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Sentence Comprehension.

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Chapter 7

Canonical Sentence Templates

In this chapter, we review some of the evidence that supports the pervasive use of canonical sentence templates during an early stage of comprehension. These templates include roughly:

NVN = agent-action-object
NV = agent/experiencer-action
NVNN = agent-action-patient-recipient/location

Rather than using the cumbersome NV(N(N)), we refer to sentence templates generically as the NVN template, with the assumption that argument-requiring properties of the verb stimulate alternative sentence-level templates.

First, we compile many of the studies on reduced object relative clause constructions, such as (1).

- (1) *Reduced object relative passive clause*
The horse raced past the barn fell.

An enormous number of experiments have explored the parameters that control the strength of the italicized misleading parse in reduced relative constructions. From our standpoint, these studies offer information on the kinds of cues that elicit sentence templates. Most of these have been devoted to the question of whether semantic factors have an immediate impact on parsing, or whether the garden path is strictly controlled by the sequence of syntactic categories. We review many of these studies with more attention to how they bear on the analysis-by-synthesis model than to their success or failure at revealing online semantic effects. We outline what factors should influence the processing of reduced relatives, according to LAST.

After reviewing studies on the processing of reduced relatives out of context, we review recent research on the question of how discourse context influences the comprehension of reduced relatives. The general question is, to what extent is the garden-path interpretation dependent on pure structure-assigning processes? Conversely, to what extent can the garden-path interpretation be modulated or even negated by

strong counterindicative lexical, semantic, or discourse information? There are many studies on such questions, often producing orthogonal and sometimes apparently conflicting results. We will see that the architecture of LAST explains the wide-ranging data on reduced relatives.

The reduced relative constructions can reveal the power of the entire NVN template, since it involves both the subject-verb relation and the verb-object relation. But other constructions have been studied, which concentrate on the isolated tendency to treat the initial noun as agent, as in the contrast between subject and object relative sentences:

(2) *Subject relative*

The horse that raced the dog fell.

(3) *Object relative*

The horse that the dog raced fell.

Correspondingly, other studies have explored the tendency to take a verb-noun sequence, as action-patient, as in the contrast between direct object and complement constructions:

(4) *Direct object*

The horse knew the trainer.

(5) *Complement*

The horse knew the trainer is nice.

In addition, we summarize other garden-path examples of the role of sentence templates in comprehension. Overall, it is startling to see the explanatory power of this simple formulation. It accounts for data in several hundred published articles and conference presentations. But given our theoretical scheme, that is exactly what one would predict.

7.1 Reduced Relative Clauses out of Context

The main-clause/relative clause (MC/RC) ambiguity is the classic garden-path sentence, and it plays an important role in virtually all theory development (e.g., Crocker 1996; Frazier and Clifton 1996; Gibson 1998; Gorrell 1995; MacDonald et al. 1994; Marcus 1980; Pritchett 1992). The following sentence from Bever 1970a illustrates the MC/RC ambiguity:

(6) The horse [raced past the barn] fell.

This sentence is particularly tough to interpret, but is grammatically acceptable, as revealed by the corresponding

(7) The classes [scheduled for next Tuesday] are canceled.

From the viewpoint of LAST, it is instructive to consider the factors that make sentences like (6) difficult and those like (7) easy.

In chapter 6, we reviewed evidence that the comprehension system uses pseudosyntax to establish an initial meaning-form hypothesis. Pseudosyntax is sensitive to grammatical morphemes and function words, lexical information such as the relative strength of subcategorization requirements, and sentence-level templates. We also reviewed evidence that the comprehension system uses this initial representation of meaning to generate a detailed syntax, which it then compares with a representation of the linguistic signal. According to LAST, sentence-level templates, lexical category information, grammatical morphemes, and subcategorization and other lexically based strategies will play important roles in producing the garden path in reduced relatives. What should not play a role in the immediate processing of reduced relatives is conceptual information that requires syntactically precise combinatorial processing of phrases within the sentence, because LAST claims that the initial meaning-form hypothesis is based on statistical patterns and lexical-associative information only.

7.1.1 The NVN Pattern in Reduced Relatives

As a rough approximation to LAST's processing of (8), the initial meaning-form hypothesis is based on the fact that the sequence *the horse raced past the barn* elicits an NVN template.

(8) The horse raced past the barn fell.

The horse is assigned the agent role, the intransitive *raced* is assigned as the action, and *past the barn* is assigned the role of a locative prepositional phrase.

The subcategorization properties of the verb define what counts as a complete semantic unit. In this case, the verb *raced* may be transitive, intransitive, or a passive participle, as in

(9) *Transitive*

The horse raced the turtle.

(10) *Intransitive*

The horse raced on Tuesday.

(11) *Passive*

The horse was raced by the jockey.

All other things being equal, we assume that whenever pseudosyntax accumulates enough information to form a complete semantic unit, it does so. However, it may be that NVN represents a canonical sentence pattern more than other sequences, such as NV.¹ That is, although *the horse raced* forms a complete semantic unit in the intransitive sense of *raced*, the comprehension system may still assume that the verb

is used transitively and expect a second noun phrase immediately after the verb. In the case of (8), the sequence of words *the horse raced past the barn* completes a semantic unit based on the intransitive interpretation of *raced*. The comprehension system uses this meaning to generate a candidate syntax.

- (12) [[The horse] [raced [past the barn]]]

The comprehension system finds that this candidate syntax matches the surface sequence up through *barn*. The match between the candidate syntax and the surface sequence confirms the syntax and the corresponding meaning is stored. *Fell*, however, indicates that the candidate syntax is incorrect, and the previously accepted parse is now inhibited. Therefore, the pseudosyntax elicits a less strongly primed meaning-form hypothesis for the grammar to generate a new candidate syntax. Thus, in general, the garden path occurs because of faulty application of the NVN template, which assigns the initial noun as agent of the embedded verb.

Several experimental demonstrations are consistent with the view that the comprehension system presents an initial meaning-form hypothesis based on the NVN pattern. Rayner, Carlson, and Frazier (1983) found that eye-fixation times were greater in reduced relative clauses (13) than in unreduced relative clauses (14).

- (13) *Reduced relative*

The florist [sent the flowers] was very pleased.

- (14) *Unreduced relative*

The florist [who was sent the flowers] was very pleased.

This difference persisted even when the initial noun was an implausible agent, as in

- (15) *Reduced relative*

The performer [sent the flowers] was very pleased.

- (16) *Unreduced relative*

The performer [who was sent the flowers] was very pleased.

Ferreira et al. (1996) examined the processing of reduced relative clauses in speech. They used the auditory moving-window technique, in which listeners control the rate of presentation of spoken words. The results showed that listening times on *agreed* were greater for reduced relatives such as (17) than for active sentences such as (18).

- (17) *Reduced relative*

The editor [played the tape] agreed the story was important.

- (18) *Active*

The editor played the tape and agreed the story was important.

The classic example of the MC/RC ambiguity is a particularly powerful garden path. People typically have great difficulty in detecting that the sentence is gram-

matical when they first examine it. As we noted earlier, reduced relatives differ widely in their ease of processing, and it is instructive to examine the factors that influence the strength of the MC/RC garden path. Depending on their associative strength, these factors increase or decrease the strength of the NVN template, and thus how easily the garden path can be overcome.

7.1.2 Grammatical Morphemes

The reduced relative construction works as a garden path only insofar as the interpretation as a simple past declarative sentence is supported. Morphological cues associated with the initial verb can strengthen or weaken this interpretation. The garden-path effect depends on the use of a verb in the relative clause that is morphologically homonymous with a past tense. Thus, a variety of studies have shown that if the embedded verb is morphologically distinct from a simple past, it will not elicit a garden-path interpretation, as in:

(19) The horse [ridden past the barn] fell.

Since the *-en* ending on *ridden* makes it unambiguously a passive participle, the unambiguous passive morphology inhibits the NVN template.

7.1.3 Subcategorization Properties

According to LAST, embedded verbs that do not have the potential interpretation of the intransitive but are ambiguous between past tense, transitive, and passive participle should still produce a garden path. In this case, however, the garden path should be far less compelling. The reason the garden path will still occur is that pseudosyntax at first assigns the initial noun as the agent of the embedded verb. The reason the garden path will be less compelling is that without the intransitive interpretation being possible, the comprehension system will not detect an initial meaning-form hypothesis, will not initiate synthesis of a surface form, and will not check the synthesized form against the input.

Consider the following example from Pritchett 1992 (see section 4.2.3):

(20) *Transitive embedded verb*

The spaceship [destroyed in the battle] disintegrated.

Sentence (20) is much easier than one such as (21) in which the embedded verb is potentially intransitive.

(21) *Potentially intransitive embedded verb*

The spaceship [disintegrated in the battle] destroyed many enemy ships.

Technically, both sentences could have a direct object somewhere after the embedded verb. But the placement of the prepositional phrase *in the battle* intervenes, and would make the ultimate appearance of an object rather awkward, in (22) and (23).

(22) *Transitive-only verb + prepositional phrase + direct object*

The spaceship destroyed in the battle all of the enemy cruisers and several of the enemy battleships.

(23) *Potentially intransitive verb + prepositional phrase + direct object*

The spaceship disintegrated in the battle all of the enemy cruisers and several of the enemy battleships.

The NVN template is inhibited because the canonical location for the object noun phrase is directly after the verb. We return to this issue in more detail later in this section.

Nonetheless, a past tense verb form that does not have an intransitive sense still elicits a much weaker garden path even when the object phrase is ultimately presented. The potentially intransitive *disintegrated* allows the formation of a complete semantic unit before the actual main verb, as in *The spaceship disintegrated in the battle*. This complete initial meaning-form hypothesis leads to syntax generation and checking and to readiness for a new analysis-by-synthesis cycle. On the other hand, the past form *destroyed*, which does not have an intransitive sense, does not allow the comprehension system to form a complete semantic unit before the actual main verb, as in *the spaceship destroyed in the battle*. Thus, pseudosyntax does not present an initial meaning-form hypothesis for it. This greatly weakens the lure of the garden-path NVN.

The importance of homonymy with an intransitive main verb is made even clearer when an agentive *by*-phrase is present:

(24) *Potentially intransitive verb with by-phrase*

The spaceship [disintegrated by the enemy] disappeared.

(25) *Transitive-only verb with by-phrase*

The spaceship [destroyed by the enemy] disappeared.

When a verb such as *destroyed* cannot be intransitive, the presence of the clear agentive phrase appears intuitively to completely neutralize the garden path available with potentially intransitive verbs.

MacDonald (1994) systematically investigated the impact of several of these factors that govern the strength of the garden path. First, she contrasted self-paced word reading times for reduced relatives with embedded verbs that are potentially intransitives (PI) such as *fought*, verbs that are transitive-only (TO) such as *capture*, and verbs that are unambiguously passive participles such as *overthrown*. The unambiguous passive participles were half from potentially intransitive verbs such as *drawn*, and half from transitive-only verbs such as *overthrown*.

(26) *Potentially intransitive*

The ruthless dictator fought in the coup was hated.

(27) *Transitive only*

The ruthless dictator captured in the coup was hated.

(28) *Unambiguous passive participle verb*

The ruthless dictator overthrown in the coup was hated.

Note that since *fought* is potentially intransitive, the NV template applies, and pseudo-syntax detects the acceptable surface form in (29), which matches the input.

(29) *Intransitive*

The ruthless dictator fought in the coup.

Thus, at the point of *coup*, the comprehension system has generated a complete meaning-form hypothesis and matched it to the input. The system is then ready for another analysis-by-synthesis cycle.

MacDonald (1994) used a self-paced moving-window paradigm to examine ambiguity effects in potentially intransitive versus transitive-only verbs. In table 7.1, we show the difference in reading times for ambiguous and unambiguous trials, in which the relative clause morphology *that was* appears after the initial noun (*dictator*). When there is a garden path, this difference is large and positive, and it is called an *ambiguity effect*. For the data reported in table 7.1, reading times were adjusted for differences in phrase and word length in each region. The results clearly show that the ambiguity effect on the main verb (*was hated*) is larger for potentially intransitive verbs (a 40-ms difference) than for transitive-only verbs (a 15-ms difference). MacDonald (1994) supported this conclusion further by contrasting potentially intransitive verbs that have an intransitive bias (e.g., *move*) with those having a transitive bias (e.g., *push*). The corresponding data for this study appear in parentheses in table 7.1. These results suggested to MacDonald that the transitive-bias embedded verbs tend much less to create the classic garden-path elevation of reading times at the main-verb disambiguation point.

Table 7.1

Ambiguous – unambiguous word reading time (ms) for potentially intransitive (PI) and transitive-only (TO) verbs by region

	Relative clause	Main verb
PI (IB)	–14 (0)	40 (32)
TO (TB)	–2 (–8)	15 (4)
Difference	–16 (–8)	+25 (+28)

Note: Ambiguity effects for intransitive bias (IB) vs. transitive bias (TB) in parentheses

Source: From MacDonald 1994, exp. 1, fig. 1, collapsed across goodness of cue; exp. 3, fig. 4, intransitive bias vs. transitive bias

7.1.4 Lexical-Category Effects on the Strength of NVN

Information that supports the NVN template should increase the garden-path effect. As we noted earlier, lexical-category information that follows the verb but decreases the likelihood that there is a direct object for the verb weakens the strength of the NVN pattern. LAST maintains that lexical-category information is part of pseudo-syntax, and hence, available for eliciting an initial meaning-form hypothesis.

MacDonald (1994) explored the effect of postverbal evidence for a transitive (NVN) interpretation. She varied the first word following the verb so that it either was or was not consistent with a possible direct object following it:

(30) *Initially implausible direct object (~DO)*

The dictator [fought in the coup] was hated.

(31) *Initially plausible direct object (DO)*

The dictator [fought just after dawn] was hated.

In the sentences in which a direct object is initially implausible (~DO), the presence of *in* immediately after *fought* indicates that the embedded verb (*fought*) is not likely to be transitive. In the sentences with an initially plausible direct object (DO), the word *just* immediately after the verb conceivably may be part of a direct object, as in *just one soldier*, and so the ambiguous verb may have a transitive interpretation.

Using optionally intransitive verbs, MacDonald (1994) found no ambiguity effect within the relative clause for sentences like (30). However, there was a highly significant ambiguity effect on the main verb for sentences like (31). In sentences like (31), the adjunct phrase prolonged the possibility of a transitive garden-path interpretation of the embedded clause.

MacDonald argued from this that what makes reduced relatives garden-path is not just the tendency to interpret the embedded verb as a simple past intransitive, but also the tendency to interpret it as a simple past transitive. That is, *any* information that supports the inappropriate assignment of NVN of some kind can increase the garden-path effect. This interpretation is puzzling, however, since the garden path with transitive-prolonging cues is much larger for optionally intransitive verbs than for the transitive-only verbs. It would seem that the availability of a potential intransitive still plays an important role in eliciting the garden path.

Another postverbal lexical category cue that can affect the strength of the garden path is the word *by*. The word *by* following a verb that is ambiguous between past tense and passive participle is strong but not decisive evidence that the verb is being used as a passive participle. In (32) the *by*-phrase may be interpreted as the agent of *moved*, suggesting that *moved* is a passive participle and the construction is a reduced relative interpretation.

- (32) *Potentially intransitive verb + by*
The cattle moved by the cowboys.

Alternatively, the *by*-phrase may be interpreted as a locative phrase, suggesting that *moved* is a past-tense intransitive verb and the construction is a main clause. Frequency counts of the use of *by* following a verb indicate that it is used much more frequently as an agent phrase than as a locative phrase. Unfortunately, several studies on the processing of reduced relatives have acknowledged but failed to appreciate fully the possibility that a postverbal *by*-phrase can weaken the NVN interpretation, and hence the garden path. (See Clarke, Townsend, and Bever 2000, who systematically show that the preposition *by* does tend to inhibit the garden-path interpretation, compared with other prepositions.)

7.1.5 Animate vs. Inanimate Initial Nouns

Another factor that influences the strength of the NVN pattern is animacy of the initial noun. When the initial noun is animate, it is likely that it is the agent of the verb. When the input contains a initial animate noun and words and phrases that correspond to N + V + N, pseudosyntax likely will assign the meaning sequence agent + action + patient. If an animate initial noun increases the garden-path effect, this is evidence that semantic factors can be integrated during processing.

