted, it can prime an initial meaning-form hypothesis. It also can influence the integration of sentence meaning into a conceptual representation of discourse. The model predicts that a discourse context that supports sentence meaning will have larger behavioral effects when the grammar projects a relatively complete unit, and the corresponding meaning is integrated into a conceptual representation.

We (Townsend and Bever 1989) showed that story contexts have greater effects at the end of a sentence, which corresponds, by hypothesis, to the end of an analysis-by-synthesis cycle at the sentence level. As in Townsend and Bever (1988) we used script-based stories. We embedded a critical sentence in a passage that strongly or weakly supported the sentence. There was strong support for the critical sentence when it

stated an event that was central to the underlying script for the story and weak support when it was peripheral.

In one study, subjects read texts line by line in a self-paced reading task. The lines randomly ended either at a clause boundary, or just before the final word of a clause. A major variable was whether the entire critical sentence,

(19) He took down some cereal.

appeared entirely on one line, as above, or with the last word of the sentence on the next line. The following two stories present the critical sentence entirely on one line, but differ in their support for the critical sentence:

(20) *Supportive, complete clause*
Johnny woke up very hungry for
breakfast. He found a bowl and a
spoon in the kitchen. He got a
pitcher of milk form the refrigerator.
He took down some cereal.
Then he filled the bowl
and ate until he wasn't hungry anymore.

(21) *Neutral, complete clause*
Johnny was watching his favorite
programs on TV. He started to get
hungry for a snack. He waited for
a commercial to go into the kitchen.
He took down some cereal.
Then he filled the bowl
and ate until he wasn't hungry anymore.

When the critical clause was presented on separate lines, it appeared as follows:

(22) He took down some
cereal. Then he filled the bowl

The critical data were times to read the line containing the complete target clause, *he took down some cereal*, compared to a line containing all but the last word of the target clause, *he took down some* ... To facilitate comparison, reading times were adjusted for number of words in the line. The results appear in table 8.4.

When the target clause appeared as a complete clause entirely on one line, target-line reading times were faster for passages that strongly supported the target than for passages that supported it only weakly (285 vs. 373 ms/word). When the target clause was not entirely on one line (''incomplete clause''), target-line reading times did not differ for passages with strong versus weak support for the target event (401 vs.

Table 8.4
Mean reading times (ms/word) depending on contextual support and clause completeness

	Clause completeness	
Context	Incomplete	Complete
Neutral	401	373
Supportive	404	285
Facilitation	−3	88

Source: Adapted from Townsend and Bever 1989, table 3

404 ms/word). Since discourse-level support had a positive effect on reading only complete clauses, much of its effect appears at the end of a clause. Discourse-level support does not eliminate structural processing prior to the end of a clause.

There is, of course, the alternative interpretation that a discourse effect does not occur with incomplete clauses because the context supports a key word such as *cereal* rather than an entire event, and this key word appears on the next line. Acknowledging this possibility, we tentatively take these results to demonstrate that integration of clause meaning into the representation of discourse is more likely to occur at the end of a clause. It is at this point that the comprehension system checks the generated syntax against the input. In case of a match, the comprehension system integrates the corresponding meaning into the ongoing representation of discourse (see also Caplan 1972; Chang 1980; Jarvella 1971; Just and Carpenter 1980; Haberlandt and Graesser 1985; Sachs 1967).

8.2.4 Attention to Sentence Level vs. Discourse Level

Nevertheless, there is evidence that discourse context affects certain aspects of comprehension independently of the end of an analysis-by-synthesis unit. According to LAST, these effects will occur most naturally in the initial assignment of a meaning/form, or at conceptual integration of sentence meaning with local context and background knowledge.

- In the initial assignment of meaning, context effects will involve activating words and sentence frames.
- At conceptual integration, context effects will involve primarily propositions.

Thus, the mechanism by which meaning influences comprehension depends on the point at which meaning has its effect.

We (Townsend and Bever 1991) tested the hypothesis that context effects on word recognition and sentence integration can involve different mechanisms. We used a change-of-speaker detection task in which one word was uttered by a speaker other

Box 8.1
The change-of-speaker detection task

The change-of-speaker detection task (Townsend and Bever 1991; O'Bryan et al. 2000) is a monitoring task in which subjects listen to a sentence or a discourse for a speech sound uttered by someone other than the primary speaker. Linguistic materials are recorded by a primary speaker and by a secondary speaker who usually is of a different gender than the primary speaker. Using the recording by the primary speaker, the target word is replaced by the secondary speaker's recording of the same word as it appears in the same context. For experiments that measure response time, a timing tone is placed on a second channel and is made inaudible to the subject. The timing tone initiates a timer that is stopped by the subject's detection response.

Subjects are instructed to listen to the recorded linguistic materials for the purpose of making judgments about aspects of the story and the storyteller, such as the plausibility of the story or the mood of the storyteller. A secondary task is to determine whether there is a word spoken by someone other than the primary storyteller. Response-time measure can be taken online, or subjects can make their judgments about whether their was a change of speaker after the story has ended.

The change-of-speaker detection task has the advantage that the material that subjects must detect is a part of the speech signal. In addition, it is not unnatural to listen to speech in which a word uttered by another speaker appears in the speech.

than the main storyteller (see box 8.1). Targets occurred at the end of a clause (high within-sentence constraint) or at the beginning of a clause (low within-sentence constraint), corresponding to the high- and low-constraint conditions in Marslen-Wilson and Welsh 1978. These within-clause constraint conditions differ based on the common notion that within-clause predictability tends to increase later in the clause. In the examples below, the target word is italicized.

(23) *High within-sentence constraint*
Because she is a sweet cute *girl* boys asked her out often.

(24) *Low within-sentence constraint*
Because she is a sweet cute girl *boys* asked her out often.

The target-containing sentences were taken from Bever, Lackner, and Kirk 1969; see chapter 2. *Girl* is subject to a high within-sentence constraint because of syntactic and lexical-associative information, such as the fact that only an adjective or a noun can appear in the position that *girl* occupies. *Boys* is subject to a low within-sentence constraint because the position that *boys* occupies at the beginning of a clause may be filled with a pronoun, determiner, adjective, or noun. In addition to the within-sentence variation in constraints, the sentences that contained the target word itself were either highly or weakly constrained by the discourse context.

Table 8.5
Mean response times (ms) for detecting a change in speaker depending on discourse constraints and within-sentence constraints

Within-sentence constraints	Discourse constraints		
	Low	High	Mean
Low	510	544	527
High	470	490	480
Mean	490	517	

Source: Adapted from Townsend and Bever 1991, fig. 2

(25) *High discourse constraint*
Mary went to South Side High School. She was voted the most popular girl in the class. . . .

(26) *Low discourse constraint*
My friend has not lived at home for years. Through high school she constantly battled with her parents. . . .

The discourse materials were obtained from undergraduate students who wrote stories around the critical sentences. Discourses were selected for experimental materials if the critical sentence was either high or low in plausibility, as determined by graduate student ratings. Unlike the high-discourse-constraint condition shown here, the discourses did not contain another instance of the target word.

