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Abstract

Current linguistic theories suggest that inherent temporal boundedness (telicity) may underlie syntactic representations of sentences. Corpus analysis and acceptability judgments showed a weak relation between telicity and syntactic form. Two experiments on self-paced reading of sentences with reduced relative clauses showed that argument structure preferences had immediate effects on the garden path but verb telicity did not, nor did the garden path depend on an interaction of verb telicity with object specificity or preposition. A probe recognition experiment showed that response times were faster for sentences with a telic predicate. The results suggest early access to argument structure preferences and later access to a derived semantic representation of temporal boundedness.

The Linguistic Representation and Processing of Event Structure

The event structure of a sentence describes various kinds of temporal properties. This aspect of language has received much attention among linguists who are concerned with the relation between syntax and semantics, but it has received little attention in studies of sentence processing. In this paper, we first present the linguistic rationale for treating event structure as the basis for the syntactic structure of a sentence. We then describe major theories of event structure, and present some new data that examine some of the assumptions of these theories of event structure. We develop several hypotheses about the implications of linguistic theories of event structure for sentence processing, and present experimental data that test these hypotheses. Our results show that comprehenders primarily use event structure for organizing sentence meanings into a conceptual representation of discourse.

Argument Structure

Much sentence comprehension research has assumed that an essential part of comprehension is obtaining the argument structure of sentences (e.g., Carlson & Tanenhaus, 1988; Frazier, 1987; Gibson, 1998; Gorrell, 1995; MacDonald, Pearlmutter, & Seidenberg, 1994; Pritchett, 1992; Townsend & Bever, 2001). *Argument structure* refers to the number of phrases that must occur with a verb and their syntactic position in a sentence. The arguments of a verb are "internal" if they are generated inside the verb phrase and "external" if they are generated outside the verb phrase. An internal argument may be direct or indirect. The external argument corresponds to the traditional category of subject, while the direct and indirect internal arguments are usually direct and indirect objects, respectively. Consider the sentences below, which mark unacceptable sentences with an asterisk:

1. a. *John* $_{<external>}$ *slept.*

b. **John slept a nap.*

c. *The army* <*external*> *captured the city* <*internal direct*>.

d. **The army captured.*

e. *John* <*external*> *gave Bill* <*internal indirect*> *a book* <*internal direct*>.

f. **John gave Bill.*

g. **John gave a book.*

h. *John* <*external*> *broke the window* <*internal direct*>.

i. *The window* <*external*> *broke.*

Sleep requires an external argument only; *capture* requires an external and an internal direct argument; *give* requires an external, an internal direct, and an internal indirect argument; and *break* requires either an external argument, or an external and internal direct argument.

Example (1d) shows that a transitive verb such as *captured* requires an internal direct argument in its underlying representation. The underlying representation is the abstract structure that exists before any syntactic operations have modified them through movement or deletion. In the passive voice, an underlying internal argument becomes the explicit subject, as in *The city was captured by the army*. A passive verb may also occur without an underlying external argument, as in *The city was captured*. Thus, a transitive verb requires an underlying internal argument, though it may or may not have an underlying external argument. Intransitive verbs such as *slept* and *broke* in (1a, 1i) have an explicit subject but they do not have an explicit direct object.

Thematic Roles

A further assumption that has been made in sentence comprehension research is that the mental representation of a verb contains information about its required thematic roles (Fillmore,

1968; Gruber, 1965; Carlson & Tanenhaus, 1988). *Thematic roles* are meaningful relations that exist between a verb and its NP arguments. While there is as yet no consensus on the number of thematic roles necessary to account for the facts of natural languages, the following list includes those that many linguists would recognize:

AGENT: the animate initiator of an action

THEME: the thing that changes location or possession

PATIENT: the thing that is affected by an action

EXPERIENCER: the animate thing that experiences the action

GOAL: the person or place toward which an action is directed

SOURCE: the person or place at which an action originates

LOCATION: the location where something takes place

In terms of thematic roles, *sleep* requires an AGENT but must not have a PATIENT, *capture* requires an AGENT and a PATIENT, and *give* requires an AGENT, a GOAL, and a PATIENT. *Break* requires at least a PATIENT, but it also may require an AGENT.