While it is not intuitively controversial that semantic factors should have such an effect, the scene about it was set confrontationally by Ferreira and Clifton (1986). They studied eye-fixation patterns when reading reduced relative clause sentences with animate and inanimate initial nouns with materials like the following:

- (33) *Animate initial noun, reduced relative*
The defendant [examined by the lawyer] turned out to be unreliable.
- (34) *Animate initial noun, unreduced relative*
The defendant [that was examined by the lawyer] turned out to be unreliable.
- (35) *Inanimate initial noun, reduced relative*
The evidence [examined by the lawyer] turned out to be unreliable.
- (36) *Inanimate initial noun, unreduced relative*
The evidence [that was examined by the lawyer] turned out to be unreliable.

For both animate and inanimate subject nouns, Ferreira and Clifton (1986) reported the same degree of increase in reading time for the *by*-phrase when the relative pronoun and past tense were deleted. They concluded that the animacy of the noun did not control the garden-path effect, consistent with their theoretical viewpoint that the garden path is itself the result of a syntactic attachment process, not influenced by semantic factors (see section 4.2.1). In their view, “minimal attach-

ment” gives a higher priority to the NVN interpretation of reduced relatives than to the correct reduced relative interpretation. Thus, this study served as a strong argument in favor of the notion of an independent process of assigning surface phrase structure.

The challenge from Ferreira and Clifton (1986) launched a number of counter-studies by researchers promoting the nonmodular connectionist view of parsing. In that view, semantic and syntactic factors commingle during every stage of parsing, and thus semantic factors should show an immediate effect (see section 4.3.4).

MacDonald (1994) investigated the question of whether the animacy of the initial noun influences the effectiveness of the garden path. She contrasted animate and inanimate initial nouns in combination with postverbal information that makes a direct object plausible or implausible, as in:

- (37) *Inanimate subject, direct-object plausible*

The shipment [transported almost two thousand miles] would help ...

- (38) *Inanimate subject, direct-object implausible*

The shipment [transported to the polluted beaches] would help ...

- (39) *Animate subject, direct-object plausible*

The workers [transported almost two thousand miles] would help ...

- (40) *Animate subject, direct-object implausible*

The workers [transported to the polluted beaches] would help ...

MacDonald (1994) measured self-paced word-reading times in sentences like these, as well as in control sentences with unreduced relative clauses, as in *the shipment that was transported* ...

MacDonald (1994) predicted that animate subjects would elicit larger differences in reading time between reduced and unreduced relative clauses. Table 7.2 shows the average reduced minus unreduced differences in word-reading time. On the disambiguating main verb, sentences with an animate initial noun showed a larger ambiguity effect than sentences with an inanimate initial noun. When the initial noun was animate, plausible-direct-object sentences showed a 26-ms ambiguity effect on the main verb. But when the initial noun was inanimate the corresponding ambiguity effect was only 11 ms. The implausible-direct-object sentences showed a 10-ms ambiguity effect on the main verb for animate initial nouns, but only a 4-ms ambiguity effect on the main verb for inanimate initial nouns. These results demonstrate that animacy of the initial noun, as well as the beginning of a potential patient noun phrase after the embedded verb, support the NVN pattern, and therefore increase the strength of the garden path.

MacDonald’s reading time data within the relative clause supports this interpretation. Sentences with an animate initial noun actually have smaller ambiguity effects

Table 7.2

Adjusted ambiguous–unambiguous word-reading time by region

	Region	
	Relative clause	Main verb
<i>Direct object (DO)</i>		
Animate	10	26
Inanimate	29	11
DO overall	20	19
<i>Not direct object (~DO)</i>		
Animate	18	10
Inanimate	24	4
~DO overall	21	7

Source: From MacDonald 1994, fig. 3, exp. 2

during the relative clause compared to sentences with inanimate subjects. That is, the difference in reading time between reduced and unreduced relative clauses is smaller when the initial noun is animate than when it is inanimate. For plausible-direct-object sentences, the ambiguity effect within the relative clause was 10 ms for animate initial nouns and 29 ms for inanimate initial nouns. This result suggests that the animate nouns facilitate the NVN interpretation. This interpretation is further strengthened by the fact that the facilitation is much larger for plausible-direct-object sentences than for implausible-direct-object sentences. Clearly, this difference occurs because the postverbal material in the relative clause of plausible-direct-object sentences prolongs the possibility of a direct object. Unfortunately, in this experiment (MacDonald's experiment 2) the reported results collapse across equal numbers of optionally and obligatorily transitive verbs. Since MacDonald's other studies show that there are considerable differences in strength of the garden path with these kinds of embedded verbs, we must be cautious in interpreting the results.

Trueswell, Tanenhaus, and Garnsey (1994) responded directly to Ferreira and Clifton (1986). Trueswell and colleagues first noted that Ferreira and Clifton's materials had a number of flaws. In particular, a number of sentences had embedded verbs that could serve as good predicates for inanimate nouns, as in *the trash smelled*. In other cases, the verb could allow an instrumental interpretation of the inanimate subject of the embedded verb, as in *the car towed*. Trueswell and associates reckoned that about half of Ferreira and Clifton's materials had such properties that would allow good garden-path continuations for their inanimate nouns. Trueswell et al. also noted that Ferreira and Clifton presented the sentences with the embedded verb as the final word of the first line of print. This might independently trigger segmentation regardless of the subject noun's animacy.

Table 7.3

First-pass reading times (ms) for reduced (R) and unreduced (U) relatives

Sentence type	Region			
	NP	V + <i>ed</i>	<i>by</i> -phrase	MV
<i>Animate noun</i>				
Reduced	390	350	625	490
Unreduced	400	350	500	490
R – U	–10	0	125	0
<i>Inanimate noun</i>				
Reduced	420	350	520	450
Unreduced	440	320	490	440
R – U	–20	30	30	10

Source: From Trueswell, Tanenhaus, and Garnsey 1994, fig. 3, exp. 2

Trueswell, Tanenhaus, and Garnsey ran a set of redesigned studies with reworked materials and a presentation format that had the complete sentence on a single line. They used the eye-tracking procedure, and measured first-pass reading times. Their results appear in table 7.3. They reported a significant effect of the animacy of the initial noun. In fact, the only ambiguity effect was for reduced relatives with animate subject nouns. This effect occurred on reading the *by*-phrase.

7.1.6 Conceptual Fit

We have seen that the garden path in a reduced relative occurs because of the incorrect detection of a NVN pattern, which elicits assignment of the initial noun as agent of the embedded verb. The independent pattern that an initial animate noun is the agent of the verb can compound the garden path. We have suggested that pseudo-syntax accesses noun animacy immediately on recognition of the word, but that local associations between particular nouns and verbs come into play only after they are set in conceptual relation to each other. In this section, we examine conceptual fit and its interactions with subcategorization properties of verbs. We will see that the immediate effect of conceptual fit is not as strong as that of animacy, and that its effect depends greatly on the argument requirements of the embedded verb.

Several researchers have investigated the role of local associations in the effectiveness of the garden path. It has been noted that nouns may differ in their appropriateness as an agent for verbs independently of their animacy. For example, both (41) and (42) contain animate initial nouns, but these nouns differ in their plausibility as agents/recipients of the action of sending a bouquet of flowers:

(41) *Implausible agent/plausible recipient*

The performer sent the bouquet was very pleased.

(42) *Plausible agent/implausible recipient*

The florist sent the bouquet was very pleased.

A florist is more likely to send a bouquet of flowers compared to a performer, and less likely to receive a bouquet of flowers. Thus, comprehenders may be more likely to misinterpret the reduced relative clause in the second sentence as actually being a main clause. The question arises whether this type of plausibility information influences the initial meaning-form hypothesis, and hence the strength of the garden path.

Trueswell and associates followed up their work on animacy, which we reviewed in the previous section, with additional work on “conceptual fit.” They performed a post hoc analysis on the conceptual fit of the inanimate nouns as good patients of the embedded verb. They acquired ratings to such questions as:

(43) *Goodness-of-patient questions*

- a. How typical is it for evidence to be examined by someone?
- b. How typical is it for a power plant to be attacked by someone?

(44) *Goodness-of-agent questions*

- a. How typical is it for evidence to examine someone?
- b. How typical is it for a power plant to attack someone?

These ratings showed, for example, that *evidence* is a better patient than *power plant* in the following sentences:

(45) The evidence examined by the lawyer turned out to be unreliable.

(46) The power plant attacked by the terrorists suffered heavy losses.

The mean patient-goodness rating for *evidence* was 6.3 out of 7, and for *power plant*, 4.4 out of 7.

Trueswell and colleagues then determined the correlation between the size of the ambiguity effect and the rating of the initial inanimate nouns as good patients. The correlation between patienthood of inanimate nouns and first-pass ambiguity effect on the verb was $r = -.42$, $p = .12$, while the corresponding correlation on the *by*-phrase was $r = -.51$, $p < .05$. The results showed a nonsignificant negative correlation at the embedded verb, but a significant negative correlation on the *by*-phrase.

Trueswell et al. (1994) then isolated the inanimate noun + embedded verb sequences that had a simultaneous good conceptual fit as patients and poor conceptual fit as agents of the embedded verb, as determined by the ratings described above. Ambiguity effects on reading time for poor patients, good patients, and animate nouns appear in table 7.4. The data show showed that the garden-path effect is entirely absent for sequences with inanimate nouns that are good patients for the embedded verb. This result follows from the view that the good patients were interpreted immediately as patient of the embedded verb because they do not serve well as agent of the embedded verb.

Table 7.4

Ambiguity effect for animate nouns, and for inanimate nouns divided into those that are good patients/poor agents and poor patients/good agents of the embedded verb (RT for reduced relative minus unreduced relative)

Sentence type	Region	
	verb + <i>ed</i>	<i>by</i> -phrase
<i>Inanimate noun</i>		
Poor patient	44	46
Good patient	7	−9
<i>Animate noun</i>		
	5	100

Source: After Trueswell, Tanenhaus, and Garnsey 1994, fig. 5

Table 7.5

Mean reading times (ms) for the initial noun phrase and verb depending on animacy of the initial noun

	Region	
	Initial NP	Embedded verb
<i>Reduced relative</i>		
Inanimate	420	345
Animate	380	345
I – A	40	0
<i>Unreduced relative</i>		
Inanimate	435	320
Animate	390	345
I – A	45	−25

Source: Adapted from Trueswell, Tanenhaus, and Garnsey 1994, fig. 3, exp. 2

Before going further, we consider these kinds of data in light of LAST. According to LAST, associative information in the form of statistical regularities, common sentence patterns, and global associations to lexical items such as animacy immediately elicits an initial meaning-form hypothesis. Local relations between words that require computation will not appear immediately. The distinction between the immediacy of global information and the delay in local relations makes several predictions. First, the effects of animacy on reading time may appear very quickly. For example, in experiment 2 of Trueswell et al. the reading time for the initial animate noun phrase itself was about 40–45 ms faster than for the inanimate noun phrase (see table 7.5). Yet the reading time for the embedded verb was actually about 25 ms faster for the inanimates than animates in the unreduced constructions, while there

was no difference in the reduced constructions. As we noted in the previous section, the animate-noun/agent association may combine with the initial noun/agent association to facilitate rapid reading and agent assignment of an initial animate noun phrase, compared with an inanimate noun phrase. Thus, inanimate nouns like *evidence* are read more slowly than animate nouns like *lawyer*. But in the reduced relative construction, there is not time for the difference between the plausibility of the two nouns as patients of *examine* to have an effect on reading time. Second, if patienthood has any influence on the size of the ambiguity effect at the embedded verb, it should occur because of faster reading times in unreduced constructions, which allow sufficient time for the noun and verb to be set into conceptual relation. In the unreduced case, pseudosyntax may establish a relatively complete proposition for the relative clause, corresponding to *the defendant was examined*, with the agent unspecified.

(47) *Unreduced*

The defendant [that was examined] . . .

N = agent = defendant

[N = agent = ?]

V = action = examined

N = patient = defendant

But for a reduced relative such as (48), there are not enough cues to overcome the NVN pattern and establish the corresponding proposition for the relative clause:

(48) *Reduced*

The defendant examined . . .

N = agent = defendant

V = action = examined

Thus, any difference in the conceptual fit between the initial noun and the verb can emerge at the verb, but primarily in the unreduced sentences, which enable the system to present a meaning-form hypothesis for the relative clause. This will establish the conceptual fit between the noun and the verb.

Table 7.6 contrasts the effect of a good patient on verb reading time for reduced and unreduced relative clauses in a number of studies (McRae, Spivey-Knowlton, and Tanenhaus 1998; Pearlmutter and MacDonald 1992; Tabossi et al. 1994). The table presents mean reading times for good-agent initial nouns minus mean reading times for good patient initial nouns. As predicted by LAST, these studies show that reading times for the embedded verb are faster for good patients than for good agents primarily in unreduced relative clauses. They also show that the goodness of the patient has the predicted reduction in reading time on reading the *by*-phrase. This follows from the fact that by that time, there is sufficient time and information

Table 7.6

Reading-time effects of conceptual fit (good agent – good patient word-reading times in ms)

Sentence type	Region		
	Verb	<i>by</i> -phrase	Main verb
<i>Pearlmutter and MacDonald 1992:</i>			
Unreduced	2	25	25
Reduced	–50	–2	82
	Verb + <i>by</i>	det + NP	Main verb
<i>McRae, Spivey-Knowlton, and Tanenhaus 1998:</i>			
Unreduced	20	35	–10
Reduced	–17	47	40
<i>Tabossi et al. 1994:</i>			
Unreduced	22	47	23
Reduced	6	35	77

Source: From Pearlmutter and MacDonald 1992, fig. 1; McRae, Spivey-Knowlton, and Tanenhaus 1998, fig. 5; Tabossi et al. 1994, table 24.1

to extract the noun-verb conceptual relations. Note that none of these studies reports data with the same effect of patient goodness on verb reading time in reduced constructions.

The point at which goodness-of-patient has an effect distinguishes LAST from more global spreading activation models. Spreading activation models predict that the effect of goodness-of-patient will occur on the verb, but LAST predicts that it will come at the completion of an analysis-by-synthesis cycle. Consider first the predictions of spreading activation models and the evidence for these predictions. In unmodified versions of spreading activation models, all kinds of information are accessed immediately, and good patients should immediately squelch the garden-path interpretation. Spreading activation models predict that for good-patient nouns, there will be little difference in reading time for reduced versus unreduced relative clauses. If a good-patient noun immediately establishes the initial noun as patient of the verb, additional information provided by the relative clause morphology *that was* cannot increase the strength of that interpretation. But for poor-patient nouns, spreading activation models predict a large garden-path effect. Indeed, Trueswell and colleagues found that the correlation between patient goodness and the size of the ambiguity effect on the embedded verb was negative, so that as the goodness of the initial noun as a patient increased, the size of the ambiguity effect decreased. However, in both of their experiments that examined the relation between goodness-of-patient and ambiguity effect, Trueswell and associates failed to find that this correlation was significant.

Table 7.7

Ambiguity effects (ms) in four experiments on goodness of patient (ambiguous – unambiguous word reading times)

Patienthood	Region		
	Verb	<i>by</i> -phrase	Main verb
<i>Pearlmutter and MacDonald 1992:</i>			
Good patient	30	25	20
Poor patient	–20	–5	75
	Verb + <i>by</i>	det + NP	Main verb
<i>McRae, Spivey-Knowlton, and Tanenhaus 1998, fig. 5:</i>			
Good patient	61	35	0
Poor patient	25	44	60
<i>Tabossi et al. 1994, animates only:</i>			
Good patient	39	47	18
Poor patient	21	21	73
<i>McRae, Spivey-Knowlton, and Tanenhaus 1998, fig. 2:</i>			
Good patient	66	0	10
Poor patient	60	44	9

Source: From same studies as in table 7.6, with the addition of MacRae, Spivey-Knowlton, and Tanenhaus 1998, fig. 2

Several studies explicitly varied goodness-of-patient of the initial noun in order to examine ambiguity effects in various regions of the sentence. Table 7.7 summarizes the ambiguity effects in these studies by presenting the ambiguous minus unambiguous reading-time differences at various regions. The specific regions vary across experiments because of procedural differences in the studies. The four studies summarized in table 7.7 agree that good patients do not eliminate the garden-path effect on the initial verb. In these studies, the ambiguity effects on the initial verb for good patients ranged from 30 to 66 ms. It is only on the following noun phrase or even later that a good-patient initial noun eliminates the garden path. Of the four studies in table 7.7, only MacRae, Spivey-Knowlton, and Tanenhaus (1998, fig. 2) found that good patients eliminated the garden path as early as the *by*-phrase.