The results appear in table 8.5. Within-sentence constraints showed the expected result (see also Marslen-Wilson and Welsh 1978). Response times were faster in the within-sentence high-constraint condition than in the low-constraint condition (480 vs. 527 ms). Discourse-level constraints showed the opposite effect: response times to detect a change of speaker were significantly *slower* in the high-discourse-constraint condition (517 vs. 490 ms). A second experiment measured detection accuracy, and obtained corresponding results: increasing within-sentence constraints improved detection accuracy, but increasing discourse-level constraints reduced detection accuracy.

These results show that increasing discourse-level constraints interferes with reports of word-level processing. The slower response times in high-discourse-constraint contexts presents difficulties for a strictly constraint-based theory, which predicts that if there is any difference effect of discourse context at all, it is in the direction of more strongly constrained contexts facilitating recognition of a change of speaker.

LAST explains these results in terms of a series of overlapping processes:

1. *Extract words and major phrases.* The pseudosyntax deploys probabilistic information patterns to yield an initial meaning as soon as possible.

2. *Meaning proposed.* The words, phrase grouping, and most plausible sentence meaning are presented to the synthetic component.
3. *Syntax generated.* The grammar generates a candidate syntactic derivation for the proposed meaning.
4. *Surface attention for syntax checking.* Attention is focused briefly on surface form for the purpose of determining whether the generated syntax matches the input.
5. *Meaning integrated.* If the generated syntax matches the input, the corresponding meaning is integrated into a representation of discourse.

We assume that attention tends to focus on one process at a time (Kahneman 1973). In terms of LAST, the within-sentence effects may actually be end-of-clause effects. That is, the faster response times at the end of the clause (high within-sentence constraint) may involve checking of the candidate syntax to determine whether it accounts for all of the input. As a result, there is increased attention to the acoustic form. The discourse-level effects may be a result of a focus of attention on the initial meaning-form hypothesis. At the point of the target word, the system is determining a plausible initial guess about sentence meaning. When this initial guess is consistent with context, attention is drawn away from the acoustic details.

8.3 Sentence-Internal Contexts and Connectives

We turn now to the effect of the information in a clause on processing the immediately following clause within the same sentence. It is intrinsic to the architecture of LAST that surface and semantic representations can be developed simultaneously. The comprehension system stores the input surface representation for later syntax checking, while developing a semantic representation. This raises the obvious question of whether these representations from one clause influence the processing of the next clause. It also seems reasonable to ask whether higher-level processes use these representations. Discourse-processing models generally assume that the basic building blocks of discourse representations are propositions, produced by sentence-level processing mechanisms. Do these higher-level processes require only meaning representations, or do they take advantage of the availability of surface representations? LAST makes no particular prediction on this question, but it does raise the possibility. The studies we review in this section can inform us about how LAST is integrated into the processing of multiclause sentences, and discourses.

8.3.1 Resolving Ambiguities

Tyler and Marslen-Wilson (1977) reported a widely cited study that has been interpreted as showing that the semantic analysis of information in an initial subordinate clause can influence the immediate syntactic processing of the following main clause.

Table 8.6
Mean target naming times (ms) depending on ambiguity and probe type

	Probe type	
Sentence type	Appropriate	Inappropriate
Ambiguous	519	555
Unambiguous	554	581

Source: From Tyler and Marslen-Wilson 1977

In fact, the results of their study support LAST, since semantic context can influence the integration of the initial meaning into a full conceptual representation. Tyler and Marslen-Wilson presented spoken sentence fragments like the following:

(27) *Singular bias*
If you want to take a cheap vacation, visiting relatives ...

(28) *Plural bias*
If they arrive unexpectedly, visiting relatives ...

Subjects then had to name a visually presented word, such as *is* or *are* (see box 6.2). The word *is* signals that *visiting relatives* has a gerund structure, and, according to pretest ratings, this interpretation is more consistent with the first sentence fragment above (i.e., singular bias). The word *are* signals that the ambiguous phrase is an adjectival construction, which is more consistent with the second fragment. The results appear in table 8.6.

Tyler and Marslen-Wilson (1977) found that target-word-naming times for *is* and *are* were faster when the context supported the interpretation of the ambiguous phrase that was determined by the target word (519 vs. 555 ms). Since the context effect was no smaller than the structural effect of unambiguous phrases (e.g., *mixing drinks*, *diving submarines*), this result has been interpreted as showing that the semantic context guides local syntactic decisions.

There is another interpretation of the Tyler and Marslen-Wilson 1977 result that is uniquely consistent with LAST: semantic context is integrated with linguistic meaning once the comprehension system has checked the generated syntax against the input. This interpretation requires that much of the semantic-context effect occurs in sequences that have initiated synthesis and conceptual integration. To separate the locus of the semantic-context effect, Townsend and Bever (1982) introduced a number of controls into the materials of Tyler and Marslen-Wilson (1977; see also Cowart and Cairns 1987; Marslen-Wilson and Tyler 1987). These controls showed that the context effects on naming time are indeed due to a variety of sources of priming, including explicit morphological number information on the context verb,

priming from specific lexical items, and conceptual integration at the completion of relatively complete semantic units. Following an explanation of how *landing planes* can lead to synthesis in some cases and not others, we review the evidence for priming from these sources.

The two interpretations of an ambiguous phrase like *landing planes* differ in functional completeness. That is, they differ in how explicitly they state the details of the canonical sentence (see Carroll 1978; Tanenhaus and Carroll, 1975). The transitive interpretation of *landing planes* corresponds to a gerund structure like *mixing drinks*, in which *drinks* is the object of the verb *mixing*. The intransitive interpretation of *landing planes* corresponds to an adjectival structure like *diving submarines*, in which *diving* is a modifier of the head noun *submarines*. The verb *is* in

(29) *Gerund structure*
Landing planes is easy.

signals that the ambiguous phrase has a gerund structure, while *are* in

(30) *Adjectival structure*
Landing planes are hazardous.

signals that it has an adjectival structure. The two structures differ in how closely they correspond to complete canonical NVN sentences. The gerund structure is closer than the adjectival because it presents the final phrase (verb-object) of the canonical common English sentence pattern, subject-verb-object. Since the gerund maintains a piece of the canonical order, it activates more strongly the NVN strategy:

polishing glasses = VN
glittering glasses = AN

Hence, we would expect that contextual information will interact with ongoing processing more for gerund structures than for adjectival structures (see the "whole iguana" point in section 8.1). This prediction follows from the assumption that the NVN template can match a sequence without a match of the initial noun—that is, that template matching is not strictly linear.

Morphological Number Context With respect to morphologically primed number, we (Townsend and Bever 1982) found that context effects occurred only when the context contained a singular verb and the target was singular as well (see also Cowart and Cairns 1987). We compared sentence fragments like the following:

(31) *Singular morphological bias, singular target*
If the pit crew works very efficiently, racing cars ... IS

(32) *Singular morphological bias, plural target*
If the pit crew works very efficiently, racing cars ... ARE

Table 8.7
Mean response times (ms) depending on morphological number bias

	Target number		
Bias	Singular	Plural	Bias effect
Singular	641	733	92
Plural	653	653	0

Source: Townsend and Bever 1982, table 5

(33) *Plural morphological bias, singular target*
If the pit crews work very efficiently, racing cars ... IS

(34) *Plural morphological bias, plural target*
If the pit crews work very efficiently, racing cars ... ARE

The materials above all have a singular nonmorphological (semantic) bias, as determined by pretest ratings. Additional materials context clauses with a plural nonmorphological bias were used as well (see below). The results for morphological number matching appear in table 8.7.