2. a. *John* <*agent*> *slept.*

   b. **John slept a nap.*

   c. *The army*<*agent*> *captured the city* <*patient*>.

   d. **The army captured.*

   e. *John*<*agent*> *gave Bill* <*goal* > *a book* <*theme* >.

   f. **John gave Bill.*

   g. **John gave a book.*

   h. *John* <*agent*> *broke the window* <*patient* >.

   i. *The window* <*patient* > *broke.*

While the concept of thematic roles seems to carry an important insight about meaning relationships, linguists have so far not succeeded in reaching a consensus as to the nature of thematic roles, the number of roles, or their exact place in linguistic representations. For example, some linguists have argued for as few as two thematic roles and others for more than one hundred (see Dowty, 1991). Still others have argued that thematic roles are epiphenomena that fall out of the syntactic structure and have no explanatory role in linguistics (e.g., Hale & Keyser, 1993).

Although linguists have tried to relate thematic roles to argument positions, it has been difficult to do so since there does not seem to be a one-to-one relationship between theta roles and grammatical functions like subject and object. Thus, it is frequently the case that the AGENT will be the subject and the PATIENT will be the object, but it is not always so. For example, the PATIENT appears as internal argument in *John fears elevators* but as external argument in *Elevators frighten John*, and the subjects in *John slept* and *The ice melted* appear to have different thematic roles.

Event Structure

More recently, linguists have explored the role of *event structure* in linguistic descriptions. Among other things, the event structure of a linguistic constituent indicates whether the event described by that constituent has an inherent temporal boundary. Consider (3):

3. a. *John drew a circle*

   b. *John pushed a cart.*

Both sentences describe an event that ended earlier than the time of the utterance. But these sentences differ in a subtle way: It is the nature of drawing a circle that it must end at some point, namely, at the point where the two ends of the curved line meet. Until that point is reached, we

cannot say that John drew a circle. The same cannot be said of pushing a cart, which has no inherent end. John may push a cart for a period of time and feel that he wants to push it some more. But if we stop him from pushing the cart any longer, we still can say *John pushed a cart*. Thus, the two sentences in (3) differ in their event structure. Events that have an inherent temporal boundary are called telic and those that do not are "atelic." Telic events must have something that changes state or location, or comes into existence to *delimit* the event; this thing is the "delimiter." In (3), *circle* is a delimiter but *cart* is not.

The event structure of a sentence may include the roles of CAUSER, MEASURE, and DELIMITER. For example, consider (4):

4. a. *John* <*causer*> *drew a circle* <*delimiter*>

   b. *John* <*causer*> *ran to the store* <*delimiter*>

   c. *John* <*causer*> *pushed a cart* <*measure*>

   d. *John* <*causer*> *pushed a cart* <*measure*> *to the store* <*delimiter*>

   e. *John* <*measure*> *slept*

   f. *John* <*causer*> *melted the chocolate* <*delimiter*>

   g. *The chocolate* <*delimiter*> *melted*

Typically, if there is no MEASURE in the event structure of a sentence, the DELIMITER emerges as an internal direct argument; if there is no CAUSER, it emerges as the external argument. Thus, the requirement that a telic event has an underlying internal direct argument is true even for intransitive sentences, which do not have an overt object. For example, linguists analyze *The chocolate melted* as having an underlying object *chocolate* that undergoes a change of state. The notion that a telic event must have something to delimit the event suggests that event structure may predict and underlie syntactic structure.

Event structure is part of the broader category of aspect that deals with such properties as whether an event is ongoing or completed. One of the problems that arises in the study of aspect is known as the imperfective paradox: how can we describe an event that has a natural end point but is presented as ongoing, as in *Fred was drawing a circle?* "Draw a circle" is telic, and yet the foregoing sentence describes an event that need not be completed, as shown by the acceptability of *Fred was drawing a circle, but his pencil broke and he couldn't finish it.* In order to resolve this paradox, we adopt the distinction drawn by Smith (1991) between situation aspect and viewpoint aspect. Situation aspect is a property of the event, and viewpoint aspect deals with how the event is presented. Thus the example above refers to a telic event (*drawing a circle*) that is presented as in progress.

Objects, Patients, or Delimiters

Representations of event structure have the potential of helping us understand the relation between the structure and meaning of sentences. Linguistic discussions have suggested that event structure might serve to link the meaning and syntactic form of sentences, and thereby help us solve certain puzzles about sentences (Borer, 1994; Hale & Keyser, 1994; Rosen, 1996; Sanz, 2000; Tenny, 1994). For example, ideas about event structure have been useful in explaining the differences between various intransitive verbs.