There is a consistent feature across these experiments. The ambiguity effect for reading time on the verb (or verb + *by*) is actually larger for good patients than for poor patients. It is not until the main verb that the studies generally demonstrate the predicted result of poor patients showing a larger ambiguity effect than good patients. Close examination of actual experimental sentences used in the studies reveals a clue to this puzzle. In short, the obtained effects of patienthood depend on subcategorization properties of the verb, and hence, when an analysis-by-synthesis

Table 7.8

Percentage of sentences with potentially intransitive (PI) embedded verbs used in studies of reduced relative garden paths

Study	Percent PI verbs
1. Ferreira and Clifton 1986, exp. 1	31
2. MacDonald 1994, exp. 2	28
3. McRae, Spivey-Knowlton, and Tanenhaus 1998	20
4. McRae, Ferretti, and Amyote 1997	10
5. Pearlmuter and MacDonald 1992	100
6. Tabossi et al. 1994	31
7. Trueswell 1996, low PP condition	70
high PP condition	0
8. Trueswell, Tanenhaus, and Garnsey 1994, exp. 1	13
exp. 2	25

Note: Potentially intransitive verbs in the above studies: attacked, burned, cooked, dissolved, entertained, exploded, helped, hunted, interviewed, investigated, kicked, lectured, lifted, listened, moved, paid, painted, popped, poured, read, ripened, scratched, searched, served, shattered, sketched, smelled, stalked, studied, surrendered, taught, visited, washed, watched, widened, worshipped

cycle is to be completed. Recall MacDonald's (1994) finding that garden-path effects are more reliable when the embedded verb is potentially intransitive. It turns out that almost all studies both before and after MacDonald (1994) used more purely transitive than potentially intransitive embedded verbs. Table 7.8 shows the proportion for each of the studies we have discussed. This is a startling state of affairs. How could four years of research continue to study reduced relative garden-path effects with a preponderance of transitive-only embedded verbs, when MacDonald actually found no ambiguity effect for them, especially at the main-verb disambiguation point? In most spreading activation models, constraints are additive. While there may not be an overall garden-path effect for transitive-only embedded verbs, such models still predict that transitive-only verbs will show a larger ambiguity effect for poor patients than for good patients. Thus, within the spreading activation framework, it should be possible to study the effect of the independent effects of patient fit regardless of verb type. The imbalance in favor of pure transitive verbs in most experimental materials may be an instance in which a theory has driven researchers to ignore their own work.

7.1.7 Interactions of Conceptual Fit and Subcategorization

In this section, we examine the issue of whether conceptual fit effects depend entirely on the argument requirements of verbs. We will find evidence that they do. In short,

Table 7.9

Ambiguity effects depending on conceptual fit for sentences with potentially intransitive embedded verbs

Noun	Region		
	Verb + <i>by</i>	Det + noun	Main verb
Good agent	68	97	208
Good patient	2	16	34
Difference	66	81	174

Source: Reanalysis of Tabossi et al. 1994 data

at the point when a verb requires an agent to form a complete proposition, good agents have an effect. Similarly, when a verb requires a patient to form a complete proposition, good patients have an effect. This evidence establishes that semantic compositional information influences processing only at a later stage of comprehension, in contrast to lexically specific semantic information, which influences the initial meaning-form hypothesis.

Tabossi et al. (1994) examined conceptual fit between the initial noun and the embedded verb. The study by Tabossi and colleagues is particularly useful because it included a detailed appendix with data for each individual sentence. Since there were thirty-two experimental sentences with animate subjects, it is possible to contrast differences between sentences that allow for an intransitive reading of the embedded verb, and those that do not. We did this, finding that about a third of their sentences have potentially intransitive embedded verbs. Consider first the ambiguity effects for sentences with potentially intransitive verbs that appear in table 7.9.

These results are quite striking. Good agents show noticeably larger ambiguity effects compared to good patients. A large ambiguity effect for good agents appeared even on the embedded verb + *by*. This result limits MacDonald's (1994) finding of greater ambiguity effects for intransitive verbs than for transitive verbs to those that appear with good agents.

Both the standard connectionist models and LAST predict greater ambiguity effects for good agents than for good patients when the verb is intransitive, but for different reasons. In the standard connectionist model, a good agent should stimulate more activity for the main-clause garden-path interpretation.

(49) *Good patient*

The performer applauded by ...

(50) *Good agent*

The audience applauded by ...

The word *by* presented at the same time as the verb to some extent triggers the passive even in the reduced relative construction, making the passive interpretation more consistent with a good-patient initial noun. Hence, the word *by* following the verb in a sentence with a good-patient initial noun works against the main-clause garden path. This greatly reduces the ambiguity effect for good-patient nouns. An initial main clause proposition on the NV pattern is complete at the intransitive embedded verb. A good agent supports the main-clause interpretation, but a following *by* interferes with this interpretation, making the ambiguity effects larger for good agents than for good patients.

The two theories may be differentiated by their predictions for the transitive-only embedded verbs. On the standard connectionist version, the same relative effect should occur for transitive-only versus potentially intransitive verbs. Good patients should be more consistent with the correct reduced relative assignment and therefore show smaller ambiguity effects on the embedded verb. This is not the case, as table 7.10, with transitive-only verbs, shows when compared with table 7.9, with potentially intransitive verbs. Tables 7.9 and 7.10 clearly show that conceptual fit has *opposite* effects on processing the embedded verb for transitive-only versus potentially intransitive verbs.

Before turning to an explanation of tables 7.9 and 7.10 within the framework of LAST, consider for a moment how confusing these results are for interpreting the several dozen major experiments with reduced relatives. Most of the published materials show more than half of the sentences to use embedded verbs that are only transitive. This may explain why the reported impact of conceptual fit on ambiguity effects at the embedded verb is so variable. The two kinds of sentences appear to have opposite effects at that point.

Why should conceptual fit interact with verb subcategorization type? To explain this, we must examine additional syntactic and semantic properties of the two kinds of verbs. There are two importantly different kinds of passives, which we will call agent-requiring verbs and patient-requiring verbs.

Table 7.10

Ambiguity effects depending on conceptual fit for sentences with transitive-only embedded verbs

Noun	Region		
	Verb + <i>by</i>	Det + noun	Main verb
Good agent	4	–38	32
Good patient	58	63	10
Difference	–54	–101	22

Source: Reanalysis of Tabossi et al. 1994 data

(51) *Agent-requiring*

The performers were applauded by the audience.

(52) *Patient-requiring*

The thief was captured by the cop.

Agent-requiring verbs always require an agent, at least implicitly (see Mauner et al. 1995; Mauner and Koenig 1999; Melinger and Mauner 1999), or something else such as an adverb that can mark them as an event, whereas patient-requiring verbs do not. Hence the relative oddness of (53) and (54) compared to (55) to (58).

Agent-requiring

(53) ?The performers were applauded.

(54) ?The applauded performers ...

Agent-requiring

(55) The performers were applauded at the end.

(56) The loudly applauded performers ...

Patient-requiring

(57) The thief was captured.

(58) The captured thief ...

The fact that verbs like *applaud* require agents may also allow them to appear intransitively with only an agent. But (59) to (62) show that patient-requiring verbs like *capture* may not appear intransitively with only an agent:

Agent-requiring

(59) The audience applauded.

(60) The audience's applauding was unexpected.

Patient-requiring

(61) *The cop captured.

(62) *The cop's capturing was unexpected.

The requirement that agent-requiring verbs have an agent also explains why these verbs can be ambiguous when they appear as a deverbal nominal as in (63) and (64).

Agent-requiring

(63) The applauding of the audience was unexpected.

(64) The audience's applause was unexpected. (either interpretation)

Sentences (65) and (66) show that the corresponding deverbal nominals with patient-requiring verbs allow only a patient interpretation of the noun.

Patient-requiring

(65) The capturing of the thief was unexpected.

(66) The thief's capture was unexpected. (patient only)

The ambiguity of the agent-requiring verbs in (63) and (64) depends on the fact that they can be interpreted as transitive or as intransitive. If there is a patient, the verb is interpreted as transitive, but if not, it is interpreted as intransitive. On the other hand, patient-requiring transitive-only verbs must have a patient in all their various constructions, either explicitly or implied, but they can often lack an agent. According to LAST, lexically specific information is accessed only after the obligatory argument positions are filled. Thus, LAST predicts that the primary effect of conceptual fit will be for good agents with potentially intransitive embedded verbs and for good patients with transitive-only verbs. This is exactly the obtained pattern of results.

LAST makes a further prediction. The early ambiguity effect with transitive-only verbs will be due primarily to an asymmetry in the unreduced constructions. At the auxiliary and passive participle, unreduced constructions explicitly mark the initial noun as object and a potential patient. When the verb is patient-requiring, it requires a patient and not an agent, and so its required arguments are filled and the specific fit of the initial noun as a patient with a particular verb will have an immediate effect.

(67) *Patient-requiring, good patient*

The thief [that was captured by ...]

(68) *Patient-requiring, good agent*

The cop [that was captured by ...]

Thus, for unreduced patient-requiring verbs reading times will be faster with a good patient as in (67) than with a good agent as in (68). Conversely, agent-requiring verbs are potentially intransitive, and should show no effect of conceptual fit on unreduced constructions, because their required agent argument has not yet been encountered:

(69) *Agent-requiring, good patient*

The performer [that was applauded by ...]

(70) *Agent-requiring, good agent*

The audience [that was applauded by ...]

Thus, for unreduced agent-requiring verbs reading times will be similar with good patients and good agents.

The data from Tabossi and colleagues confirm both of these predictions. Table 7.11 shows the difference in reading time between good agents and good patients within the relative clause, beginning with the embedded verb. For transitive-only verbs, the reading time for unreduced constructions was consistently longer during

Table 7.11
Reading-time difference between good agents and good patients for unreduced relative clauses (good agent – good patient)

Type of verb	Good agent – good patient
Potentially intransitive	–29
Transitive only	93

Source: From Tabossi et al. 1994

Table 7.12
Ambiguity effects within relative clauses for primarily transitive-only verbs (reading times for reduced – unreduced)

Study	Region		
	Verb + <i>by</i>	Det + noun	Main verb
<i>Spivey-Knowlton, Trueswell, and Tanenhaus 1993:</i>			
Exp. 1	46	110	50
Exp. 2	34	55	26
<i>McRae, Ferretti, and Amyote 1997</i>	63	24	10

Sources: Spivey-Knowlton, Trueswell, and Tanenhaus 1993 (exps. 1 and 2, tables 2 and 4, 1 referent condition only) and McRae et al. 1997 (exp. 3, fig. 2)

the relative clause with good agents than with good patients. There was no such difference for potentially intransitive verbs.

Tabossi et al. did not design their study to distinguish between the two types of verbs, so we need to look for independent confirmation of the pattern shown in their results. As we noted earlier, several studies of reduced relatives (it appears by chance) use a preponderance of one or the other kind of verb (see table 7.8). First, Spivey-Knowlton, Trueswell, and Tanenhaus (1993) and McRae, Ferretti, and Amyote (1997) used almost all transitive-only verbs in self-paced reading time studies. In both sets of studies, the initial noun was an acceptable patient. Like Tabossi et al. they both report more ambiguity effect during the relative clause than at the main verb, as shown in table 7.12.

A few studies contrasted potentially intransitive with transitive-only verbs. As we noted earlier in this section, MacDonald (1994) pointed out that the classic main-verb reading-time elevation occurs only with potentially intransitive verbs. But her data also show the *reverse* effect for the transitive-only verbs (see table 7.4). That is, transitive-only verbs show more relative garden-path elevation of reading time during the relative clause.

Table 7.13

Relative clause ambiguity effects for potentially intransitive (PI) vs. transitive-only (TO) verbs (combined into mean word reading time for two-word regions)

Verb type	Region		
	Verb + <i>by</i>	Det + noun	Main verb
PI	−4	49	85
TO	22	25	5

Source: Trueswell 1996

Finally, in two different studies Trueswell (1996) contrasted single-word self-paced reading of materials that contained almost entirely potentially intransitive verbs in one study with materials that had almost entirely transitive-only verbs in the other. The initial nouns were acceptable as both an agent and patient of the critical verb. The ambiguity effects for transitive and intransitive verbs appear in table 7.13. The results neatly contrast the two kinds of verbs in the same way as in Tabossi et al. (1994).

Trueswell's results are a striking within-study confirmation of the pattern of data from Tabossi and colleagues. However, Trueswell was interested in showing that what controls the strength of the garden path is the relative frequency with which the particular passive participle is used in the passive. He predicted that the garden-path effect would be larger for verbs that appear in the passive form relatively infrequently. It is obvious that the relative frequency of the past being used as a passive is likely to be a function of the total number of constructions the verb can appear in. Thus, potentially intransitive verbs have relatively fewer appearances in the passive because they can appear in a larger number of different construction types. Indeed, Trueswell's materials group with mostly potentially intransitive verbs was his "low passive participle frequency" group. The frequency distinction is almost completely confounded with the verb-type distinction in his materials, so further research is needed to untangle the variables.

This complex of results is generally consistent with LAST, but of course, must be taken cautiously. First, as we noted earlier, these studies were not designed explicitly to differentiate the effects of potentially intransitive versus transitive-only embedded verbs. This variable needs to be embedded within several replications of various studies that we have discussed. Second, there remains the systematic confound of the distinction between the two kinds of verbs and the relative frequencies of the passive participle. In principle, this can be teased apart by using verbs of only one type and varying the relative frequency of the passive participle within that type. If the relative frequency of the passive participle accounts for the variance within each verb type, that would argue strongly for it as the overall cause, depending on the strength of the

effect. Third, we can imagine a variety of implementations of spreading activation models that might make the same propositional structure-dependent predictions as made by LAST. We predict that such models will turn out to be either explicit or happenstantial implementations of the critical features of LAST. That too remains to be seen.

7.1.8 Unergative vs. Unaccusative Verbs

We have noted that the transitive-intransitive distinction is critical in producing a garden path. Research by Stevenson and Merlo (1997) suggests that within the class of potentially intransitive verbs the unergative-unaccusative distinction is important in processing sentences with reduced relatives. Intransitive verbs can take only one argument, which is either agent or experiencer. Intransitive verbs typically are differentiated into verbs such as *melt*, which are *unaccusative*, and verbs such as *race*, which are *unergative* (see section 6.3.3). The action depicted by an unaccusative verb typically “happens to” its subjects and cannot be intentional, while the converse is true of an unergative verb.

(71) *Unaccusative verbs*

- a. What happened to the butter was it melted
- b. *The butter intentionally melted

(72) *Unergative verbs*

- a. *What happened to the horse was it raced
- b. The horse intentionally raced.

In addition, both unergative and unaccusative verbs alternate between intransitive and transitive uses, but these types are distinguished in terms of whether the agent of the intransitive verb and the patient of the transitive verb causes an action. In both uses of the unergative *raced*, for example in (73) and (74), *horse* in some sense causes the action of racing.

(73) *Unergative, intransitive*

The horse raced past the barn.

(74) *Unergative, transitive*

The rider raced the horse past the barn.

This is not true for *butter* in (75) and (76), which have an unaccusative verb.

(75) *Unaccusative, intransitive*

The butter melted in the pan.

(76) *Unaccusative, transitive*

The cook melted the butter in the pan.

Stevenson and Merlo (1997) argued that unergative verbs as a class are intuitively more susceptible to garden path in sentences with a reduced relative clause, compared to unaccusative verbs. Thus, (77) seems harder than (78).

(77) *Unergative, reduced relative*

The horse raced past the barn fell.

(78) *Unaccusative, reduced relative*

The butter melted in the pan was lumpy.

Filip et al. (1997) presented survey data that suggested that unergative and unaccusative verbs overlap in their difficulty in sentences with reduced relatives. Since there have been no online studies reported comparing unergative and unaccusative verbs, the relevance of this distinction as a syntactic versus semantic dimension needs clarification. It may well turn out that these properties of verbs interact with sentence-level units, just as the argument-requiring properties of verbs do. In addition, it seems likely that verb features such as telicity may underlie the unergative-unaccusative distinction (see sections 3.4.1 and 5.4.7). Such semantic features translate directly into functional syntactic categories, and thus have immediate effects during formation of the initial meaning-form hypothesis.