Table 8.7 shows that the morphological-bias effect occurs only for morphological contexts that match singular targets. In terms of LAST, there is priming of morphological number, but this priming exerts an effect only at the point of conceptual integration of the relatively complete gerund structure. Conceptual integration of the gerund phrase is most natural with singular targets.

Lexical Context The morphological matching effect was largely due to lexical priming from an adversative context introduced by *though* (see section 8.3.3). Townsend and Bever (1982) included materials in which there was a specific present tense form of *be* in the context clause. Some examples are:

(35) *Singular lexical bias, singular target*
If the pilot is required to attend flight school, landing planes ... IS

(36) *Singular lexical bias, plural target*
If the pilot is required to attend flight school, landing planes ... ARE

(37) *Plural lexical bias, singular target*
If the pilots are required to attend flight school, landing planes ... IS

(38) *Plural lexical bias, plural target*
If the pilots are required to attend flight school, landing planes ... ARE

The context clauses were either an *if*-clause, a main clause, or a *though*-clause. The morphological-bias effects with and without a form of *be* in the context appear in table 8.8.

Table 8.8
Morphological bias effects (ms) for ambiguous fragments depending on presence or absence of IS/ARE in the context

	Context		
Connective	IS/ARE present	IS/ARE absent	Bias effect
if	35	53	−18
main	5	28	−23
though	120	36	84

Source: From Townsend and Bever 1982, table 7

The results showed that the morphological-context bias effect was greatest when the context contained a form of *be* and was introduced by the connective *though*. We return to the implications of the connective effect later in the chapter. For now, it is sufficient to point out that specific lexical items may prime words in a following clause, at least under some conditions. This priming occurs in the earliest phase of LAST.

Conceptual Integration Townsend and Bever (1982) examined the independent effects of nonmorphological (semantic) bias as well. In addition to the singular nonmorphological contexts for *racing cars* that were listed above, they used plural nonmorphological contexts as well. Examples of plural nonmorphological bias for *racing cars* include the following:

(39) *Singular morphological bias, singular target*
If a young boy enjoys intense competition, racing cars ... IS

(40) *Singular morphological bias, plural target*
If a young boy enjoys intense competition, racing cars ... ARE

(41) *Plural morphological bias, singular target*
If young boys enjoy intense competition, racing cars ... IS

(42) *Plural morphological bias, plural target*
If young boys enjoy intense competition, racing cars ... ARE

The results for nonmorphological bias appear in table 8.9.

In general, the semantic-context effects were weaker than those in Tyler and Marslen-Wilson 1977, as expected when relevant controls are introduced into the materials, (as discussed earlier in this section and in section 8.3.4). In particular, the effects of context were limited to singular biases. These results follow from LAST. Since the sequence of words in the gerund interpretation (Verb + Noun → action +

Table 8.9
Mean response times (ms) depending on nonmorphological number bias and target number

	Target number		
Bias	Singular	Plural	Bias effect
Singular	623	710	87
Plural	658	666	−8

Source: Townsend and Bever 1982, table 5

patient) is a more reliable cue to meaning, this interpretation is strongest. The initial meaning hypothesis is the basis for generating a candidate syntax. The candidate syntax is checked against the input sequence and integrated with the meaning of the context. Hence, context effects are greater for *is* than for *are*.

Local Agreement Farrar and Kawamoto (1993) replicated certain aspects of the results of Townsend and Bever (1982) and Tyler and Marslen-Wilson (1977). In two subject-paced word-by-word reading tasks (see box 6.3), Farrar and Kawamoto examined the effects of pragmatic bias and syntactic anomaly. In one experiment, the context was a separate sentence that preceded the target sentence that contained the ambiguous phrase. The context sentence contained a subject noun that was either singular or plural, and the entire context sentence was pragmatically biased toward either a singular or a plural form for the verb following the ambiguous phrase. Morphological bias and pragmatic bias were varied independently.

(43) *Singular morphological bias, singular pragmatic bias*
The pilot must be observant. Flying planes does/do certainly ...

(44) *Singular morphological bias, plural pragmatic bias*
An astronomer must be observant. Flying planes does/do certainly ...

(45) *Plural morphological bias, singular pragmatic bias*
The pilots must be observant. Flying planes does/do certainly ...

(46) *Plural morphological bias, plural pragmatic bias*
Astronomers must be observant. Flying planes does/do certainly ...

The verb following the ambiguous verb was either *do*, signaling a gerund structure, or *does*, signaling an adjectival structure. The reading-time results for the verb following the ambiguous phrase and the next word appear in table 8.10.

Farrar and Kawamoto (1993) found no effect of pragmatic context on reading times for the verb *does/do* following the ambiguous phrase. Pragmatic bias did have a significant effect on reading times for the adverb. For plural pragmatic context, subjects read the adverb 47 ms faster when it followed the plural verb *do* than when it

Table 8.10
Mean reading times (ms) on the verb and the next word depending on pragmatic bias and disambiguating verb

	Disambiguating verb	
Pragmatic bias	DOES	DO
DOES/DO reading times		
Singular bias	414	415
Plural bias	424	413
CERTAINLY reading times		
Singular bias	421	428
Plural bias	451	404

Source: From Farrar and Kawamoto 1993, table 1

followed the singular *does*. For singular pragmatic context, subjects read the adverb only 7 ms faster when it followed the singular verb than when it followed the plural verb. The interaction was significant by subjects but not by items.

It is not clear that there is any effect of pragmatic context, as Farrar and Kawamoto noted. First, the pragmatic effect does not appear on the disambiguating verb. Thus, it is difficult to make a claim that pragmatic information has an immediate effect on a syntactic decision about the phrase that preceded the verb. In addition, the pragmatic effect that does appear on the adverb is greater for the plural bias than for the singular. All other things being equal, we would expect plural bias effects to be greater than singular bias effects if subjects applied the NVN template locally (see also Nicol, Forster and Veres 1997, as discussed in chapter 6). That is, subjects may adopt a local agreement strategy and assume that a noun-verb pair (e.g., *planes do*) corresponds to agent-action. In this case, subjects would expect the verb to agree with the immediately preceding noun in number regardless of the structure of the phrase. Because of this, a plural noun produces more efficient processing when followed by a plural verb than by a singular verb. The fact that there is no apparent effect of the plural noun in cases of singular pragmatic bias may be interpreted as showing that singular pragmatic contexts cancel the effect of local structure. As we noted in section 8.2.2, it is reasonable to expect that subjects place greater reliance on superficial word order in self-paced word-by-word reading, and hence, we would expect them to be strongly influenced by local agreement (see also Bock and Miller 1991). In short, it is not clear that there is any effect of pragmatic context even on the adverb.