Recall that intransitive verbs must have an explicit subject but must not have an explicit object. At the superficial level, there are three quite distinct kinds of intransitive verbs: *null object* verbs, which lack an overt object but which imply that this argument exists semantically; *unaccusative* verbs, in which the superficial subject is semantically the underlying object; and *unergative* verbs, which seem to have no object at any level of representation (Levin & Rappaport, 1995; Perlmutter, 1978). The following examples illustrate these three types of

intransitives:

5. a. *Bob ate* [null object because eating something is implied]

   b. *The window broke* [unaccusative because *window* is understood as the PATIENT]

   c. *Larry danced* [unergative because no object is implied]

Table 1 summarizes linguistic tests to distinguish null object, unaccusative, and unergative verbs.

Null object verbs have an internal direct argument but it is acceptable to "drop" this argument. Null object verbs do not change meaning when an appropriate object is added to the intransitive sentence, as in *John read vs. John read a book.* True transitive verbs do not allow "object drop," as shown by *The army captured the city vs. *The army captured*, since, as we noted, they require an internal direct argument. Examples of null object verbs are *read, applaud, assist*, and *attack.*

Unaccusative verbs have a subject that functions as a PATIENT. For example, in *The window broke*, window is an underlying PATIENT because it undergoes a change of state as a result of the breaking event. An intransitive sentence has an unaccusative verb if its meaning is consistent with that of a transitive sentence in which the subject of the intransitive verb becomes the object of the transitive verb. For example, *break* is unaccusative because *The window broke* is consistent with *Pat broke the window*. Thus, *break* is unaccusative because it undergoes causative alternation. Examples of unaccusative verbs are *break, awaken, bleed* and *bruise*. Unergative verbs have a subject that is AGENT or EXPERIENCER, but unlike null object verbs they have neither an explicit nor implicit object. Since unergative verbs do not have an object at any level, they arguably are the "most intransitive" type of intransitive verb. Unergative verbs pass two tests. First, a sentence with an unergative verb can be modified by an adverb that

Table 1

Tests for Different Types of Intransitive Verbs

Type	Test	Examples
Null Object	No change in meaning when an appropriate object is supplied.	*1. John read. = John read a book.* 2. *The window broke. =/=* **The window broke the silence.* → *read* is null object but *break* is not
Unaccusative	Undergo causative alternation.	1. *The window broke.* *Pat caused the window to break.* *Pat broke the window.* 2. *The children danced.* *?The teacher caused the children to dance.* **The teacher danced the children.* → *break* is unaccusative but *dance* is not
Unergative	a. Modification by manner adverbs that imply that the subject controls the action. b. No causative alternation.	1. *The children danced reluctantly.* 2. **The window broke reluctantly.* 3. *The children danced.* *?The teacher caused the children to dance.* **The teacher danced the children.* → *dance* is unergative but *break* is not

indicates that the subject is an AGENT, as in *The children danced reluctantly.* Second, because the subject of an unergative verb is a true AGENT, these verbs do not undergo causative alternation in which the intransitive subject becomes a transitive object, as in (6)-(7):

6. *The children danced*

7. **The teacher danced the children.*

Examples of unergative verbs are *dance, sleep, rest, bathe,* and *soak.*

Sentences with unaccusative and unergative verbs present a difficulty for the view that there are rules that assign thematic roles to syntactic arguments. These sentences show that a PATIENT may appear as the subject or object of a sentence. Event structure roles, however, appear to predict the linking of meaning and syntactic arguments. For example, the observations in (4) and (5) suggest the following rules for assigning event structure roles to syntactic arguments in active sentences:

- If there is no causer or delimiter, the measure becomes the external argument.

  (4. e. *John* <*measure*> *slept;* 5. c. *Larry* <*measure*> *danced.*)

- If there is no causer, the delimiter becomes the external argument.

  (4. g. *The chocolate* <*delimiter*> *melted*; 5. b. *The window* <*delimiter*> *broke.*)

- If there is a causer but no measure, the delimiter becomes the direct internal argument

  (4. a. *John* <*causer*> *drew a circle* <*delimiter*>; 4. f. *John* <*causer*> *melted the chocolate* <*delimiter*>)

Event linking rules have the advantage over thematic linking rules that event roles are less ambiguous and fewer in number. Thus, event structure may help to explain the relation between the structure and meaning of sentences more effectively than thematic roles.