To conclude our discussion of the comprehension of reduced relatives out of context, we find early effects of available propositional analyses based on subcategorization and thematic properties of verbs. Most notably, garden-path effects are greater for potentially intransitive verbs than for transitive-only verbs. Conceptual fit between the initial noun and the embedded verb interacts with subcategorization properties of the verb. Thus, good agents increase the garden path with potentially intransitive verbs by increasing the salience of the agent-action interpretation. In contrast, good patients decrease the garden path with transitive-only verbs in reduced relatives by increasing the salience of the patient-action interpretation in the unreduced version. The results attest to the compelling perceptual salience of any initial sequence that corresponds to a declarative sentence with an inflected verb. The results appear to be consistent with LAST and to present some challenges to spreading activation models insofar as structural assignment mediates the effects. The fact that different kinds of verbs have superficially opposite garden-path interactions with goodness-of-agent and goodness-of-patient requires that many studies be redone. Finally, the research has been totally dependent on reading and reading-time measures. It is high time to apply various measures of auditory processing load and auditory attention to the problem in ways that do not destroy the natural intonational structure of spoken sentences (see Ferreira et al. 1996; O'Bryan, Townsend, and Bever 2000). Intuitively we know that reduced relatives are quite as bewildering auditorally as visually, possibly more so. But it remains to be seen how the auditory processing system goes about recovering from them when it does, and what variables facilitate that.

7.2 Reduced Relative Clauses in Context

LAST relies in part on the argument requirements of verbs to elicit an initial meaning-form hypothesis. The grammar uses this initial meaning-form hypothesis to generate a candidate syntactic structure for the sentence. The comprehension system then checks the candidate syntax against the input. If the candidate syntax matches the input, the meaning of the sentence is integrated conceptually; if it does not, there is a second analysis-by-synthesis cycle.

On this model, attention to the meaning and structure of a sentence is cyclic. There is initial attention to pseudosyntax, then to its associated meaning, followed by attention to the derived syntax and then attention to meaning again when the sentence meaning is integrated into a higher-level conceptual representation. In this architecture, context can exert an effect in two ways. First, context may prime words (e.g., Forster 1981; Seidenberg et al. 1982). The associated lexical structure, such as subcategorization information, may then influence the initial meaning-form hypothesis. Second, context may prime propositions. This information is most available at the point of integrating the sentence meaning into a discourse representation (Bransford and Franks 1971). A topic of intense research effort during the 1990s was the question of whether the parser can use discourse context to resolve syntactic ambiguities. Multisentence discourses typically connect the sentences with a focused topic—that is, what the sentences are “about.” This kind of connection can make sentences with a reduced relative clause more acceptable by emphasizing the importance of the relative clause as a modifier. Altmann and Steedman (1988) pointed out that a noun phrase often is modified by a relative clause when it is necessary to identify which of two referents the speaker is talking about. Thus, a context that requires distinguishing between potential referents for a noun phrase could eliminate the processing complexity of reduced relatives.

The debate on the role of discourse context in processing sentences with reduced relative clauses has been fueled by some studies that support one position, and by others that support the opposite position. Unlike all other current models, LAST accounts for results both for and against the view that the parser uses contextual information to resolve temporary ambiguities. Briefly, studies that demonstrate contextual resolution of garden-path sentences involve the activities of the comprehension system at the point of integrating sentence meaning with discourse context. Studies that demonstrate little effect of context involve cases in which the comprehension system has presented an incorrect meaning-form hypothesis that must then be revised. In the remainder of this chapter we show how LAST accounts for the data on garden paths of the main clause/reduced relative. We return to discourse-context effects in chapter 8.

7.2.1 Potentially Intransitive Verbs Yield No Context Effect

Studies that show little effect of context on resolving main-clause/reduced relative garden paths have used embedded verbs that primarily are potentially intransitive, as in (79).

(79) *Potentially intransitive*

The wolf [hunted by the ranger] was rabid.

Since *the wolf hunted* satisfies the required arguments of *hunt*, the embedded verb elicits an initial meaning-form hypothesis when the comprehension system receives it. The initial meaning-form hypothesis leads to generating a candidate syntactic structure, checking the syntax, and recoding. Therefore, we expect that studies that used embedded verbs that are potentially intransitive will show strong evidence of a garden path when the main verb is received, regardless of contextual support. Another way of putting this is that potentially intransitive verbs elicit such a strong garden path that supportive or conflicting context is usually overshadowed.

Studies that show that context eliminates the garden-path effects have used mostly embedded verbs that are only transitive, as in (80).

(80) *Transitive verb*

The wolf [captured by the ranger] was rabid.

As we have seen, transitive-only verbs minimally require a patient. Studies that have shown that the garden path disappears in supportive discourse typically have shown the context effect on the embedded noun (e.g., *ranger*). Hence, the garden path in such studies tends to be resolved at the end of the embedded clause, and there is little difference in the processing of the main verb in reduced and unreduced constructions.

The critical issue distinguishing current approaches to the processing of sentences in context is the point during the sentence when context has an effect. Thus, it is essential to pinpoint the location at which there is processing difficulty. For this purpose we can divide a sentence with an embedded reduced relative clause into several processing regions: the initial noun phrase (NP1), the embedded verb plus preposition (EV + P), the embedded noun phrase (NP2), the main verb (MV), and the remainder of the sentence (REST). The various studies on processing reduced relatives in context differ in which of the regions they examine.

Table 7.14 summarizes the materials of six studies that investigated the effects of discourse context on the processing of sentences with reduced relative clauses. The table shows the percentage of embedded verbs that are used only in a transitive sense, and the argument role of the initial noun phrase in the preceding context sentence. It is clear that the garden-path effect disappears in context when the embedded verb is transitive-only and when the context primes a patient role for the initial noun.

Ferreira and Clifton (1986) measured eye tracking while reading sentences with MC/RR ambiguities such as (81) versus control sentences such as (82). The target

Table 7.14

Summary of studies on the role of discourse context in processing sentences with reduced relatives

Study	Garden path	Context role of NP1	%TO
Ferreira and Clifton 1986	Yes	Recipient Patient Agent	50
Britt et al. 1992	Yes	Agent	13
Rayner, Garrod, and Perfetti 1992	Yes	Patient	13
Murray and Liversedge 1994	Yes	Agent	0
Spivey-Knowlton, Trueswell, and Tanenhaus 1993	No	Patient	100
Trueswell and Tanenhaus 1991	No	Patient Agent	75

sentences appeared in contexts that supported either the reduced relative interpretation or the main-clause interpretation. In both target sentences, the word *agreed* establishes the structure of the sentence unambiguously. Accordingly, Ferreira and Clifton (1986) recorded fixation times on the word *agreed*. The target sentences were presented in one of three contexts.

(81) *Reduced relative target*

The editor [played the tape] agreed the story was a big one.

(82) *Main-clause target*

The editor played the tape and agreed the story was a big one.

One of the target sentences followed a three-sentence preamble (83) and a priming context sentence, either (84), (85), or (86). The context sentence biased the interpretation of the garden-path sentence. In one case, the context sentence supported the reduced relative interpretation by mentioning two editors in the sentence that preceded the target sentence as in (84). Thus, a relative clause would be appropriate for distinguishing which of the two editors the writer is referring to. In a second case, the context sentence supported the main-clause structure by mentioning only one editor in the preceding sentence as in (85), and in a third case, the context sentence was neutral between the reduced relative and main-clause biases as in (86).

(83) *Preamble*

John worked as a reporter for a big city newspaper. He sensed that a major story was brewing over the city hall scandal, and he obtained some evidence that he believed pretty much established the mayor's guilt. He went to his

Table 7.15

Mean first-pass fixation times (ms/character)

Context-target	Region		
	NP1 + EV + NP2	MV	REST
RR-RR	26	32	29
N-RR	24	32	28
MC-MC	24	30	24
N-MC	25	27	24

Source: Adapted from Ferreira and Clifton 1986, fig. 2

editors with a tape and some photos because he needed their approval before he could go ahead with the story.

(84) *Context sentence with reduced relative bias*

He ran a tape for one of this editors, and he showed some photos to the other.

(85) *Context sentence with main-clause bias*

He gave a tape to his editor and told him to listen to it.

(86) *Context sentence with neutral bias*

He brought out a tape for one of his editors and told him to listen carefully to it.

The average fixation times in the ambiguous region (NP1 + EV + NP2, *the editor played the tape*), the disambiguating word (MV, *agreed*), and the remainder of the sentence (REST, *the story was a big one*) appear in table 7.15 (RR = reduced relative, MC = main clause, N = neutral). Inspection of table 7.15 shows that fixation times were longer on *agreed* (region MV) and the remainder of the sentence (region REST) when the target sentence was a reduced relative. Ferreira and Clifton (1986) found that fixation times were significantly longer in the relative clause sentence than in the main-clause sentence, and that there was no interaction with context.

About 50 percent of the embedded verbs in this study were potentially intransitive (*played, taught, raced, sued, served, paid, read, asked*). As we noted earlier, an embedded verb that is potentially intransitive initially may elicit a meaning hypothesis that corresponds to the intransitive interpretation at the point of the embedded verb. Thus, *the editor played* constitutes a complete semantic unit following the NV pattern. In addition, the sequence *the editor played the tape* constitutes a complete semantic unit following the NVN pattern. The predominance of both patterns conspires to induce a garden path.

Britt et al. (1992) found that supportive contexts did not eliminate the garden-path effect in reduced relatives. Of the eight test sentences that Britt et al. used, seven contained embedded verbs that were potential intransitives, as in:

(87) *Reduced relative*

The woman / rushed to the hospital / had given birth safely.

(88) *Main clause*

The woman / rushed to the hospital / without taking her laundry.

The slashes indicate viewing windows in self-paced reading. There were three viewing windows: NP1, EV + P + NP2, and MV + REST. The contexts supporting the reduced relative were discourses in which the antecedent for *the woman* was no longer in focus:

(89) *Relative clause bias*

Harry had driven taxis for many years but he still really enjoyed it. Today there was all kinds of excitement. His first call involved rushing a pregnant woman to the hospital and at one moment he expected to have to deliver the baby himself. He then had to take a special package to the airport and only just arrived in time. On the way back he turned on his radio. They said that the woman rushed to the hospital had given birth safely ...

(90) *Main-clause bias*

John had just received the news that their mother was seriously ill in the hospital. His initial thought was to rush to the hospital as quickly as possible. But then he realized that he needed to get in contact with his sister Mary. Her roommate thought that she might be in the laundromat, so John called and described her to them. They said that the woman rushed to the hospital without taking her laundry ...

Since *the woman* in the relative biasing context is no longer in focus at the time of the target sentence, a relative clause modifying *the woman* was needed to clarify its referent. If the comprehenders establish a referent for *the woman* as soon as possible, they should interpret *rushed to the hospital* as a reduced relative clause identifying *the woman*. In this case, the sentence with a reduced relative clause should be no harder than the one with the main-clause interpretation. Table 7.16 shows the results.

Britt et al. (1992) found that reading times for the disambiguating region (MV + REST) were longer in reduced relative sentences than in main-clause sentences. The reduced relative effect occurred in both the no-context condition and in the biasing-context condition. Thus, discourse context does not eliminate the garden path.

Rayner, Garrod, and Perfetti (1992) tested the hypothesis that discourse focus influences the processing of reduced relatives. In an eye-tracking study, they used sentences with verbs that primarily are potentially intransitive (13/15), like the following:

Table 7.16

Mean first-pass fixation times (ms/character) (0 refers to no discourse context)

Context-target	Region		
	NP1	EV + P + NP2	MV + REST
RR-RR	61	70	80
MC-MC	69	68	65
0-RR	72	93	126
0-MC	69	89	105

Source: Adapted from Britt et al. 1992, table 7(91) *Reduced relative*

The coffee / spilled on the rug / was difficult / to conceal.

(92) *Main clause*

The coffee / spilled on the rug / and even marked / the new wallpaper.

The viewing windows were NP1, EV + P + NP2, MV, and REST. The contexts that supported the relative clause interpretation were of two types:

(93) *Reduced relative bias, focus*

Anne didn't know what to say to her parents when they came home. She had thrown a party and the house was in a terrible state. Her friends had spilled coffee on the rug and scratched her mother's new table. The coffee spilled on the rug was difficult to conceal ...

(94) *Reduced relative bias, nonfocus*

Anne didn't know what to say to her parents when they came home. She had thrown a party and the house was in a terrible state. Her friends had spilled coffee on the rug and scratched her mother's new table. She tried to do her best to clean things up a bit. Then she heard her parents at the front door. As they entered she tried to distract their attention. The coffee spilled on the rug was difficult to conceal ...

(95) *Main-clause bias*

Anne had spent a fortune decorating the living room and fitting an expensive new rug. So when her friends came round for coffee she really enjoyed being able to show it off to them. Imagine her embarrassment when she tripped over the table with a tray in her hand. The coffee spilled on the rug and even marked the new wallpaper ...

Table 7.17 shows the results. For the three context conditions, the only significant effect was an interaction between region and context. Fixation times on the main

Table 7.17

Mean first-pass fixation times (ms/char)

	Region		
	NP ₁	EV + P + NP ₂	MV
<i>Context</i>			
RR-bias, nonfocus	34	31	34
RR-bias, focus	34	30	36
MC-bias	33	31	28
<i>No context</i>			
RR	33	34	39
MC	33	33	34

Source: Adapted from Rayner, Garrod, and Perfetti 1992, table 4

verb were faster for the main-clause condition than for the two reduced relative conditions. The two reduced relative conditions did not differ.

Murray and Liversedge (1994) investigated the role of discourse context in processing sentences with reduced relative clauses. An example of their materials contains a potentially intransitive verb (they did not report all of their materials):

(96) *Reduced relative*

The man / dressed as a woman / looked quite ridiculous.

(97) *Unreduced relative*

The man / who was dressed as a woman / looked quite ridiculous.

(98) *Main clause*

The man / dressed as a woman / and looked quite ridiculous.

The viewing windows were NP₁, EV + P + NP₂, and REST. The contexts differed in whether there was one entity, or two, to which the initial noun phrase could refer:

(99) *Double context (reduced relative bias)*

After the auditions two people had been chosen to perform in a local village pantomime. One was a man who was playing the prince and the other was a man who was playing an old witch ...

(100) *Single context (main-clause bias)*

After the auditions two people had been chosen to perform in a local village pantomime. One was a woman who was playing the prince and the other was a man who was playing an old witch ...

Since the double contexts contain two possible referents for the initial noun phrase in the ambiguous target sentence, they support a reduced relative interpretation of the

Table 7.18

Mean reading times (ms/word) depending on type of context and type of sentence

Context-target	Region	
	EV + P + NP2	MV + REST
MC-UR	238	256
MC-RR	210	280
MC-MC	197	271
RR-UR	223	259
RR-RR	213	279
RR-MC	210	256

Source: Adapted from Murray and Liversedge 1994, tables 15.4 and 15.5

target. Murray and Liversedge (1994) measured eye-fixation times in the disambiguating region. The referential theory of Altmann and Steedman (1988) predicted that the double context would eliminate the garden path, since this context requires a relative clause to distinguish the referent of *the man*.

Murray and Liversedge (1994) found that fixation times in the initial region (*the man*) were faster in double contexts. The results for the ambiguous and disambiguating regions appear in table 7.18. Fixation times in the ambiguous region were shorter for reduced relatives than for unreduced relatives. Fixation times in the disambiguating region were longer for reduced relatives than for unreduced relatives. Context, however, had no effect on fixation time, and did not interact with sentence type.

Four studies showed that contexts in which there are two potential referents for the initial noun did not eliminate the processing difficulty of the reduced relative. All four studies found that reading times were longer for the reduced relative sentence at the point of reading the main verb, regardless of biasing contexts. The proportion of reported relative clause verbs that were potentially intransitive were 8/16, 7/8, 13/15, and 1/1. These verbs lead the comprehension system to present an initial meaning-form hypothesis that is based on an intransitive interpretation:

(101) The woman rushed to the hospital.

(102) The coffee spilled on the rug.

(103) The man dressed as a woman.

The comprehension system generates a syntax, which it then checks against the input, and accepts. The appearance of a second verb causes reanalysis.

7.2.2 Transitive-Only Verbs Yield a Context Effect

Other studies that have examined the role of context in processing reduced relative clauses have used predominantly verbs that are only transitive. Since these verbs

minimally require a patient, the comprehension system searches for a plausible patient (see section 7.1.7). Contexts that enhance the likelihood that the initial noun is a patient will decrease the effect of the reduced relative garden path. However, these effects appear most clearly on the noun at the end of the embedded clause.

Spivey-Knowlton, Trueswell, and Tanenhaus (1993) used self-paced reading to examine the effect of discourse context on processing reduced relatives. They used embedded verbs that were transitive. An example target sentence is:

- (104) The prisoner / (who was) / removed by / the guard / fought violently / to break / free of / the guard's grip.