To determine whether the delayed effects of pragmatic bias might be attributed to peculiarities of the self-paced reading task, Farrar and Kawamoto (1993) introduced a word into the ambiguous phrase that made it either unambiguous or ungrammati-

Table 8.11
Mean reading times (ms) on the verb and the next word depending on structural bias and the disambiguating word

	Verb	
Structure	IS	ARE
IS/ARE reading times		
Singular structure	541	521*
Plural structure	552*	530
CERTAINLY reading times		
Singular structure	566	595*
Plural structure	616*	517

Note: * = ungrammatical sentence
Source: From Farrar and Kawamoto 1993, table 2

cal. Subjects read sentences like the following in a self-paced word-by-word reading task:

(47) *Gerund structure*
Sinking those ship is/*are certainly not a pleasant job.

(48) *Adjectival structure*
Those sinking ships *is/are certainly in need of help.

The initial noun phrase in the first sentence is unambiguously a gerund structure, so that the sentence is grammatical when *is* follows *ships* and it is ungrammatical when *are* follows *ships*. The initial noun phrase in the second sentence is unambiguously an adjectival structure, so that it is grammatical with *are* but not with *is*. The results appear in table 8.11.

Once again, there were no significant effects on reading times for the verb. There was, however, an effect of structure on reading times for the following adverb. Reading times for adverbs were faster in grammatical sentences than in ungrammatical sentences (542 vs. 606 ms). The grammaticality effect was greater for the plural structure than for the singular (99 vs. 29 ms). Overall, the grammaticality effect on the adverb was more than double the pragmatic bias effect (59 vs. 27 ms). Thus, ungrammaticality has a larger effect than pragmatic unexpectedness.

If we assume that the pragmatic bias effects on the adverb in the first experiment are reliable, the results of the two experiments support LAST. The pragmatic effects appear *earlier* than the syntactic effects. The mean reading times were more than 100 ms per word longer when there were syntactic violations, suggesting that the pragmatic information is available earlier than the syntactic information. In terms of LAST, pragmatic information may exert an effect on the initial meaning-form

hypothesis, while syntactic information may exert its effect during the syntactic checking phase.

8.3.2 Multiclause Sentences vs. Discourse Structures

The preceding studies demonstrate that both conceptual and structural levels of representation can be maintained in parallel during comprehension. We now come to the question of whether multiclause sentences are treated as (complex) sentences or as the smallest instance of discourses. In terms of LAST, is there a sentence-level synthesis of the relations between clauses, or are the relations between clauses treated at the discourse level?

Interclause relations are governed by certain aspects of syntax, and accordingly must be subject to some degree of sentence-level synthesis. This is particularly clear in the processing of multiclause sentences that are formed by recursion of an element within one clause. In chapter 6, for example, we discussed the different kinds of processes that apply to *wh*- and NP-trace. Similar arguments apply to cases in which one clause fills an argument position of another. Indeed, clause recursion is one of the most important arguments that there are derivations (see chapter 3), and hence, a need for the synthetic process.

Adjunctive relations between clauses may call on a different kind of processing. By definition, adjuncts are added modifiers or extensions of existing phrases. There are various restrictions on the placement of adjuncts, but relatively weak syntactic constraints. Adjunct clauses characteristically are joined by connective conjunctions, such as *and*, *when*, and so on. Interclause connectives such as *because*, *if*, *although*, *after*, *before*, and so forth provide cues to the semantic relationship between the connected clauses (Caron 1997; Halliday and Hasan 1976; Noordman and Vonk 1997). These interclause semantic relations do not describe relations between elements within a clause, such as agent of action or patient of action, but rather are properties that apply to two clauses:

(49) Heidi felt very proud and happy
because she won first prize at the art show.

In this sentence from Traxler, Bybee, and Pickering 1997, the event that appears in the *because*-clause is interpreted as the cause of the event that appears in the other clause. Sentences with *because* often can be integrated readily into a conceptual representation since they make explicit the causal relationships that underlie much of narrative discourse. The underlying causal nature of much of discourse has been established with studies on sentence reading time and sentence recall (Golding et al. 1995; Haberlandt 1982; Haberlandt and Bingham 1978; Keenan, Baillet, and Brown 1984; Murray 1995, 1997; Myers, Shinjo, and Duffy 1987; Noordman, Vonk, and Kempf 1992; Segal, Duchan, and Scott 1991; Townsend 1983).

Millis and Just (1994) proposed that in sentences with interclause connectives, comprehenders use working memory resources to integrate the two clauses during or at the end of the second clause. They had subjects read two-clause sentences one word a time in the moving-window paradigm (see box 6.3). The second clause contained either *because* or no connective; in the case of no connective, there was a period marking the end of the sentence. After reading the second clause, the subjects responded to a probe for a target word in either the first or second clause (see box 6.9), and then answered a comprehension question about each of the clauses. In the load condition, the two clauses were preceded by an unrelated clause. In this case, there was a cue between the probe and the comprehension questions for the subject to recall the last word of the unrelated clause.

Here is a sample trial (from Millis and Just 1994, table 1):

Load sentence
A series of waves approach parallel to the shore line.

Clause 1
The elderly parents toasted their only daughter at the party {because/.}

Clause 2
Jill had finally passed the exams at the prestigious university.

Probe
** toasted **

Cue
RECALL LAST WORD OF LOAD SENTENCE.

Question 1
Did the parents have several children?

Question 2
Did Jill succeed in her exams?

Millis and Just recorded word reading times as well as probe recognition times, accuracy in answering questions, and response time for answering questions. Response times on the probe recognition task appear in table 8.12.

Probe recognition response times were faster in the no-load condition than in the load condition (1229 vs. 1430 ms), but load condition did not interact with connective or clause. For target words in clause 1, Millis and Just found that connectives reduced response times for probes in both no load and load conditions. For target words in the final clause, connective did not reduce probe recognition times. The fact that connectives reduced response times for targets in the initial clause but not the final clause supports the view that connectives reactivate the surface properties of the initial clause for the purpose of integrating it with the final clause. Interestingly,

Table 8.12
Mean probe recognition times (ms) depending on target location, load condition, and connective

	Target location	
	Clause 1	Clause 2
No load		
No connective	1350	1130
Connective	1300	1135
Load		
No connective	1530	1330
Connective	1500	1360

Source: Adapted from Millis and Just 1994, fig. 1

Millis and Just found in a later experiment that *although* reduced probe recognition times for targets in both the first and second clause. As we will see in section 8.3.3, this result suggests that comprehenders process clauses in different ways when they are introduced by *because* versus *although*.

Comprehension questions were answered significantly more accurately in the connective condition than in the no-connective condition (88% vs. 86%), and response times to answer questions also were faster in the connective condition (2.1 vs. 2.2 sec).

Connectives increased reading times for the last word of the second clause, but they decreased reading times for the remaining words of the second clause. The finding that reading times increased on the last word of the second clause, especially for connective trials, may be interpreted to show that interclause integration occurs most naturally at the point of checking the syntax and integrating the meaning. This point occurs when the grammar has generated a possible syntax and successfully matched it against the input.