Discourse Meaning

Besides the possibility of explaining the relation between the structure and meaning of

sentences, event structure is important at the level of discourse meaning. When we understand a story we can answer questions such as: What was the sequence of events? When did the events begin and end relative to one another?

Information about temporal boundaries obviously is relevant for answering these questions. Temporal boundaries are important in discourse structure because the end of an event moves the narrative forward in time (e.g., Dowty, 1986; Dry, 1981; Hinrichs, 1986; Kamp & Rohrer, 1983; Lascarides, 1992; Magliano & Schleich, 2000; Partee, 1984). For example, we often interpret a sequence of telic events as occurring in the order they are presented, as in *John entered the president's office. The president walked over to him* (Dowty, 1986). The temporal boundary of each event marks a point on a narrative time-line. Comprehenders assume that these points are presented in their underlying order on the time-line (Townsend, 1983). But an atelic event overlaps in time the event described in the preceding sentence in the sequence *John entered the president's office. The clock on the wall ticked loudly.* The second sentence here describes a situation that exists prior to and after the event in the first sentence. Asher & Lascarides (1995) have argued that aspectual properties of discourse context influence lexical disambiguation, while Danlos (2001) has argued that the event structure of sentences influences causal relations in discourse. All of these examples demonstrate that event structure is important in the comprehension of narratives, and they suggest that event structure is represented at a level that is more abstract than words and sentences (though it may also be represented at the levels of words and sentences).

Two Approaches to Telicity in Linguistic Representations

Two essential and related questions about telicity are: where does the grammar represent it and how do comprehenders obtain it? Clearly, telicity may occur in more than one place, since

each linguistic level incorporates information from lower levels; nevertheless, we can ask what is the "lowest" level at which such information can be found?

Two broadly-different views have been offered as to the locus of telicity information in a linguistic description. Some linguists claim that telicity is an inherent *lexical* property. Others treat event structure as a *derived* property of a sentence that is found at the syntax-semantics interface. By "derived" we mean essentially non-lexical, that event structure is represented at a level higher than the lexical category (see Salazar, 2001). Among those who treat event structure as a derived property are linguists who advocate syntactic representation of event structure, usually in the form of a functional category within the predicate of a sentence. It should be noted that there is a certain degree of overlap among these views in that, for example, linguists naturally assume that lexical properties contribute to the semantics of a sentence. Nevertheless, different linguists take different positions as to the primary locus of event structure information.

In this section we outline lexical vs. derived views of telicity. We then present acceptability and corpus evidence on these views. Then we review major approaches to sentence comprehension, and consider the implications of alternative views of telicity for sentence processing.

Lexical Models

Early discussions of telicity usually assumed that it was a binary feature associated with individual lexical items, much like transitivity, and that each verb that refers to events is either positively or negatively specified for telicity in the lexicon (e.g., Verkuyl, 1989, 1993; but cf., Olsen, 1994). The appeal of a lexical approach is that it seems to capture an intrinsic characteristic of a verb in a way that is similar to the treatment of other lexical characteristics. If we consider verbs like *find* and *run*, for example, the former seems to refer intrinsically to an

event with a natural end point (the moment at which the item sought is found) whereas the latter denotes an ongoing process with no natural end point.

Vendler (1957) first drew the attention of linguists to the study of event structure. Vendler distinguished between three aspectual classes of verbs: activities, accomplishments, and achievements:

8. a. *John pushed a cart* [activity]
   b. *John drew a circle* [accomplishment]
   c. *John arrived* [achievement]

Activities do not have an inherent end-point, and are atelic. But accomplishments and achievements do; they have a delimiter (or *telos*) and are telic. Accomplishments differ from achievements in that accomplishments occur over an extended period of time whereas achievements occur at a single moment.