The sentence was presented two words at a time, and the critical viewing windows were NP1, EV + P, NP2, MV, and REST. The goal of Spivey-Knowlton and colleagues was to test the referential theory. Spivey-Knowlton, Trueswell, and Tanenhaus (1993) further tested the referential theory with contexts like these:

- (105) *Two-referents context*

In the visiting room, two prisoners began yelling at each other. To prevent a fight, the guard removed one of the prisoners from the room but not the other ...

- (106) *One-referent context*

In the visiting room, a prisoner and a visitor began yelling at each other. To prevent a fight, the guard removed the prisoner from the room but not the visitor ...

The referential theory predicts that the two-referent context will eliminate the difference in reading reduced versus unreduced relative clauses in the target sentence:

- (107) *Reduced vs. unreduced target sentence*

The prisoner (who was) removed by the guard fought violently to break free of the guard's grip.

If contextual information is used early to resolve the ambiguity, context effects should appear on the embedded verb.

Spivey-Knowlton, Trueswell, and Tanenhaus (1993) reported reading times for two-word segments as shown in table 7.19. Reading times were faster for the unreduced sentences than for the reduced sentences, faster for the two-referent context than for the one-referent context, and the interaction between sentence type and context was significant. For the Verb + *by* region, the interaction between sentence type and context was not significant. However, the 46-ms ambiguity effect on Verb + *by* in the one-referent context was significant by items, but not by subjects. Spivey-Knowlton and colleagues concluded that the two-referent condition did eliminate the ambiguity effect on the embedded verb + *by*. These results appear to support the claim that the comprehension system uses discourse information to immediately resolve the garden

Table 7.19

Mean reading times depending on number of referents in context (ms/word)

Sentence type	Region			
	Det + N	Verb + <i>by</i>	Det + N	MV
<i>One referent</i>				
RR	612	462	494	509
UR	596	416	384	459
RR – UR	16	46	110	50
<i>Two referents</i>				
RR	547	410	422	472
UR	572	403	410	443
RR – UR	–25	7	12	29

Source: Adapted from Spivey-Knowlton, Trueswell, and Tanenhaus 1993, table 2

path. Three aspects of their results, however, suggest that we interpret them cautiously: the marginal significance, the longer reading times overall for one-referent contexts, and the differences in reading times for the initial noun. Spivey-Knowlton, Trueswell, and Tanenhaus (1993) attributed the longer reading times overall for one-referent contexts than for two-referents contexts to the infelicity of using a relative clause modifier when there is only one possible referent. But the infelicity of a relative clause in the one-referent contexts cannot account for the wide variation in reading times for the initial noun phrase. Since the initial noun appears before the relative clause is read, the comprehender has no way of knowing whether the material that the sentence that he or she is reading is going to be infelicitous.

How can we account for the faster reading times on the initial noun phrase in the two-referent contexts? One possibility is that these contexts prime the initial noun phrase by referring to it more often (see Murray and Liversedge 1994). The two-referent context refers to a prisoner three times: *two prisoners*, *one of the prisoners*, and *the other (prisoner)*. The one-referent context refers to prisoner only twice: *a prisoner* and *the prisoner*. Thus reading times may be faster in the two-referent context than in the one-referent context because of more references to the initial noun phrase.

In a second experiment Spivey-Knowlton and associates compared reading times for morphologically unambiguous passive participles (*taken*) as a baseline for ambiguous verbs (*removed*), as in

(108) *Unambiguous embedded verb*

The prisoner taken by the guard fought violently to break free of the guard's grip.

Table 7.20

Mean reading times in ambiguous vs. unambiguous sentences (ms)

Sentence type	Region			
	Det + N	Verb + <i>by</i>	Det + N	MV
<i>One referent</i>				
Ambiguous	691	532	543	594
Unambiguous	702	498	488	568
U – A	–11	34	55	26
<i>Two referents</i>				
Ambiguous	660	476	468	529
Unambiguous	635	487	470	545
U – A	25	–11	–2	–16

Source: Adapted from Spivey-Knowlton, Trueswell, and Tanenhaus 1993, table 4

(109) *Ambiguous embedded verb*

The prisoner removed by the guard fought violently to break free of the guard's grip.

The results appear in table 7.20. There was a marginal effect of ambiguity in the one-referent condition. Again, the reading times were faster overall in two-referent contexts and there was variability in reading times for the initial noun. It appears that the two-referent contexts serve to increase the salience of the initial noun and therefore to reduce generally the reading time for the entire sentence. Still unexplained, however, is why there is no effect on verb + *by* in the two-referent case, as we would expect with a standard spreading activation architecture.

With single-word presentation, Spivey-Knowlton et al. (1993) found no interactions between context and ambiguity. The failure to find such an interaction on the verb in single-word presentation indicates that context does not have an immediate effect. Spivey-Knowlton et al. did find an effect of ambiguity on the embedded noun such that reading times were longer for the embedded noun in ambiguous sentences than in unambiguous sentences. These results again show that discourse context does not eliminate the garden-path effect of a reduced relative clause. The ambiguity functionally disappears at the end of a relatively complete semantic unit, for example when *the prisoner removed by the guard* yields the semantic unit *the prisoner was removed by the guard*. The processing of the reduced relative sentence appears to be influenced primarily by the subcategorization requirements of verbs and little by discourse context.

Trueswell and Tanenhaus (1991) examined the role of temporal context in resolving main-clause/reduced relative ambiguities. They noted that a main clause that

introduces a new event must maintain the tense that has appeared earlier in the discourse. Thus, a story told in the past tense will introduce a new event in the past tense. A reduced relative clause with an ambiguous verb, however, is ambiguous concerning tense, so that (110) is ambiguous between (111), (112), and (113).

(110) The student spotted by the proctor ...

(111) The student who was spotted by the proctor ... (past)

(112) The student who is spotted by the proctor ... (present)

(113) The student who will be spotted by the proctor ... (future)

These observations suggest that the comprehension system may use temporal information in the discourse context to resolve the temporary ambiguity of a sentence with a reduced relative clause. In particular, processing reduced relatives should be easier when the context is in the future tense than when it is in the past tense. This is because it is infelicitous to introduce a new event with a main clause containing a past-tense verb, as in *The student spotted X*, when the context is future tense, as in (115).

Trueswell and Tanenhaus used discourse contexts that were in either past tense as in (114) or future tense as in (115), followed by a target sentence that had either a reduced or unreduced relative clause (116):

(114) *Past context*

Several students were sitting together taking an exam yesterday. A proctor came up and spotted one of the students cheating ...

(115) *Future context*

Several students will be sitting together taking an exam tomorrow. A proctor will come up and spot one of the students cheating ...

(116) *Target sentence*

- a. The student spotted by the proctor received a warning ... (reduced, past)
- b. The student who was spotted by the proctor received a warning ... (unreduced, past)
- c. The student spotted by the proctor will receive a warning ... (reduced, future)
- d. The student who was spotted by the proctor will receive a warning ... (unreduced, future)

The embedded verbs were mostly transitive-only verbs (about 75%). Participants read the texts two words at a time. The results appear in table 7.21.

The results showed the following effects:

V + by: There was an ambiguity effect: reading times were faster for unreduced relatives. There was no interaction of context and sentence type. How-

Table 7.21

Mean reading times depending on tense in context (ms)

Sentence	Region		
	Verb + <i>by</i>	Det + N	MV
<i>Past context</i>			
RR	485	490	520
UR	460	470	505
RR – UR	25	20	15
<i>Future context</i>			
RR	475	455	480
UR	460	450	475
RR – UR	15	5	5

Source: Adapted from Trueswell and Tanenhaus 1991, fig. 1.b

ever, the ambiguity effect was significant in past contexts but not in future contexts.

Det + N: There was an ambiguity effect for past contexts but not for future contexts.

MV: There was a context effect: reading times were faster for future contexts than for past contexts.

The fact that the ambiguity effect appears on the Det + N for past contexts but not for future contexts shows that temporal information is used at the end of the relative clause. It is at that point that the comprehension system presents an initial meaning-form hypothesis, and semantic context is integrated with the meaning that the comprehension system has presented.

The two studies that report that context can influence early decisions of a reduced relative clause have used predominately transitive-only verbs (16/16 and 12/16). They have found the clearest effect of context on the embedded noun, as in *guard* and *proctor* in:

(117) The prisoner removed by the guard ...

(118) The student spotted by the proctor ...

The results of both studies support LAST. It is on the embedded noun that a complete proposition is explicitly formed, and hence, integration with context is most natural. Discourse context thus has relatively little effect on the formation of the initial meaning-form hypothesis, but a relatively large effect at the point of integrating the derived meaning-form into a memory representation of discourse. The studies of discourse context support the importance of a propositional unit in initiating the synthesis stage.

7.3 Full Relative Clauses

In this section, we examine additional evidence for the sentence template especially with reference to subparts of it, NV = agent + action, and VN = action + patient, by considering how the first portion of the template applies to subject-first and object-first active relative clauses. Then we consider evidence that nonsequential information, such as noun animacy, information from long-term knowledge, and information from recent context, can influence the initial meaning-form hypothesis.

The following sentences illustrate subject and object relative clauses:

(119) *Subject relative*

The boy [who pushed the ball] ran home.

(120) *Object relative*

The boy [who the dog bit] ran home.

The default application of the initial position of the NVN template primes the agent interpretation for the first noun in the sentence, *boy*. But then the relative pronoun *who* (or *that*) signals the beginning of a new clause, which triggers its own fresh application of the NVN template to *who*, now treated as a noun. Thus, we can expect that the NVN template will favor subject relative sentences over object relative sentences. The obvious explanation for this is that a subject relative such as (119) matches the initial portion of the template, as in:

Template matching for subject relative

The boy	=	N	=	agent
who	=	“N”	=	agent
pushed	=	V	=	action
the ball	=	N	=	patient

Consider this in more detail. The first portion of the NVN template, in which *who* functions as initial noun, allows the pseudosyntax to prime a preliminary assignment of agent, immediately confirmed by the following verb, *pushed*. In contrast, the same agent assignment for *who* is wrong within an object relative clause such as (120).

Template matching for object relative

The boy	=	N	=	agent
who	=	“N”	=	agent?
the dog	=	N	=	agent
bit	=	V	=	action
ran	=	V	=	?

First, *who* elicits agent status, but then the following noun does not confirm that assignment. The remaining portion of the object relative, *the dog bit*, does conform to

the initial portion of the NVN pattern, and the pseudosyntax can correctly assign agent status to the noun phrase *the dog*. But then, this application of the entire template runs afoul when the main verb *ran* appears. The system now has no patient for *bit* and must find one, which requires undoing the agent status of *who* and reassigning it patient status. Accordingly, we can expect that object relative clauses will be harder than subject relative clauses and that the relative difficulty will be most apparent near the end of the relative clause.

Several experimental studies show that object relative sentences are indeed harder than subject relative sentences. For example, Wanner and Maratsos (1978) interrupted subjects' word-by-word reading of a sentence containing a relative clause with a random list of five proper names such as *John George Sam Bill Hank* (see section 6.1.4). The instructions were to read the sentence and recall as many of the names as possible. The names were presented at one of four points within the sentence (indicated by a slash below):

(121) *Subject relative*

/ The witch who despised / sorcerers frightened / little children./

(122) *Object relative*

/ The witch whom sorcerers / despised frightened / little children./

Wanner and Maratsos (1978) found that errors in name recall were greater for object relatives like (122). However, this difference was significant only in the middle of the relative clause, at the second test point (after *sorcerers*). Holmes and O'Regan (1981) found that question answering is poorer for object relatives than for subject relatives, and regressions in eye movements are greater for object relatives than for subject relatives.

These results are generally consistent with the view that the comprehension system responds to the NVN template. In addition, there is considerable evidence that the critical difficulty is most apparent in the latter portion of the object relative clause.

7.3.1 Assignment of Patient Role

King and Just (1991) measured word-reading times with a moving-window reading task (see box 6.4) in subject and object relative sentences, as in

(123) *Subject relative*

The reporter [that attacked the senator] admitted the error.

(124) *Object relative*

The reporter [that the senator attacked] admitted the error.

Mean reading times for various regions within the critical sentences appear in table 7.22. King and Just found that reading times were longer for object relatives than for

Table 7.22

Mean reading times (ms) in regions of sentences with subject relative (SR) and object relative (OR) clauses

Subject relative			
... reporter that attacked the	senator	admitted	the error
530	630	650	590
Object relative			
... reporter that the senator	attacked	admitted	the error
500	720	790	580
SR – OR difference			
30	–90	–140	10

Source: Adapted from King and Just 1991, fig. 1

subject relatives on the final word of the relative clause—that is, *attacked* in (124) versus *senator* in (123)—and on the main verb (*admitted*).

King and Just (1991) also compared reading times for subjects with high reading span versus low reading span. They found a significant difference between these subject groups only on the main verb of object relative sentences (*admitted*). High-span subjects read the main verb of object relatives more than 200 ms faster than low-span subjects. The difference between people with a large verbal memory capacity occurs at the point where the comprehender is looking for a word to fill the object role of the relative clause verb. To do this, the comprehender must recall the initial noun and use it to fill the gap.

Several other methodologies support the conclusion that an important difficulty in processing object relative clauses involves the assignment of patient role. Baird and Koslik (1974) found that recall of the action-patient relations was poorer in object relatives than in subject relatives. Frauenfelder, Segui, and Mehler (1980) found that phoneme-monitoring times for targets immediately after a relative clause were longer for object relative clauses than for subject relative clauses (see box 6.1). For targets before the end of a relative clause, however, monitoring times did not differ for subject versus object relative clauses. Cohen and Mehler (1996) confirmed both of these patterns with a click-detection methodology (see box 6.8), but no difference in click-detection times early in object versus subject relative clauses. Using a cross-modal lexical decision task (see box 6.5), Swinney, Ford, Frauenfelder, and Bresnan (as reported in Nicol and Swinney 1989) found that response times to target words that were similar in meaning to the patient were reduced after the relative clause verb, but not before it. Ford (1983) found that word-by-word lexical decision times in a reading task were longer for object relatives than for subject relatives only on the last word of the relative clause and on the main verb. The differences occur at the point at which the patient role must be assigned for the relative clause verb. If the system

recorded the sequence *the dog bit* in (120) as the beginning of an NVN pattern, we would expect slower processing times in just that region.

7.3.2 Moving the Start of a Sentence Template

Center-embedded relative clauses interrupt the NVN pattern of the main clause. We know that this interruption by itself does not present comprehenders with difficulty. Holmes (1973), Baird and Koslick (1974), and Hakes, Evans, and Brannon (1976) have shown that sentences with a single center-embedded relative clause on the main-clause subject as in (125) are no harder than ones with a right-branching relative clause on the main-clause object as in (126).

(125) *Subject relative on main-clause subject*

The dog [that bit the boy] likes the girl.

(126) *Subject relative on main-clause object*

The girl likes the dog [that bit the boy].

Pseudosyntax can start a new application of the sentence template when the relative pronoun *that* (or *who*) signals a new clause and hence a new NVN sequence:

The dog	=	N	=	agent
that	=	“N”	=	agent
bit	=	V	=	action
the boy	=	N	=	patient
likes	=	V	=	action
the girl	=	N	=	patient

Processing object relatives such as (127) and (128) does not work so smoothly because the relative pronoun is followed by another noun phrase (*the dog*) rather than a verb.

(127) *Object relative on main-clause subject*

The boy [that the dog bit] ran home.

(128) *Object relative on main-clause object*

The girl likes the boy [that the dog bit].

Consider below how sentence (127) activates the NVN template. Sentence templates activated by neither *the boy* nor *that* are completed. At the same time, *the dog* activates another NVN pattern that is confirmed immediately by the following verb, *bit*:

the boy	=	N	=	agent
that	=	“N”	=	agent?
the dog	=	N	=	agent
bit	=	V	=	action
ran	=	V	=	?

These observations suggest the surprising conclusion that the presence of the explicit relative pronoun actually disrupts the processing of object relatives more than its absence, since its absence as in *the boy the dog bit ran home* produces fewer incorrect activations of the sentence template:

The boy	=	N	=	agent
the dog	=	N	=	agent
bit	=	V	=	action
likes	=	V	=	action?

Intuitions suggest that an object relative clause without a relative pronoun is not particularly hard to understand, and may even be easier than one with a relative pronoun.

There is experimental support for this intuition. Hakes, Evans, and Brannon (1976) used a paraphrase task to examine the effects of deleting the relative pronoun in sentences like:

(129) *Object relative on the main-clause subject*

After the final curtain on opening night, the director [(that) the repertory company had hired] praised the star performer.