In a later experiment, Millis and Just tested for reactivation of the first clause at two points while reading the second clause. The probe (e.g., ** toasted **) was presented either after the first word of the second clause (e.g., after *Jill*), or after the last word of the second clause (e.g., after *university*). Whether the probe appeared early or late, the target word was the verb in the first clause (e.g., *toasted*):

The elderly parents toasted their only daughter at the party {because/.}

Jill {** toasted ** ϕ} had finally passed the exams at the prestigious university.

{ϕ ** toasted **}

The probe-recognition times appear in table 8.13. The results indicate that early in the processing of the second clause (at the "Early Probe" position), the connective

Table 8.13
Mean probe recognition times (ms) for initial-clause verb depending on probe position in second clause

	Probe location	
Condition	Early	Late
No connective	925	1160
Connective	1010	1100

Source: Adapted from Millis and Just 1994, fig. 3

because actually increases probe recognition times for the initial clause verb. At the end of the second clause, however, the connective reduces probe recognition times for the initial clause verb. Since the connective reduced probe recognition times only at the end of the second clause, Millis and Just conclude that information from the first clause is reactivated primarily at the end of the second clause. This result suggests that two clause sentences are processed differently than independent sentences. At the end of a two-clause sentence, the comprehension system regenerates the entire sentence for the purpose of checking the syntax and integrating sentence information into a conceptual representation. The presence of a connective facilitates this process. It is worth noting, however, that the connective *because* does have an immediate effect on processing, since it increased probe recognition times at the early probe position.

The integration of *because* sentences depends on clause order. Sentences with the clauses ordered as main-*because* are harder to integrate than sentences with the *because*-main order. This exception actually follows from a discourse-level statistical strategy: the canonical order of events in a story is cause-effect (e.g., van Dijk 1977; Townsend 1983; Trabasso and Sperry 1985; Trabasso, Secco, and van den Broek 1984; Trabasso and van den Broek 1985). If the discourse-processing system applies a cause-effect template as the default, the results of Millis and Just at both probe positions follow naturally. The connective *because* at the beginning of the second clause signals immediately that the default ordering of events is not fulfilled, and reorganization at the discourse level can proceed as the second clause is being read. We address clause-order effects in section 8.3.5. (A second exception to the generalization that *because* facilitates integration is that "diagnostic" statements with *because* are difficult; see Traxler, Bybee, and Pickering 1997.)

8.3.3 Adversative Connectives: The Discourse Level and Analysis by Synthesis

In Joseph Heller's novel *Catch-22* (1996:187), one of the characters yells out, "I see everything twice!" The comprehension system is similar: it accesses form twice, and it also accesses meaning twice. The surface form is stored in a memory buffer and the

comprehension system accesses function morphemes (part of pseudosyntax) to organize words into major phrase groups. The surface form is also accessed at the point of checking the generated syntax against the memory-buffer representation of the surface form. Similarly, meaning is accessed when common sentence patterns activate an initial meaning-form hypothesis, and again when sentence meaning is integrated into a conceptual representation. Thus, in the normal course of comprehension, there will be alternations in accessibility to syntactic and semantic information. As Wundt put it (Blumenthal 1970; chapter 2), attention oscillates between the outside world (surface form) and the inside world (meaning).

In general, the structural models of comprehension describe the problem as mapping a surface representation onto a conceptual representation. In a left-right parsing model, the input is serially assigned a syntactic structure that either immediately, or with a delay, feeds semantic analysis. By the end of each unit, the comprehension system recodes the surface form into one or more potential syntactic structures and conceptual realizations (Caplan 1972; Chang 1980; Jarvella 1971; Just and Carpenter 1980; Haberlandt and Graesser 1985; Rodriguez, Ravelo, and Townsend 1980; Sachs 1967). Similarly, associative and spreading activation models seek to assign a complete structure at all levels at each point in the surface sequence. Thus, on all the models we reviewed in chapter 4, the default is that the surface-sequence representation is either erased or at least is no longer relevant as processing goes on.

Yet, buffers exist. For various reasons, particular models may assume that the input string is maintained for a fixed number of words. Usually, the goal of this is to allow for backtracking and reanalysis when parsing errors occur on the first pass through the string or to avoid parsing errors in the first place (see chapter 4). But no model except LAST is required by definition to maintain a complete representation of the surface string, at least for every major derivational unit—for example, the clause. LAST requires maintenance of the input surface string to verify that the candidate syntactic analysis produced by the synthetic component actually matches the surface string. This raises the following question: Is there evidence that comprehension activities take advantage of the availability of a complete surface representation of major syntactic units? If so, this tends to support LAST—other models could include such a complete buffer, but the only reason to do so would be to accommodate that evidence.

In some circumstances, it may be necessary to retain access to the surface form, and LAST affords a natural mechanism for doing this. A case in point is

(50) a. It's not that John doesn't like sandwiches ...

This is a complete sentence syntactically, but it is not complete pragmatically. Full conceptual interpretation requires completion of a contrast. The sentence may be continued as

(50) b. ... it's just that *Mary* doesn't like them.
c. ... he just can't *eat* them on his diet.
d. ... he just doesn't like *white bread*.

These continuations demonstrate that almost any word in the sentence may serve as the basis for the contrast. Thus, the comprehension system needs some means of preventing information from being dumped out of short-term memory, even though the syntax is correct.

Another case in point is adversative conjunctions such as *although* (see Blakemore 1989; Dakin 1970; Halliday and Hasan 1976; Noordman and Vonk 1997; Quirk et al. 1972; Segal and Duchan 1997; Townsend 1983; Vonk and Noordman 1990). In

(51) a. Although Sally called up her aunt each night ...

the sentence can be continued to establish a contrast with the subject

(51) b. ... *Sam* never calls

with the verb

(51) c. ... she never *writes* to her aunt

or with the object

(51) d. ... she never calls her *grandmother*.

The use of *although* indicates that, while the information in the subordinate clause should be stored in memory as an event that did occur, the occurrence of this event did not cause the event that one would have expected. To integrate the meaning of an *although*-sentence into a coherent representation of text, the comprehender must determine what causal relation was expected but did not occur. The following sentences express the apparent causal relation (or diagnostic relation; see Traxler et al. 1997) that was expected for each of the three continuations above:

(52) Because Sally calls her aunt each night, Sam does the same.

(53) Because Sally calls her aunt each night, she writes to her as well.

(54) Because Sally calls her aunt each night, she calls her grandmother as well.

Thus, *although* is a cue that the pragmatic interpretation of a clause may depend on additional information. *Although* signals the comprehension system to use information from outside the clause to arrive at a pragmatic interpretation of the *although*-clause.

These facts show that the conceptual interpretation of an *although*-clause requires information from outside the clause. An *although*-clause generally cannot be conceptually integrated immediately. The conceptual interpretation of the information within the *although*-clause depends on which aspect of the clause is the source of the

adversative relationship. Thus, the surface form must be maintained for the purpose of conceptual integration. Therefore, attention will be directed more to the lexical/syntactic level than to the semantic/conceptual level. On the other hand, since the conceptual integration of a *because* clause does not depend on information outside of it, it can be integrated as soon as there is an initial meaning hypothesis. Thus, we expect that conceptual integration will occur as rapidly as possible, and therefore attention will be focused on a more semantic/conceptual level while processing a *because*-clause.