(130) *Subject relative on the main-clause subject*

The children [(that were) playing in the hayloft] startled the farmer's wife when she went to gather the eggs.

(131) *Object relative on the main-clause object*

After the final curtain on opening night, the star performer praised the director [(that) the repertory company had hired].

(132) *Subject relative on the main-clause object*

The farmer's wife startled the children [(that were) playing in the hayloft] when she went to gather the eggs.

Table 7.23 shows the proportion of sentences that were paraphrased correctly. Hakes and colleagues found that for object relative clauses, paraphrase performance was more accurate when the relative pronoun was absent than when it was present. For subject relative clauses, there was no difference in paraphrase performance for sentences with the relative pronoun present versus absent.

The results reported in Hakes, Evans, and Brannon confirm that a relative pronoun contributes to the difficulty of processing object relative clauses. We can explain this result in terms of the relative pronoun activating a new NVN pattern and analysis-by-synthesis cycle, which must immediately be turned off and started over again when the noun phrase *the repertory company* is received.

Table 7.23

Proportion of correctly paraphrased sentences with relative clauses depending on whether a relative pronoun is present or absent

Sentence type	Relative pronoun	
	Present	Absent
<i>Subject relative</i>		
On main subject	.679	.646
On main object	.625	.628
Average	.652	.637
<i>Object relative</i>		
On main subject	.451	.514
On main object	.409	.460
Average	.430	.487

Source: From Hakes, Evans, and Brannon 1976, tables 1 and 2

7.3.3 Plausibility and Agency

In our discussion of reduced relatives, we observed that the pseudosyntax is sensitive to semantic information such as the fact that animate nouns frequently fill the agent role of a verb (see section 7.1.5). This information can counteract to some extent the misapplication of the NVN pattern in reduced relatives.

The pseudosyntax is sensitive to semantic information in the initial assignment of argument roles in other constructions. In the study mentioned earlier, Frauenfelder, Segui, and Mehler (1980) showed that phoneme-monitoring times were longer after object relative clauses than after subject relative clauses when the relative clauses were reversible. They also showed that plausibility could eliminate the processing difficulty of object relative clauses. Frauenfelder and colleagues examined the effect of type of relative clause following nonreversible relative clauses as well. Examples of materials in all conditions appear below:

(133) *Reversible subject relative*

Le savant [qui connaît le docteur] travaille dans une université moderne.
(The scientist [who knows the doctor] works in a modern university.)

(134) *Reversible object relative*

Le savant [que connaît le docteur] travaille dans une université moderne.
(The scientist [who the doctor knows] works in a modern university.)

(135) *Nonreversible subject relative*

L'éditeur [qui publie la revue] demande beaucoup de rigueur dans les articles.
(The editor [who publishes the journal] requires much precision in the articles.)

Table 7.24

Phoneme monitoring times (ms) in reversible and nonreversible sentences with subject vs. object relative clauses

	Type of relative clause	
	Subject	Object
Reversible	421	485
Nonreversible	456	446

Source: Adapted from Frauenfelder, Segui, and Mehler 1980, fig. 2

(136) *Nonreversible object relative*

Les articles [que publie la revue] demandent une lecture attentive.

(The articles [that the journal publishes] require attentive reading.)

In French the relative pronoun *que* is the only syntactic cue to an object relative structure. Frauenfelder and associates found that phoneme-monitoring times for the initial phoneme of the final noun of the relative clause were longer for object relative clauses than for subject relative clauses (see table 7.24), confirming that object relative clauses are harder to process, even with an unambiguous object relative pronoun. The materials for nonreversible relative clauses, however, vary the plausibility of the initial noun of the sentence as fulfilling potential argument roles of the embedded verb. It is more likely that editors publish journals than that journals publish editors, and it is more likely that journals publish articles rather than that articles publish journals. Frauenfelder, Segui, and Mehler (1980) found no difference in monitoring times for main-verb targets (*demande*, *demandent*) between subject and object relatives when the relative clause was nonreversible. The results suggest that pseudo-syntax is sensitive to information about plausibility in filling the patient gap in an object relative clause. This can reduce the processing complexity of subject versus object relative clauses (but see Holmes 1979).

Weckerly and Kutas (as reported in Kutas 1997) examined brain responses to animate versus inanimate nouns during the processing of object relative clauses. They used materials that had an inanimate initial noun and an animate noun in the relative clause, I(A), or an animate initial noun and an inanimate noun in the relative clause, A(I):

(137) *Inanimate initial noun, animate embedded noun*

The poetry [that the editor recognized] depressed the publisher of the struggling magazine.

(138) *Animate initial noun, inanimate embedded noun*

The editor [that the poetry depressed] recognized the publisher of the struggling magazine.

Weckerly and Kutas found a reading-time difference starting on the noun in the relative clause. For the relative clause noun and for each of the next four words, reading times were faster in I(A) than in A(I). This result suggests that animate nouns are more readily interpreted as agents. Weckerly and Kutas also measured event related potentials (ERPs) when the words were presented visually and sequentially for 500 ms each. These results showed an effect of animacy on the initial noun and on the noun in the relative clause. There also was an animacy effect on the main verb, which is just at the point when comprehenders would expect a noun to fill the patient role of the relative clause verb. These results suggest that the animacy of the initial noun elicits assignment of it to the agent role of the embedded verb, which must then be corrected at the verb.

7.4 Direct-Object/Sentential Complement

Several theorists have discussed the direct-object/sentential complement (DO/SC) ambiguity (Crocker 1996; Frazier and Clifton 1996; Gorrell 1995; MacDonald, Pearlmutter, and Seidenberg 1994; Pritchett 1992; Tabor, Juliano, and Tanenhaus 1997; see chapter 4). An example of a DO/SC ambiguity is:

(139) *Direct-object/sentential complement ambiguity*

John knew the answer was wrong.

Some demonstrations show that there is a tendency to take the first noun after the verb (*the answer*) as patient, consistent with the NVN template, rather than immediately assigning the noun as the beginning of a complement.

The theoretical discussion has centered on two questions: What causes the garden path, and when is it noticed? Several researchers have found that the DO/SC ambiguity has behavioral effects, yet both Pritchett (1992) and Gorrell (1995) have noted that it is not a *conscious* garden path. Nevertheless, the local DO/SC ambiguity is both behaviorally and intuitively easier than the MC/RC ambiguity that is created by a reduced relative clause even though both ambiguities appear to involve equally complex revisions in phrase structure. For example, the MC/RC ambiguity involves changing assignment of a main verb to a verb in a subordinate clause that modifies the initial noun. The DO/SC ambiguity involves changing the direct object of a verb to the subject of a subordinate clause that is a complement of the verb. Thus, the ease of the DO/SC ambiguity is a puzzle, especially for many syntax-first models.

In terms of LAST, (139) elicits the following initial meaning-form hypothesis:

John	=	N	=	agent
knew	=	V	=	action
the answer	=	N	=	patient

Then the verb *was* is encountered, immediately requiring an agent, and forcing recoding *the answer* as the beginning of a complement, itself in the patient role.

According to Pritchett (1992), so long as *the answer* remains part of the patient of the same verb, reanalysis is not conscious. We do not have enough cases of this kind to support the broad claim, but it is tempting to agree with the spirit of Pritchett's proposal that recodings are hard to detect if they maintain an argument in the same general thematic relation to a verb. In terms of LAST, however, plausibility, verb preferences, and their interactions with the NVN template may contribute to the ease of assigning the noun phrase to the patient role and recoding it as a complement when needed.

7.4.1 Plausibility

Several studies have established that the direct-object interpretation is preferred over the sentential-complement interpretation. The plausibility of the postverbal noun as a patient of the verb may have a weak effect on the DO/SC garden path at the syntax-checking and semantic integration stage. Pickering and Traxler (1998) examined eye-movement patterns while reading sentences such as:

- (140) *Sentential complement, plausible direct object*

The criminal confessed his sins that upset kids harmed too many people.

- (141) *Sentential complement, implausible direct object*

The criminal confessed his gang that upset kids harmed too many people.

If plausibility of a noun as direct object influences fixation times, *his sins* and its modifying relative clause *that upset kids* should be read faster than the corresponding regions in the second sentence. When *harmed* is read, however, reading times should increase in the first sentence, relative to the second, since *his sins* turns out to not be the direct object of *confessed*, but rather a sentential complement. Pickering and Traxler found no interaction of this sort in first-pass reading times. However, they did find an interaction in number of regressive eye movements between the relative clause region and the disambiguating verb. Regressions were relatively more frequent for the sentences with an implausible direct object within the relative clause, but relatively more frequent for the sentences with a plausible direct object on the disambiguating verb.

Garnsey et al. (1997) examined eye-fixation times and self-paced reading times in sentences such as:

- (142) *Equal bias, plausible direct object*

The senior senator regretted (that) the decision had ever been made public.

- (143) *Equal bias, implausible direct object*

The senior senator regretted (that) the reporter had ever seen the report.

Counts of frequency of usage show that verbs like *regretted* are used equally often with a noun phrase direct object versus a sentential complement. For these verbs,

Garnsey et al. found a trend toward the plausibility of the postverbal noun phrase as a direct object influencing the size of the ambiguity effect. The ambiguity effect was numerically greater when the noun phrase was a plausible direct object (*decision*) than when it was an implausible direct object (*reporter*). The marginal effect of plausibility for balanced verbs is consistent with LAST. Pseudosyntax elicits the meaning-form hypothesis corresponding to NVN = agent-action-patient. At the checking stage, plausible direct objects are integrated into a complete meaning, while implausible direct objects are not.

7.4.2 Verb Preferences

Garnsey et al. (1997) also examined reading times when the verb showed a strong preference for use with a direct object versus a sentential complement. An example sentence with a verb that is more often used with a noun phrase direct object is

(144) *Direct-object bias, plausible direct object*

The art critic wrote (that) the interview had been a complete disaster.

The results appear in table 7.25. For direct-object bias verbs, Garnsey et al. (1997) found that reading times were longer in the region of disambiguation (*had been*) when the complementizer *that* was omitted than when it was present (361 vs. 346 ms.) When *that* is omitted, pseudosyntax finds an NVN pattern and presents the meaning hypothesis:

The art critic = N = agent
wrote = V = action
the interview = N = patient

Table 7.25
Mean first-pass fixation times (ms) in the disambiguating region depending on verb bias and DO-plausibility

	Verb bias		
	DO	Equal	SC
<i>Plausible DO</i>			
No <i>that</i>	364	352	337
<i>That</i>	343	335	338
Ambiguity effect	21	17	−1
<i>Implausible DO</i>			
No <i>that</i>	357	345	347
<i>That</i>	349	344	340
Ambiguity effect	12	1	7

Note: DO = direct object; SC = sentential complement
Source: Adapted from Garnsey et al. 1997, table 6

The comprehension system generates a syntax that matches the input up through the word *interview*. The word *had*, however, signals that this analysis is incorrect. For direct-object bias verbs, Garnsey et al. even found a 17-ms ambiguity effect when the second noun was implausible as a direct object:

(145) *Direct-object bias, implausible direct object*

The art critic wrote (that) the painting had been a clever forgery.

For direct-object bias verbs, the system presents the guess that the postverbal noun phrase is patient of the verb regardless of plausibility.

Garnsey et al. (1997) found a different pattern of results with verbs such as *confessed* that are used more frequently with a sentential complement. They used sentences like (146) and (147).

(146) *Sentential-complement bias, plausible direct object*

The bank guard confessed (that) the robbery had been his own idea.

(147) *Sentential-complement bias, implausible direct object*

The bank guard confessed (that) the vault had been left open intentionally.

There was no effect of plausibility in sentences with verbs like *confessed* that frequently are used with a sentential complement. They also found no effect of the complementizer *that* in sentences with sentential-complement bias verbs (see also Holmes, Stowe, and Cupples 1989). This result suggests that the subcategorization preferences of verbs automatically influence the initial meaning-form hypothesis. A subcategorization preference for a sentential complement triggers special patterns that allow the system to project the information that is required of the verb.

Trueswell, Tanenhaus, and Kello (1993) used a naming task to show that there is immediate use of verb-subcategorization preferences. The technique relies on the fact that *him* is appropriate as a direct object for a verb, whereas *he* is appropriate as subject of a sentential complement for a verb. Trueswell and colleagues used materials like the following:

(148) *Sentential-complement bias*

The old man insisted (that) ... HIM/HE

(149) *Direct-object bias*

The young boy observed (that) ... HIM/HE

Subjects heard the lowercase material. After either the verb or *that* depending on the condition, subjects saw a printed version of *him* or *he*. Their task was to read aloud the printed word as fast as possible. The results appear in table 7.26. Without *that* present, naming times were faster when the pronoun was congruent with the bias. With sentential-complement bias, *he* was faster than *him*, but with direct-object bias, *him* was faster than *he*. This result suggests that the subcategorization information

Table 7.26

Mean naming times (ms) depending on complementizer, target pronoun, and verb bias

	Verb bias	
	DO	SC
<i>he target</i>		
No <i>that</i>	532	519
<i>That</i>	499	486
Ambiguity effect	33	33
<i>him target</i>		
No <i>that</i>	492	532
<i>That</i>	533	539
Ambiguity effect	-41	-7

Note: DO = direct object; SC = sentential complement

Source: Adapted from Trueswell, Tanenhaus, and Kello 1993

primes the appropriate sentence template and projects different patterns depending on this information. With *that* present, naming times were faster for *he* than for *him* for both types of verbs. This result shows that the complementizer provides a local cue that can override the lexical preferences for subcategorizing verbs.

Trueswell and Kim (1998) have obtained further evidence that the use of subcategorization information of verbs can be primed. In a self-paced word-by-word reading task, a priming word was presented visually for 39 ms immediately before the main verb. At this duration, the prime is perceived as a flicker. Trueswell and Kim found that briefly displaying an ambiguous priming verb that is strongly biased toward taking a sentential complement (e.g., *realized*) significantly reduced the processing difficulty of a sentence that contains a main verb that is strongly biased toward a direct object (*accepted*).

7.4.3 Interactions of NVN

Holmes, Stowe, and Cupples (1989) demonstrated how the NVN pattern interacts with subcategorization information. They varied the length of a potential direct object by presenting a simple noun phrase (*the teacher*; *the woman*) or a noun phrase modified by a relative clause (*who walked past*; *who had arrived*), as in (150) and (151).

(150) Sentential-complement bias

The principal knew (that) the teacher (who walked past) had already been working.

(151) Direct-object bias

The reporter saw (that) the woman (who had arrived) was not very calm.

Table 7.27

Mean reading times (ms) in the disambiguating region depending on complementizer, length, and verb bias

	Verb bias	
	DO	SC
<i>Long NP</i>		
No <i>that</i>	520	510
<i>That</i>	480	470
Ambiguity effect	40	40
<i>Short NP</i>		
No <i>that</i>	555	455
<i>That</i>	475	470
Ambiguity effect	80	–15

Note: DO = direct object; SC = sentential complement

Source: Adapted from Holmes, Stowe, and Cupples 1989, fig. 3

As shown in table 7.27, Holmes and colleagues found that increasing the length of the potential direct object increased reading times on the two words of the disambiguating auxiliary verb (*had already*) for sentential-complement bias verbs without *that* (from 455 to 510 ms). For direct-object bias verbs (e.g., *saw*), reading times in the disambiguating region were greater without *that* than with *that* regardless of length.

These results demonstrate the interactions of the NVN pattern with verb subcategorization. The verb *knew* might take a noun phrase object, or it might take a sentential complement. At the point of reading *teacher* the NVN applies. The strength of this meaning-form hypothesis, however, is relatively weak since *know* is used more frequently with a sentential complement. If the next word is part of a verb phrase, such as *had*, the system relinquishes the NVN analysis of *the principal knew the teacher*, and the NVN template is elicited again with *teacher* as the first noun and *had* as the verb or part of the verb. If instead the next word after *teacher* is *who*, the NVN analysis of *the principle knew the teacher* is accepted and the sentence template reapplies with *who* as the first noun and *walked past* as the verb (intransitive). By the time *had already* is received, the NVN pattern has been fulfilled twice, and consequently reanalysis is difficult. This interaction does not occur with direct-object bias verbs, since the direct-object bias leads the system to accept the initial NVN analysis whether or not there is a potential relative clause modifying the noun phrase.

7.4.4 NVN Interactions in DO/SC vs. MC/RC

As we noted above, recovery from the direct-object misanalysis in a DO/SC ambiguity is intuitively much easier than recovery from a MC/RC ambiguity. Apart from

any statistical differences in the frequency of occurrence of particular sentence-level patterns, this difference may occur because of the extent to which the system must give up previous meanings based on the NVN pattern (see Pritchett 1992).

In the DO/SC ambiguity, the NVN template applies in both the mistaken analysis and the correct analysis. The system must change the analysis from the first meaning below to the second, in which system assigns the sentence pattern N + BE + Pred corresponding to *the tree is tall* to the material after the main verb to serve as the object of the main verb:

Direct-object interpretation

John	=	N	=	agent
knew	=	V	=	action
the answer	=	N	=	patient

Sentential-complement interpretation

John	=	N	=	agent
knew	=	V	=	action
the answer	=	N		
was	=	V		
wrong	=	Pred		

Thus, the initial direct-object analysis needs only slight modification.

In the MC/RC ambiguity, however, the application of the NVN template must be undone in the embedded relative clause. That is, for (1), repeated here, *raced* must be disconnected from *horse* as agent, with the role of *horse* in the main clause undetermined.

(1) The horse raced past the barn fell.

In addition, *raced* must be reinterpreted as an action that happens to the patient *horse*:

Main-clause interpretation

The horse	=	N	=	agent
raced	=	V	=	action
past the barn	=	PP	=	location

Reduced relative interpretation

The horse	=	N	=	agent
raced	=	V	=	action
[the horse	=	N	=	patient]
past the barn	=	PP	=	location
fell	=	V	=	action

The role of the NVN template in recovering from a MC/RC ambiguity is shown by the fact that embedding this ambiguity as a complement clause reduces the impact of the ambiguity. For example, the MC/RC garden path is reduced greatly in

(152) *Embedded MC/RC ambiguity*

He knew the horse raced past the barn fall.

The reason appears to be that *horse* is initially assigned the role of patient of *knew*. This weakens the strength of the NVN template for the sequence *the horse raced*, producing a weaker garden path. This corresponds to our intuitions, but needs empirical support.

7.5 Sentential Complement/Relative Clause

We observed in the discussion of reduced relative clauses that appropriate sentence context may play a role in motivating a relative clause as a selective modifier, thereby facilitating its correct interpretation. We can study this in relative clauses on main-clause objects by contrasting the processing of sentential complement/relative clause (SC/RC) garden-path sentences. In (153) the preferred interpretation of *that he was having trouble with* is a sentential complement of the verb *told*.

(153) The psychologist told the wife that he was having trouble with . . .

Thus, comprehenders experience a garden path when the sentence continues *to leave her husband*. In this case, the sequence *that he was having trouble with* must be a relative clause.

As we discussed in section 7.2, the referential theory (Altmann and Steedman 1988) proposed that a relative clause interpretation may be appropriate for the above sentence when there are two wives, one of which the psychologist was having trouble with. Thus, the garden-path sentence may not present difficulty if it appears in an appropriate discourse context.

Crain and Steedman (1985) tested whether referential context influences the processing of SC/RC garden paths. Subjects read discourses in Rapid Serial Visual Presentation at a rate of one word every 550 ms. Following a tone, a target sentence appeared. The subjects' task was to judge whether the target sentence was grammatical. Examples of target sentences are:

(154) *Sentential complement*

The psychologist told the wife that he was having trouble with her husband.

(155) *Relative clause*

The psychologist told the wife that he was having trouble with to leave her husband.

Table 7.28

Percentage judgments of ungrammaticality

Contextual support	Clause in target sentence	
	Complement	Relative
Complement	12	50
Relative	54	22

Source: Derived from Crain and Steedman 1985

The relative-supporting context implied that there were two wives, while the complement-supporting context implied only one:

(156) *Complement-supporting context*

A psychologist was counseling a married couple. One member of the pair was fighting with him but the other one was nice to him . . .

(157) *Relative-supporting context*

A psychologist was counseling two married couples. One of the couples was fighting with him but the other one was nice to him . . .

The results appear in table 7.28. Judgments of ungrammaticality were more common when the context did not match the structure of the target sentence. This result supports the referential theory: a context that requires differentiating between two possible referents facilitates comprehension of a garden-path sentence in which the less preferred interpretation is appropriate.

Further studies have examined the role of discourse context in the online processing of SC/RC ambiguities. Mitchell, Corley, and Garnham (1992) examined self-paced reading times for groups of words in sentential-complement/relative clause garden-path sentences. The following sentence is temporarily ambiguous between sentential complement and relative clause up through the word *with*:

(158) *Object relative*

The taxi driver told the woman that he / had been / arguing with / that she wouldn't miss her train.

The slashes mark the boundaries of displays in the study by Mitchell, Corely, and Garnham, so that in this sentence there were four displays. In our application of LAST, the preference is to interpret *that he had been arguing with* as the patient or theme of *told* and *the woman* as its recipient. The system presents this initial meaning-form hypothesis, confirms a correct syntax, and stores a meaning for the sentence. When the second *that* appears, it is apparent that *that he had been arguing with* is a relative clause, and reanalysis must occur. This reanalysis produces longer reading times on the material after *arguing with* compared to either of the following sentences

(159) *Subject relative*

The taxi driver told the woman that / had been / arguing with him / that she wouldn't miss her train.

(160) *Sentential complement*

The taxi driver told the woman that he / had been / arguing with / the councilors about the bus lane.

LAST predicts that reading times for *had been* will be shorter in the object relative and sentential-complement sentences, since the preceding *he* in both of these cases allows the interpretation of *had been* as part of the theme of *told*. The lack of an explicit subject of *had been* in the subject relative sentences rules out this interpretation. Mitchell and associates did find that reading times for *had been* were longer in subject relatives than in the other two cases. They dubbed the faster reading times on object relatives than on subject relatives the *object relative advantage*.

Mitchell et al. (1992) also examined the role of discourse context in processing these garden paths. The relative-supporting context mentioned two women, while the complement-supporting context mentioned only one. Importantly, the relative-supporting context supported the subject and object relative sentences equally by not establishing either *taxi driver* or *woman* as agent or patient:

(161) *Relative-supporting context*

A taxi driver dropped two women off at the station. On the way they had run into a traffic jam. The taxi driver and one of the women had been arguing but the other remained calm . . .

(162) *Complement-supporting context*

A taxi driver dropped a man and a woman off at the station. On the way they had run into a traffic jam. The taxi driver and the woman had been arguing but the man remained calm.

The referential theory predicts that a relative-supporting context will eliminate the differences in reading time for *had been*. Mitchell and colleagues, however, found that reading times on *had been* were longer for the subject relative sentence regardless of context. The results appear in table 7.29. In this table, display 2 refers to *had been*, display 3 refers to *arguing with* (object relatives and sentential complements) or *arguing with him* (subject relatives), and display 4 refers to the remainder of the sentence. The results in table 7.29 suggest that pseudosyntax initially assigned *that he had been arguing with* to the role of theme. Further indication of this initial assignment comes from comparing reading times for the disambiguating region (display 4) in the relative-supporting contexts: reading times are longer for the object relative cases than for the subject relative cases. The longer reading times on display 4

Table 7.29
Mean reading times depending on context (ms/word)

Sentence	Region		
	D2	D3	D4
<i>Relative context</i>			
OR	600	621	2561
SC	602	681	2561
SR	773	915	1995
<i>Complement context</i>			
OR	604	651	2396
SC	652	612	2245
SR	729	774	2158

Notes:

- D1 = OR: The taxi driver told the woman that he ...
SC: The taxi driver told the woman that he ...
SR: The taxi driver told the woman that ...
D2 = ... had been ...
D3 = OR: ... arguing with ...
SC: ... arguing with ...
SR: ... arguing with him ...
D4 = OR: ... that she wouldn't miss her train.
SC: ... the councilors about the bus lane.
SR: ... that she wouldn't miss her train.

Source: From Mitchell, Corley, and Garnham 1992, table 4

for object relatives compared to subject relatives indicates that pseudosyntax had presented the theme interpretation for the object relatives.

To summarize, Mitchell, Corely, and Garnham found an object relative advantage on reading times for the embedded verb in SC/OR garden-path sentences, compared to the embedded verb in subject relative sentences. They attributed this difference to an initial preference for the minimally attached complement clause. In terms of LAST, the object relative advantage occurs because *told* activates a template with the theme role. In the object relative case, the theme interpretation is possible through the ambiguous region, but in the subject relative case, the lack of an explicit subject for *had been* rules out the theme interpretation.

Altmann, Garnham, and Henstra (1994) suggested that measuring processing load on the embedded verb is too late to find the immediate effect of context, since the earlier appearance of the embedded subject in the SC/OR sentences has already ruled out the subject relative interpretation. Accordingly, they compared fixation times for *that had been* (subject relative) and *that he'd been* (object relative).

Altmann et al. (1994) used an eye-tracking methodology to examine the processing of SC/RC ambiguities like the following:

(163) *Object relative*

He told / the woman / that he'd been / waiting / for *that they* were both very lucky.

(164) *Subject relative*

He told / the woman / that *had been* / waiting / for him that they were both very lucky.

The italicized portion indicates the disambiguating region, and slashes indicate the scoring regions. The object relative example is ambiguous between a complement clause and an object relative until the disambiguating region. Altmann and colleagues also used contexts like these:

(165) *Object relative supporting context*

A firefighter was talking to two women after a fire at their house. He was telling them how serious the situation had been. The firefighter had been waiting to speak to one of the women about it. He thought that the other woman had been too shocked by the fire to talk about it . . .

(166) *Subject relative supporting context*

A firefighter was talking to two women after a fire at their house. He was telling them how serious the situation had been. One of the women had been waiting to speak to him about it. The other woman had been too shocked by the fire to want to talk about it . . .

The results appear in table 7.30. When the target sentences were presented out of context, Altmann, Garnham, and Henstra (1994) found that fixation times for *that he'd been* (object relative) were shorter than those for *that had been* (subject relative) (29.2 vs. 35.2 ms/character). In contexts that support the relative clause structure of the target sentence, there was no difference in fixation times for this region depending on type of relative clause (23.6 vs. 23.3 ms/character). Altmann and associates concluded that appropriate referential contexts can resolve the ambiguity of *that* as a relative pronoun versus complementizer.

When interpreting the effect of discourse context, it is important to distinguish the use of conceptual information and lexical sequence. The essence of this difference is captured in the priming of *maybe* from a prior occurrence of *perhaps* (conceptual) versus a prior occurrence of *maybe* (lexical). The Altmann et al. result that the object relative advantage disappeared when the target sentence was presented in context likely is due to priming of particular lexical sequences. To illustrate this point, notice that the object relative context-target pairs consisted of (167) and (168), while the

Table 7.30

Mean first-pass fixation times (ms/character) in the disambiguating region depending on context

Contextual support	Structure of target sentence	
	OR	SR
None	29.2	35.2
OR/SR supportive	23.6	23.3

Source: Adapted from Altmann, Garnham, and Henstra 1994, table 1

subject relative context-target pairs consisted of (169) and (170). In (167) to (170), corresponding subscripts indicate corresponding lexical prime-target pairs.

(167) *Object relative–supporting context*

The firefighter₁ had been₂ waiting ...

(168) *Object relative target sentence*

that he₁'d been₂ waiting for ...

(169) *Subject relative–supporting context*

one of the women₁ had been₂ waiting ...

(170) *Subject relative target sentence*

the woman₁ that had been₂ waiting ...

Each context-target pair presented the coreferring noun and auxiliary verb in the same order. The equivalent reading times for *that he'd been* and *that had been* may occur simply because the two contexts primed the specific sequence of noun and auxiliary verb. The contexts in the studies by Altmann and colleagues may have primed specific sequences of subject noun phrase and auxiliary verb.

7.6 Direct Object/Subject

An example of local Direct Object/Subject (DO/S) ambiguity is

(171) *Direct-object/subject ambiguity*

While Mary was mending the sock fell off her lap.

Crocker (1996), Frazier and Clifton (1996), and Pritchett (1992) have all discussed this type of garden-path sentence. We can explain the garden path simply in terms of LAST model. The system matches the NVN pattern to *Mary was mending the sock* and assigns *Mary* as the agent, *was mending* as the action, and *the sock* as the patient. Based on this initial meaning-form hypothesis, the comprehension system generates a syntactic structure, and checks it against the input sequence. Since the candidate

syntax matches the input sequence, the meaning is stored. When *fell* is received, the system cannot match an initial verb with any common sentence pattern, and so an error is detected. In this case, the assignment of *the sock* as patient of *was mending* is replaced by accessing a different subcategorization of the verb (as an intransitive) and reassigning *the sock* as an “agent” of *fell*.

7.6.1 A Classic Demonstration

Frazier and Rayner (1982) measured eye movements while reading sentences in which a noun phrase could be interpreted as direct object of a verb or as the subject of a second clause. In early-closure sentences, the verb does not take the following noun phrase as direct object, and in late-closure sentences it does. Frazier and Rayner also varied the length of the potential direct object, as in (172) to (175).

(172) *Early closure, short*

Since Jay always jogs a mile seems like a short distance to him.

(173) *Early closure, long*

Since Jay always jogs a mile and a half seems like a short distance to him.

(174) *Late closure, short*

Since Jay always jogs a mile this seems like a short distance to him.

(175) *Late closure, long*

Since Jay always jogs a mile and a half this seems like a short distance to him.

The results appear in table 7.31. Early-closure sentences with a long potential direct object required more time to read than the other sentences. These results support LAST. Each of these sentences elicits the NVN template, but correctly only in the case of late-closure sentences. Why is it easier to recover from the incorrect assignment of NVN in the early-closure cases when the potential direct object is shorter? The NVN template may be activated less strongly for a shorter noun phrase (see

Table 7.31

Mean first-pass fixation times (ms/letter) in the disambiguating region depending on sentence type and length

Sentence type	Length of second NP	
	Short	Long
Early closure	41	54
Late closure	47	40

Source: Adapted from Frazier and Rayner 1982, table 2

Crocker 1996). When the next word after the noun is a verb, the incorrect analysis is discovered more quickly. When the next words begin a conjoined noun phrase, this has the effect of maintaining the NVN analysis longer, and makes it harder to reclassify the complex noun phrase as the start of a new NVN pattern.

7.6.2 Interactions of NVN

Evidence from Ferreira and Henderson (1991, 1995) shows that potential NVN patterns interact to predict other examples of garden-path sentences with the DO/S pattern. Ferreira and Henderson (1991) used a grammaticality judgment task with rapid serial visual presentation at 250 ms/word and self-paced reading to examine the effects of length and complexity of the potential direct object in DO/S ambiguities. Some examples of early-closure and late-closure sentences with a relatively short second noun phrase (NP₂) are:

(176) *Early closure, short NP₂*
When men hunt the birds typically scatter.

(177) *Late closure, short NP₂*
When men hunt the birds the deer typically scatter.

In general, Ferreira and Henderson found that sentences were correctly judged grammatical more often in late-closure sentences than in early-closure sentences (81% versus 63% for sentences with a short NP₂ in experiment 1). This supports the view that the system relies greatly on the NVN pattern.

Ferreira and Henderson (1991) also examined the ability to make grammaticality judgments depending on the length and complexity of the second noun phrase:

(178) *Early closure, long NP₂ with relative clause*
When men hunt the birds that cheetahs eat typically scatter.

(179) *Early closure, long NP₂ with prepositional phrase*
When men hunt the birds with bright plumage typically scatter.

(180) *Late closure, long NP₂ with relative clause*
When men hunt the birds that cheetahs eat the deer typically scatter.

(181) *Late closure, long NP₂ with prepositional phrase*
When men hunt the birds with bright plumage the deer typically scatter.

The results appear in table 7.32. Ferreira and Henderson (1991) found that sentences were correctly judged grammatical more often when the potential direct object was short as in (176) and (177) rather than long as in (178) and (181). Their explanation of the length effect is in terms of the distance between the head of the second noun phrase and the disambiguating material. When this distance is short, it is easier to make the grammaticality judgment. Ferreira and Henderson found no difference in

Table 7.32

Percentage of sentences judged grammatical

Sentence type	Nature of second NP		
	Short	Long with RC	Long with PP
Early closure	63	35	34
Late closure	81	67	69

Source: Adapted from Ferreira and Henderson 1991, fig. 5

grammaticality judgments when the potential direct object contained a relative clause modifier as in (178) and (180) or a prepositional phrase modifier as in (179) and (181), which were both harder than the short version.

In the case of both the relative clause and the prepositional phrase, there are three words between *birds* and the potential disambiguation point on *typically*. In a later experiment, Ferreira and Henderson (1991) found that lengthening the potential direct object with pre-nominal adjectives produced only slight difficulty. For example, the early-closure sentence with pre-nominal adjectives was nearly as easy as the one with a short noun phrase. The percentage of judgments of grammaticality were 61 percent for short NP₂ as in (182), 24 percent for long NP₂ with relative clause as in (183), and 51 percent for long NP₂ with pre-nominal adjectives as in (184).