Townsend and Bever (1978) obtained support for the view that adversative conjunctions shift attention toward a superficial level of linguistic representation. They presented two different probe tasks near the ends of spoken clauses that were introduced by one of several connectives. One probe task depended on structural information, while the other depended on semantic associations. The materials included the following examples using *if*, *though*, or main clauses without a connective and similar materials using the relatively neutral *when*:

(55) If, *early target, word probe*
If Pete calls up his aunt each ... UP

(56) If, *late target, word probe*
If Pete calls his aunt up each ... UP

(57) If, *associative-meaning probe*
If Pete calls up his aunt each ... USING THE PHONE

(58) Though, *early target, word probe*
Though Pete calls up his aunt each ... UP

(59) Though, *late target, word probe*
Though Pete calls his aunt up each ... UP

(60) Though, *associative-meaning probe*
Though Pete calls up his aunt each ... USING THE PHONE.

(61) *Main, early target, word probe*
Pete calls up his aunt each ... UP

(62) *Main, late target, word probe*
Pete calls his aunt up each ... UP

(63) *Main, associative-meaning probe*
Pete calls up his aunt each ... USING THE PHONE

In all cases, the speech stopped immediately after *each* (i.e., before the end of the surface structure clause) and the probe item appeared visually. For the word-probe examples, subjects said whether *up* had appeared in the sentence fragment. This task

Table 8.14
Relative accessibility to surface form and meaning in the online processing of initial subordinate clauses

	Task	
Connective	Surface form[a]	Meaning[b]
if	−159	+136
when	−67	−19
though	+399	−340

a. Word probe response time for late targets—word probe response time for early targets in subordinate clause relative to main clause
b. Meaning probe response time for subordinate clause—meaning probe response time for main clause
Source: Adapted from Townsend 1983, fig. 1

requires attention to the words of the clause. Since the target *up* appears in different positions within the clause in the early and late target conditions, any difference in response times for the early versus late targets will indicate relative attention to the location of words within clauses. For the associative-meaning probe, subjects said whether *using the phone* is associated with any part of the sentence fragment. This task requires attention to information that is associated with words and phrases in the clause. In this case, *using the phone* and *calls up* are associated.

The results appear in table 8.14. The entries in the first column of table 8.14 are response times for late targets minus response times for early targets, relative to target position differences in main clauses. Response time differences between early and late targets were greater for *though*-clauses than for *if*-clauses. This result suggested that *though* directs attention to the surface order of words which results in a left-to-right serial search for the target word. However, on the associative-meaning probe, shown in the second column of table 8.14, response times were relatively faster for *if* than for *though*. These results show that *if* directs resources toward associative information. This pattern of results was replicated by Townsend (1983) using other tasks, by Townsend, Carrithers, and Bever (1987) using auditory probes, and by Lehman (1990; Townsend 1997) using visual materials.

Townsend, Hoover, and Bever (2000) confirmed that connectives influence how comprehenders allocate attention between levels of representation during sentence comprehension. Subjects first read a cue word or phrase, and then listened to sentences like those below.

(64) *Synonym target*, if
YOUNG PEOPLE: If Harry keeps snakes on the farm kids visit every day.

Table 8.15
Mean response times (ms) depending on conjunction and monitoring task

	Monitoring task	
Conjunction	Synonym	Nonsense
if	624	391
when	726	347
though	765	342

Source: Adapted from Townsend, Hoover, and Bever, forthcoming

(65) *Synonym target*, though
YOUNG PEOPLE: Though Harry keeps snakes on the farm kids visit every day.

(66) *Nonsense syllable target*, if
KIG: If Harry keeps snakes on the farm kig visit every day.

(67) *Nonsense syllable target*, though
KIG: Though Harry keeps snakes on the farm kig visit every day.

The subjects' task was to monitor for either a synonym or a nonsense syllable. If the subjects received *young people* as a cue, they were to monitor for a word that was associated semantically with this phrase. If they received a nonsense syllable like *kig* as a cue, they were to monitor for a syllable that matched it. The results appear in table 8.15.

Response times for semantic associates were faster for *if* than for *though*. This result suggested that the availability of a causal chain, signaled by *if*, directs attention more to semantic associations. Response times for nonsense words, however, were faster for *though* than for *if*. This result suggested that the demand for determining the expected causal relation that is required by *though* directs attention to structural units (syllables). Since these differences between connectives occur in online monitoring tasks, they appear to depend on how comprehenders allocate attention resources during comprehension.

The series of studies on connectives fits naturally with LAST, which posits a late reaccess of both superficial form and conceptual information. Connectives that differ in their requirements for integration into a conceptual representation influence the focus of attention on form versus conceptual information. In this view, responses to *though*-clauses occur at the point of syntax checking, making superficial form including word order and syllables highly accessible. Responses to *if*-clauses occur at the point of conceptual integration. The studies reported in the next three sections elaborate on this conclusion.

8.3.4 Syntax Checking: Discourse-Level Effects

Townsend and Bever (1982; see section 8.3.1 of the present book) used the word-naming task from Tyler and Marslen-Wilson 1977 to examine how conjunctions affect accessibility to syntactic information. Subjects heard initial clause fragments that contained unambiguous phrases, such as

(68) *Initial* if
   a. If polishing glasses . . . [gerund]
   b. If glittering glasses . . . [adjectival]

(69) *Initial main*
   a. Polishing glasses . . .
   b. Glittering glasses . . .

(70) *Initial* though
   a. Though polishing glasses . . .
   b. Though glittering glasses . . .

Immediately after hearing *glasses*, subjects saw a single word such as *is* or *are*. Their task was to name the word as quickly as possible.

Polishing is transitive and *glittering* is intransitive. Hence, *polishing glasses* is a gerund structure with *glasses* as theme, and *glittering glasses* is an adjectival structure with *glasses* as the noun that it modifies. A gerund structure requires a main verb that is singular, as in

(71) Polishing glasses is tedious work.

If the main verb is plural, the sequence is ungrammatical. On the other hand, an adjectival structure requires a main verb that agrees with the head noun, in this case the plural *glasses*, as in

(72) Glittering glasses are sometimes found in chandeliers.

If the main verb for an adjectival phrase like *glittering glasses* is singular, the sequence is ungrammatical. Response times to name a singular versus plural verb indicate how closely comprehenders have processed the syntactic information at the time the target word appears.