(182) *Early closure, short NP₂*

While the boy scratched the dog yawned loudly.

(183) *Early closure, long NP₂ with relative clause*

While the boy scratched the dog that is hairy yawned loudly.

(184) *Early closure, long NP₂ with prenominal adjectives*

While the boy scratched the big and hairy dog yawned loudly.

These results are consistent with LAST. In terms of this model, the real factor is amount of commitment to the NVN analysis. When the commitment lasts longer, reanalysis is harder. Thus, (183) is harder than (184) because *that* initiates a new analysis-by-synthesis cycle. This has the effect of increasing the commitment to assigning *dog* as patient. For (178) to (181), both the relative clause and the prepositional phrase modifiers increase the commitment to *birds* as patient.

7.6.3 Plausibility

Christianson et al. (forthcoming) have reported evidence that the temporarily incorrect assignment of the noun following a verb as the patient of the verb can influence the ultimate interpretation. After reading sentences such as the following (185) or (186), subjects answered questions about meaning such as (187).

(185) *Potentially intransitive verb followed by NP*

While the grocer hunted, the rabbit ran into the woods.

(186) *Intransitive-only verb followed by NP*

The rabbit ran into the woods, while the grocer hunted.

(187) *Meaning question*

Did the grocer hunt the rabbit?

Subjects were more likely to report that the grocer hunted the rabbit in response to (185) than to (186). Christianson and colleagues argued that this result shows that *the rabbit* is temporarily assigned patient status, but only when it immediately follows the verb *hunted*. This intriguing fact shows two things. First, it reflects the local organizing power of the NVN template and immediate access to a conceptual representation. Second, it shows that the initial meaning-form representation persists, despite the later incompatible syntactic information that forces the patient of the first verb to be changed to the agent of the second. In this case, the premature semantic information is compatible with the final interpretation.

7.6.4 Prosodic Patterns

Prosodic patterns can influence the initial meaning-form hypothesis. These prosodic patterns can reduce the effect of DO/S garden paths in speech.

Kjelgaard and Speer (1999; Speer, Kjelgaard, and Dobroth 1996) established that prosodic information can eliminate DO/S garden paths. Subjects listened to tape recordings of early-closure and late-closure sentences in three conditions: cooperating, conflicting, and baseline. In the cooperating condition, the sentences were recorded so that prosodic boundaries had a lengthening and a drop in pitch on the final word of the phrase, as in (188) and (189), which originally are from Slowiaczek (1981) and published in Carroll and Slowiaczek (1987). The / indicates a syntactic clause boundary, and the % indicates a prosodic boundary. Underlining indicates pronunciation appropriate for a late-closure sentence, and capitals indicate pronunciation appropriate for early closure. Since the syntactic clause boundaries and the prosodic boundaries coincide in each of the above sentences, these are examples in which the syntactic and prosodic cues cooperate.

(188) *Cooperating cues, early closure*

BECAUSE HER GRANDMOTHER KNITTED% /PULLOVERS KEPT
WARM IN THE WINTERTIME.

(189) *Cooperating cues, late closure*

Because her grandmother knitted pullovers% /Kathy kept warm in the
wintertime.

In the conflicting condition, cross splicing yielded prosody that conflicted with the syntactic structure:

(190) *Conflicting cues, early closure*

Because her grandmother knitted /pullovers% KEPT WARM IN THE WINTERTIME.

(191) *Conflicting cues, late closure*

BECAUSE HER GRANDMOTHER KNITTED% PULLOVERS /Kathy kept warm in the wintertime.

The underlined material in these examples came from sentences that were recorded with the late-closure prosody, while capitalized material came from sentences recorded with early-closure prosody. Since the syntactic (/) and prosodic (%) boundaries occur at different points in (190) and (191), they illustrate a conflict between syntactic and prosodic cues.

In the baseline condition, early-closure and late-closure sentences were recorded with the same prosodic contour. Pretesting showed that subjects judged the baseline and cooperating sentences to be equally acceptable.

In Kjelgaard and Speer (1999) subjects listened to the sentences and pressed a response key to indicate whether the sentence was uttered as the speaker had intended. The results appear in table 7.33. Kjelgaard and Speer (1999) found that response times were faster for cooperating sentences than for baseline sentences, which in turn produced faster response times than conflicting sentences. Response times were faster for late-closure sentences than for early-closure sentences in the baseline condition and in the conflicting condition. But in the cooperating condition, there was no difference in response times for early- versus late-closure sentences.

These results show that pseudosyntax relies greatly on prosodic patterns to develop an initial meaning-form hypothesis. The associative pattern is that a prosodic boundary corresponds to the completion of a semantic unit. In the absence of a clear prosodic boundary, the system relies on other nonprosodic patterns, such as NVN.

Table 7.33

Mean grammaticality judgment times (ms) depending on cues and sentence type

Sentence type	Nature of cues		
	Cooperating	Baseline	Conflicting
Early closure	1170	1490	1530
Late closure	1175	1270	1300

Source: Adapted from Kjelgaard and Speer 1999, fig. 3

Kjelgaard and Speer (1999, 1998) provide additional evidence that pseudosyntax uses prosodic patterns online. Subjects listened to sentence fragments in cooperating, baseline, and conflicting conditions, and then read aloud as quickly as possible a visually presented word. Examples of cooperating conditions are:

(192) *Cooperating cues, late closure*

Whenever the guard checks the door⁰/' ... IT'S

(193) *Cooperating cues, early closure*

Whenever the guard checks % /the door' ... IS

The word to be named was a plausible continuation according to the syntactic structure. For example, for late-closure fragments, *it's* could plausibly begin a new clause; for the early-closure condition, *is* could plausibly be a verb that has *the door* as subject. Again, % indicates a prosodic boundary and / a syntactic boundary; in the cooperating conditions, these boundaries coincide.

Examples of conflicting conditions are:

(194) *Conflicting cues, late closure*

Whenever the guard checks % the door/' ... IT'S

(195) *Conflicting cues, early closure*

Whenever the guard checks /the door⁰' ... IS

The results appear in table 7.34. Naming times were faster in the cooperating condition than in the baseline condition, and faster in the baseline condition than in conflicting condition. The late-closure sentences produced faster response times than early closure in the baseline and conflicting conditions but not in the cooperating condition.

This line of research indicates that speech provides additional patterns that pseudo-syntax uses to provide an initial meaning-form hypothesis. More recent research suggests that readers do not use corresponding patterns, even when they are available (Speer and Dobroth 1998).

Table 7.34

Mean naming times (ms) depending on cues and sentence type

Sentence type	Nature of cues		
	Cooperating	Baseline	Conflicting
Early closure	640	810	905
Late closure	670	675	740

Source: Adapted from Kjelgaard and Speer 1999, fig. 5

7.6.5 Subcategorization Preferences

The subcategorization requirements and preferences of verbs will influence the likelihood and strength of DO/S and other potential garden paths (see section 7.1.7). The more frequently the verb is used as a transitive, the stronger the garden path when it is discovered that the verb actually is used intransitively. The relevant factor, however, may not be frequency of use of the verb as transitive, but instead, the plausibility of the agent-action-patient sequence. Thus, the garden-path effect appears stronger in (196) than in (197).

(196) *Plausible direct object*

While Mary was mending the socks fell off her lap.

(197) *Implausible direct object*

While Mary was mending the clouds grew in the sky.

A related case in which the system projects an argument structure is direct-object/indirect-object ambiguities (DO/IO), as in (198) and the corresponding unambiguous sentence (199).

(198) *Direct-object/indirect-object ambiguity*

Fred pushed the dog the bone.

(199) *Unambiguous three-argument verb*

Fred gave the dog the bone.

Sentence (198) is a mild garden path because the sequence *Fred pushed the dog* fits the canonical NVN pattern. *Pushed* may take two arguments (agent and patient) or it may take three (agent, patient, recipient). Only when *the bone* is received is it clear that *the dog* should be assigned the role of recipient rather than the role of patient. The garden-path effect does not occur with (199) because *gave* cannot occur with only two arguments, except as an idiom such as *I gave blood*.

7.7 Conjoined Noun Phrase/Coordinate Clause

The conjoined noun phrase/coordinate clause type of ambiguity (NP/CC) is illustrated by

(200) *Conjoined noun phrase/coordinate clause ambiguity*

Jacob kissed Miriam and her sister laughed.

Frazier and Clifton (1996) consider such sentences to be subject to a principle of “late closure.” The late-closure analysis converges with application of the NVN template. Since the NVN pattern is present in *Jacob kissed Miriam*, the grammar uses the corresponding meaning-form hypothesis to generate a syntax, the system then checks the derived syntax against the input, and accepts it. When *and her sister* is received, this

analysis is modified to a complex object noun phrase, and a new syntax is generated, checked and accepted. This new analysis is rejected when *laughed* is received. The second recovery is relatively easy because *her sister laughed* fits the NVN template as well, and it is plausible. These examples and the examples of DO/IO ambiguities (see section 7.6.5) suggest that the NVN template keeps applying as long as incoming material is consistent with a verb-appropriate common sentence pattern.

7.8 Interactions of Complex Subcategorizations

In this section, we discuss three different kinds of garden-path sentences that depend on subcategorization requirements that are more complex than two arguments. We discuss ambiguities that involve verbs that can take patient and recipient roles, verbs that require locative phrases, and verbs that can take complement clauses.

Frazier and Clifton (1996) explain direct-object/relative clause (DO/RC) ambiguities such as (201) in terms of minimal attachment of *the dog* as an argument of *gave*. This analysis must be revised when *bit* is received.

(201) *Direct-object/relative clause ambiguity*

Fred gave the man [the dog bit] the package.

LAST explains the DO/RC ambiguity in terms of activation of sentence templates that verbs elicit. For example, *gave* is an “alternating dative” verb that optionally subcategorizes for two noun phrase and one prepositional phrase arguments (NVN + PP) as in (202), in which the second noun phrase (*a raise*) is patient and the object of the prepositional phrase (*Harry*) is recipient. The verb *gave* also optionally subcategorizes for three noun phrase arguments (NVNN) as in (203), in which the second noun phrase (*Harry*) is the recipient and the third (*a raise*) is patient (see section 6.4.4 for further discussion of alternating datives).

(202) *Two noun phrase and one prepositional phrase arguments*

The boss gave a raise to Harry.

(203) *Three noun phrase arguments*

The boss gave Harry a raise.

Thus, for (204) *dog* completes the NVNN template, thus assigning *Fred* as agent, *man* as recipient, and *dog* as patient.

(204) Fred gave the man [the dog bit] the package.

Template matching for DO/RC ambiguity

Fred	=	N	=	agent
gave	=	V	=	action
the man	=	N	=	recipient
the dog	=	N	=	patient

The comprehension system uses this meaning-form hypothesis to initiate a syntactic derivation, which is accepted. The garden path, however, is detected on receiving *bit*, which activates its own argument requirements. The NVNN template for *gave* must be partially deactivated, so that *dog* fulfills the agent role of *bit* and *man* the patient role of *bit*. *Package* is then assigned the role of patient of *gave*.

Reactivation of sentence templates in DO/RC ambiguity

Fred	=	N	=	agent
gave	=	V	=	action
the man	=	N	=	recipient
the dog	=	N	=	agent
bit	=	V	=	action
[the man	=	N	=	patient]
the package	=	N	=	patient

The subcategorization information that *gave* requires both a recipient and a patient is an important factor in producing the DO/RC garden path. Notice, for example, that the garden path is weaker in (205).

(205) *DO/RC ambiguity with optionally three-argument verb*

Fred pushed the man [the dog bit] the package.

In (205), the system presents the initial meaning-form hypothesis that *Fred* is agent and *man* is patient corresponding to NVN = agent, action, patient. Even though *pushed*, like *gave*, may take three noun phrase arguments, the tendency to assign *dog* to the role of patient is not as strong as with *gave*, since *pushed* also may take just two noun phrase arguments, and these complete the more common NVN pattern.

A similar garden path should occur when verbs require locative phrases. For example, *put* requires an agent, a patient, and a location, producing the template N + V + N + PP. In sentences (206) and (207) from Frazier and Clifton (1996), the system does not present a meaning to the system after *book* based strictly on the NVN template, since *put* also requires a locative phrase.

(206) *PP attachment to main verb*

I put the book [that you were reading] in the library.

(207) *PP attachment to embedded verb*

I put the book [that you were reading in the library] into my briefcase.

The phrase *in the library* completes this required N + V + N + PP template, presenting an initial meaning-form hypothesis for the grammar to generate a candidate syntactic structure, which the system checks and accepts. The processing of (207) is similar until *into my briefcase* is received, producing a garden path. The garden path in (207) depends on the fact that *reading* optionally takes a locative phrase, but *put*

obligatorily takes a locative phrase. In the (208), *found* requires modification either with an agent or a location.

(208) I put the book [found in the library] in my briefcase.

For (208), *in the library* allows the system to present the meaning-form hypothesis about the reduced relative clause *found in the library* that *book* is patient of *found* and *in the library* is the location. Consequently, there is no garden path when *in my briefcase* is received.

Sentences like these, in which the main verb requires a locative argument, allow a comparison of the relative role of subcategorization information and minimal attachment. Frazier and Clifton (1996), for example, have proposed that the phrase *in the library* in (207) is initially attached to *reading*. There is evidence that comprehenders prefer to attach a locative phrase to *put* rather than to *apple* in *Put the apple on the towel in the box* (Tanenhaus et al. 1995; see also Britt 1994; Ferreira and Clifton 1986; Trueswell et al., forthcoming). But we know of no research on the processing of locative phrases that follow an embedded verb that optionally takes a locative phrase.

A related garden path occurs when the verb optionally takes a sentential complement. For example, *tell* may take two noun phrase arguments (agent and patient) in (209), three noun phrase arguments (agent, patient, and recipient) in (210), or two noun phrase arguments (agent and patient) and a sentential complement (theme), as in (211) and (212).

(209) *Two noun phrase arguments*

Ian told a joke.

(210) *Three noun phrase arguments*

Ian told the man a joke.

Two noun phrase arguments and a sentential complement

(211) Ian told the man [to leave].

(212) Ian told the man [that he hired a secretary].

A garden path arises in (212) because of the interaction of subcategorization requirements for *tell* and *hire*. *Hire* can take two noun phrase arguments, as in (212), where *he* is agent and *secretary* is patient, and in (213), where *he* is agent and *man* is patient. Alternatively, *hire* can take two noun phrase arguments and a sentential complement as in (214), where *he* is agent, *man* is patient, and *to plow the field* is theme.

(213) *Hire takes two noun phrase arguments*

Ian told the man [that he hired] a story.

(214) Hire *takes two noun phrase arguments and a sentential complement*

Ian told the man [that he hired to plow the field] a story.

A garden path occurs in (213) because the strength of the NVN template leads the system to propose that *story* is patient of *hire*, just as *secretary* is patient of *hire* in (212). Assigning *story* as patient of *hire* leaves unfilled a possible third argument for *tell*.

Sentence (214) above may or may not produce a garden path. It seems likely that intonation in normal speech will prevent a garden path. However, the sentence does raise the interesting question of the extent to which subcategorization information is available to guide the system's development of an initial meaning-form hypothesis, and the extent to which the system relies on an independent NVN template. If the system relies strongly on the fact that *tell* requires either an additional noun phrase argument or a sentential complement, we expect that *to plow the field* will complete a semantic unit for *tell*. To present this initial meaning-form hypothesis, however, the system would also have to override the NVN template in the relative clause, and present the meaning that the patient of *hire* is *man*. Since this analysis requires undoing the NVN template, such sentences provide an interesting test of the relative importance of an independent NVN template and subcategorization information.

7.9 Conclusion

In chapter 5, we pointed out that the analysis-by-synthesis model explains why sentence-level canonical templates will be the most reinforced of any associative completion patterns in language. In this chapter, we have reviewed explorations that reveal the explanatory power of the canonical NV(N(N)) = agent action (patient(recipient)) template as a whole, and in its subparts. In general, structures that violate the canonical sentence-mapping schema are relatively hard to understand. Correspondingly, sentences with apparent but incorrect NVN garden path lures tend to be confusing. Most telling is the paradoxical but predicted fact that deleting the relative pronoun from an object relative clause actually makes it easier to comprehend.

Note

1. Bever (1970a) reported that children actually understand transitive NVN sentences before they understand intransitive NV sentences.

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