Several factors in these materials operate to influence responses on the word-naming task. First, differences in processing of transitive and intransitive verbs involve filling the argument requirements of verbs, such as whether the verb requires a patient, as with transitive verbs such as *polishing*, or an agent experiencer, as with intransitive verbs such as *glittering*, as we noted in earlier chapters. If comprehenders utilize such information immediately to generate a syntactic structure, they should respond faster to congruent target words than to incongruent target words. Second, application of the NVN template locally will produce faster response times for plural target words,

Table 8.16
Effect of congruity of target word with structure bias: naming times for incongruent targets—naming times for congruent targets (in ms)

	Structure	
Connective	Singular	Plural
if	120	124
main	3	82
though	20	−18

Source: Adapted from Townsend and Bever 1982, fig. 1

which agree with the local noun (*glasses*). Third, connectives will influence attention to semantic information. Since initial *if* best fits the cause-effect template at the discourse level, a syntactic structure based on the argument requirements of verb will be generated quickly. Since *though* fits the cause-effect template worst and depends on extraclausal information, syntax generation will be delayed. Since a main clause provides no specific cues to discourse-level information, the more canonical sentence templates will apply, producing faster response times for plural bias.

The results appear in table 8.16. There was a large structural bias effect for both gerund and adjectival structures for *if*, no bias effect for either structure for *though*, and a large bias effect only for adjectival structures for main clauses. The results for *if* suggest that it shifts attention toward meaning. In LAST, activating the meaning of a verb such as *glittering* also activates the information that it is intransitive and requires an agent experiencer, and therefore must be a modifier of *glasses*. The results for *though* suggest that it shifts attention away from meaning, and hence, there is no effect of syntactic information.

The results for main clauses suggest that listeners apply the NVN template locally, to the noun and the verb. Subject nouns and verbs must agree in number (Bock and Miller 1991). Since the noun *glasses* is plural, it should take a plural verb. The NVN template appears to apply equally to adjectival and gerund structures. However, the fact that there was no target number effect for gerund structures suggests that the gerund requirement for a singular verb cancels the effect of the locally applied NVN template, which would require a plural verb for the plural noun. That is, the NVN template conflicts with the local-agreement strategy, producing no effect of gerund structures.

8.3.5 Syntax Checking: Clause-Order Effects

In general, memory is better when the clauses in a two-clause sentence are ordered as main-subordinate (Clark and Clark 1968; Flores d'Arcais 1978; Irwin and Pulver 1984; Jou and Harris 1990; Townsend 1983) and this order is preferred in production

as well (McCabe and Peterson 1988). In comprehension and memory, there are a number of reversals of results depending on the order of main and subordinate clauses (Clark and Clark 1968; Townsend and Bever 1978; Bever and Townsend 1979; Shedletsky 1975; Townsend 1983; Townsend, Ottaviano, and Bever 1979; Townsend and Ravelo 1980). The general finding is a variable that interacts with clause type in a particular way in the initial clause of a sentence but interacts in the *opposite* way in the final clause of the sentence. Reversals depending on clause order occur as a function of both the semantic role of the clause and the structural role. Reversals that depend on the structural role of a clause suggest that the entire two-clause sentence is a relevant unit in an analysis-by-synthesis cycle.

Consider, for example, the results we reviewed above (section 8.3.3) showing that information in *though*-clauses is accessed more readily in a surface form, while in *if*-clauses it is accessed more readily at a conceptual level. Those results were for initial clauses only. In the same study Townsend and Bever (1978) administered word-probe recognition and associative-meaning probe tasks for final clauses, as in:

(73) *Main first,* though *second, early target*
There is little danger of a major depression though good jobs are now quite scarce in most large . . . NOW

(74) *Main first,* though *second, late target*
There is little danger of a major depression though good jobs are quite scarce now in most large . . . NOW

(75) Though *first, main second, early target*
Though there is little danger of a major depression good jobs are now quite scarce in most large . . . NOW

(76) Though *first, main second, late target*
Though there is little danger of a major depression good jobs are quite scarce now in most large . . . NOW

The auditory presentation of the sentence was stopped just before the last word of the sentence, and the word probe *now* was presented. Similar materials were used for the associative-meaning probe task. The response-time results depending on the conjunction that introduces the final clause appear in table 8.17.

For both tasks, the pattern of results for final clauses was very nearly the opposite of the results for initial clauses (see table 8.15). Table 8.17 contrasts the relative accessibility to serial position of words in subordinate clauses, relative to main clauses, and the relative accessibility to associative meaning, relative to main clauses. The most notable exception to a mirror-image reversal between *if* and *though* for initial versus final clause probes is that the large surface form effect for initial *though* (399 ms; table 8.15) is much smaller for final *if* (86 ms; table 8.17). This result suggests that

Table 8.17
Relative accessibility to surface form and meaning in the online processing of final subordinate clauses

	Task	
Connective	Surface form[a]	Meaning[b]
if	+86	−295
when	−125	−117
though	−267	−21

a. Word probe response time for late targets—word probe response time for early targets in subordinate clause relative to main clause
b. Meaning probe response time for subordinate clause—meaning probe response time for main clause
Source: Adapted from Townsend and Bever 1978

increased access to surface form does not occur because the clauses are presented out of the normal cause-effect order in a main-*if* sentence, but rather, it occurs because an *if*-clause, unlike a *though*-clause, does not require information from outside the clause.

Following our earlier interpretation, the reversed results suggest that in final clause position, *though*-clauses actually are accessed at a conceptual level, while *if*-clauses are accessed more serially. We (Townsend and Bever 1978) interpreted the reversal for *though* as follows: In a final *though*-clause, a conceptual analysis provided by the initial assignment mechanisms can immediately identify the adversative component because the entire main event has been recoded into conceptual terms. A more literal analysis of *if*-clauses is required because a final *if*-clause is out of canonical cause-effect order, and the entire two-clause sentence has to be put back into a correct sequence, thereby emphasizing serial order in general.

We also (Townsend and Bever 1978) reported a reversal in the results for the word-probe task depending on the structural role (main versus subordinate) of the clause. In this case, we used the connective *when*, which is neutral as to causal and temporal order. The results appear in table 8.18.

The results showed that response times were significantly longer for late targets than for early targets in initial subordinate clauses, and also in final main clauses (see table 8.18). These results suggested a serial, left-to-right search in these types of clauses. In terms of LAST, these clauses are searched for the word target at the syntax-checking stage, when superficial form is reaccessed. According to the model, clauses that do not show evidence of serial left-to-right search are at the point of conceptual integration, when superficial form is no longer readily accessible. These results follow from the assumption that initial main clauses and final subordinate

Table 8.18
Response times (ms) on word probe task depending on clause type, clause position, and target position

	Initial clause			Final clause		
Clause type	Early	Late	L – E	Early	Late	L – E
Main	1098	1125	27	1117	1207	90
Subordinate	1085	1181	96	1157	1057	−100

Source: Adapted from Townsend and Bever 1978

clauses are readily integrated into a conceptual representation. Initial subordinate and final main clauses require further processing to integrate them with the other clause in the sentence.

Bever and Townsend (1979) reported a similar reversal in word-probe results depending on the number of syllables in the clause. Their experimental logic relied on the argument that an increasing relationship between set size and probe recognition time is evidence for a serial exhaustive scan of memory (e.g., Sternberg, 1966). Subjects heard two-clause sentences such as

(77) *Initial main, short*
The cat killed the parrot when Sam left the house for a week ... KILLED

(78) *Initial main, long*
The young sailor dropped the anchor when nobody had spotted any whales ... DROPPED

(79) *Initial subordinate, short*
When the cat killed the parrot Sam left the house for a week ... KILLED

(80) *Initial subordinate, long*
When the young sailor dropped the anchor nobody had spotted any whales ... DROPPED

Short clauses contained six or seven syllables, while long clauses contained eight or nine syllables. The results appear in table 8.19.

Response times were longer for long clauses than for short clauses. Length of clause had a larger effect in initial subordinate clauses and in final main clauses, compared to the other two conditions.

This series of studies on clause-order effects shows that the representation that is searched in a word-probe task is a more superficial representation when the target is located in a clause that does not appear in the canonical structural or semantic order. Since an initial subordinate clause, particularly one that denies the normal cause-effect organization of discourse, is dependent on the main clause, the syntax is checked

Table 8.19
Response times (ms) on word probe task depending on clause type, clause position, and clause length

	Initial clause			Final clause		
Clause type	Short	Long	L – S	Short	Long	L – S
Main	1342	1352	10	1243	1336	93
Subordinate	1374	1406	32	1274	1276	2

Source: Adapted from Bever and Townsend 1979, table 6.10

somewhat later than for sentences with an initial main clause. This late checking makes the superficial representation more accessible, producing target position effects and length effects.

8.3.6 Discourse, Connectives, and Conceptual Integration

After syntax checking for complete units, final conceptual integration with context is possible. Conceptual integration may clearly vary in complexity depending on the nature of the context (e.g., Haberlandt 1982). Townsend (1983) examined the interactions of connectives and a context sentence in conceptual integration. Subjects read a two-sentence story and created a sentence to continue the story. The first sentence had one clause and the second had two clauses, one of which was introduced by *although* or *because*. The sentences appeared in either main-first or subordinate-first order. The first sentence paraphrased either the main clause or the subordinate clause of the second sentence. Some sample materials for *although*-sentences are:

(81) *Paraphrase of* although-*clause*
   a. Harry takes care of reptiles in his house.
   b. Although he raises snakes, kids often visit Harry.

(82) *Paraphrase of main clause*
   a. Children are always hanging around Harry's place.
   b. Although he raises snakes, kids often visit Harry.

Some sample materials for *because*-clauses are:

(83) *Paraphrase of* because-*clause*
   a. Harry takes care of reptiles in his house.
   b. Because he raises snakes, kids often visit Harry.

(84) *Paraphrase of main clause*
   a. Children are always hanging around Harry's place.
   b. Because he raises snakes, kids often visit Harry.

Table 8.20
Mean continuation times (sec) depending on conjunction and paraphrased clause

	Clause paraphrase	
Connective	Subordinate	Main
because	9.1	9.7
although	9.3	6.3

Source: Adapted from Townsend 1983, fig. 7

As we have noted, sentences with *although* deny an expected causal relation. A pragmatic interpretation of an *although*-sentence requires determining what causal relation the speaker or writer had expected. This can be done by drawing an inference from the main clause of the sentence, or from context. Thus, discourses that paraphrase the main clause ought to make it easier to integrate an *although*-sentence conceptually. Townsend (1983) tested this hypothesis by measuring the time that subjects took to create a sentence that plausibly continued to discourse. The average continuation times appear in table 8.20.

Paraphrases of the main clause significantly reduced continuation times only for *although*-sentences (by 1.0 sec). The main clause of an *although*-sentence provides information that can be used to determine the expected causal relation that is being denied by *although*. The fact that paraphrases of the main clause reduced continuation times for *although*-sentences confirms that *although*-clauses are interpreted in terms of information outside of the clause, and, in this case, in terms of information outside of the sentence. When the information contained in the main clause is available at the time of reading an *although*-sentence, conceptual integration is facilitated.

We (Townsend and Bever 1989) found similar results with script-based contexts. Townsend and Bever used the materials described earlier (sections 8.22 and 8.23):

(85) *High support*
Johnny woke up very hungry for breakfast. He found a bowl and a spoon in the kitchen. He got a pitcher of milk from the refrigerator. Although he took down some ... GETTING THE CEREAL

(86) *Low support*
Johnny was watching his favorite programs on TV. He started to get hungry for a snack. He waited for a commercial to go into the kitchen. Although he took down some ... GETTING THE CEREAL

Subjects listened to the story until they heard a short tone after the word *some*. Three hundred ms later, a two- to four-word phrase (*getting the cereal*) appeared on a screen. The subject's task was to say whether or not the phrase was similar in mean-

Table 8.21
Mean probe recognition times (sec) depending on conjunction and contextual support

	Connective	
Context	because	although
Low support	2.31	2.39
High support	2.30	2.22
Facilitation	.01	.17

Source: Townsend and Bever 1989, table 2, Skilled Readers

ing to any part of the last sentence. Response times on this meaning-probe task appear in table 8.21. Supportive contexts significantly reduced response time only for *although* (by 170 ms) not for *because* (the facilitation effect for *because* was 10 ms).

These results show that a supportive context increases attention to meaning near the end of an *although*-clause. *Because*-sentences can be directly integrated conceptually as the phrases and corresponding meaning become available. But for their pragmatic interpretation, *although*-sentences require knowledge of what causal relation the speaker is denying. Since the stories in this study were based on a stereotypical sequence of events (i.e., script; see section 8.2.2), the subjects have this knowledge before hearing the story. Comprehenders can use this knowledge for conceptual integration of an *although*-clause as they hear it. Together with the results of Townsend 1983, these results suggest that discourse context influences the integration of sentence meaning into a coherent representation of discourse.

8.4 Conclusion: Representations, Discourses, and Modules

This chapter reviewed the role of different kinds of representations that flicker on and off during comprehension. One fundamental point is that LAST offers a way to explain both data that support apparent syntactic processing modularity, and data that support ongoing conceptual integration effects. The synthetic aspect of comprehension has some characteristics of modularity, but the initial meaning hypothesis is based on nonmodular processes.

We are now in a position to answer the question we posed earlier: Do higher-level discourse processes take advantage of the architecture of the sentence-comprehension system by utilizing the persistence of both meaning and surface representations? Many researchers have found evidence for the immediate postclause salience of meaning as we have with connectives like *because*. Studies of the processing of sentences with *although* suggest that the comprehension processes also maintain and use surface representations for developing discourse-level representations. These surface

representations persist as a natural outcome of the requirement that syntax checking occurs after the synthesis of the surface form. The ease of access to phonological representations, the persistence of representations of superficial word order and lexical items, and clause-length effects on word-probe recognition that connectives such as *although* stimulate all demonstrate the availability of surface information. The availability of surface information has functions both in the normal course of sentence comprehension and in developing higher-level discourse representations. It is an intrinsic feature of LAST that two pairings of meaning and surface representations are retained and accessed during comprehension.

We must interpret the data we reviewed in this chapter cautiously. Both structure-first and constraint-based models can accommodate the facts regarding the maintenance of different types of representations. For example, we could add to these models a buffer that maintains superficial representations. While such a change could account for the data, it is an ad hoc change that does not follow from the basic assumptions of the model. The persistence of surface representations, however, is an intrinsic part of LAST.