Dowty (1979) isolated a number of tests to identify Vendler's aspectual classes (see Table 2). Among these tests are the *in/for* test (lines 1 and 2 in Table 2). Events with an inherent temporal boundary are more acceptable when modified with phrases like *in an hour* compared to those without an inherent temporal boundary. On the other hand, events without an inherent temporal boundary are more acceptable with phrases like *for an hour*:

9. *John drew a circle in an hour.*
10. *?John drew a circle for an hour.*
11. *?John pushed a cart in an hour.*
12. *John pushed a cart for an hour.*

A "?" preceding a sentence indicates that the sentence is odd but not necessarily ungrammatical. In sentence (9) the delimiter of the drawing event is the circle, and the sentence states that it

Table 2

Tests for Vendler's Events (adapted from Dowty, 1979)

	Atelic	Telic	
	Activities	Accomplishments	Achievements
Test	*X = …pushed a cart*	*X = …drew a circle*	*X = … crossed a line*
1. *X for an hour*	*Yes*	*no*	*No*
2. *X in an hour*	*No*	*yes*	*Yes*
3. *X for an hour* entails *X at all times in the hour*	*Yes*	*no*	-
4. *…is Xing* entails *… has Xed*	*Yes*	*no*	*No*
5. complement of *stop*	*Yes*	*yes*	*No*
6. complement of *finish*	*No*	*yes*	*No*
7. ambiguous with *almost*	*No*	*yes*	*No*
8. *X in an hour* entails *… was Xing during the hour*	-	*yes*	*No*
9. occurs with *carefully*	*Yes*	*yes*	*No*

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required an hour to reach this delimiter. Sentence (10) is odd because the circle is a delimiter, but the phrase *for an hour* implies that the drawing event arbitrarily ended after a period of an hour. On the other hand, sentence (11) is odd because it does not indicate that an end-point of the pushing event was reached, even though the phrase *in an hour* implies a delimiter. Note that (11) may be interpreted as saying that an hour elapsed until John began pushing a cart.

A second test shown in Table 2 is the *homogeneity test* (line 3). For an atelic activity, all sub-parts of the event are similar. If John pushed a cart for an hour, the nature of the pushing activity is similar at all points during the hour. But for a telic event, various sub-parts of the event differ. For example, the event of drawing a circle is different at the end than at the beginning because the end-point involves joining two parts of the perimeter of the circle.

Vendler thought of event structure as a property of verbs. It is clear, however, that the phrases in a sentence can influence temporal boundedness (e.g., Verkuyl, 1989, 1993; Mourelatos, 1978). A well-known example of how temporal boundedness depends on the nature of the arguments in a sentence is the following:

13. *John drank a beer.*

14. *John drank beer.*

In (13) there is a specific quantity of beer, which, when consumed, marks the end of the drinking event. But since the quantity of beer in (14) is unspecified, the consumption of the direct object cannot mark the end of the drinking event. Sentence (13) has an inherent temporal boundary, but sentence (14) does not. Notice that the pattern of acceptability with *in/for* that is shown in (9)-(12) also occurs with (13) and (14):

15. *John drank a beer in an hour.*

16. ?*John drank a beer for an hour.*

17. *?John drank beer in an hour.*

18. *John drank beer for an hour.*

Another instance of a phrase influencing temporal boundedness appears in locative phrases, as in *John ran to the store*. The phrase *to the store* marks the end-point of the running event; this phrase converts an atelic event (running) into a telic event:

19. a. *?John ran in an hour.*

    b. *John ran for an hour.*

20. a. *John ran to the store in an hour.*

    b. *?John ran to the store for an hour.*

Notice that the nature of the preposition is critical as well. For example, *John ran near the store* is atelic, unlike *John ran to the store.* Examples like these demonstrate that temporal boundedness at least partly depends on the nature of the arguments and adjunct phrases that appear in the sentence.

The Verb Class Model. The *verb class model* maintains that the meanings of verbs project syntactic arguments (Levin & Rappaport, 1996; Rappaport Hovav & Levin, 1998, 2000). The goal of the model is to represent the meaning of a verb in a way that predicts whether its arguments are expressed as internal direct, internal indirect or external arguments. Verbs fall into semantic classes that differ in the range of arguments they allow.

Levin & Rappaport note that verbs can express arguments in different ways, as shown in:

21. a. *Terry swept* [activity]

    b. *Terry swept the floor* [activity/accomplishment]

    c. *Terry swept the crumbs into the corner* [accomplishment]

    d. *Terry swept the floor clean* [accomplishment]

22. a. *Pat ran* [activity]

b. *Pat ran to the beach* [accomplishment]

c. *Pat ran herself ragged* [accomplishment]

d. *Pat ran clear of the falling rocks* [accomplishment]

e. *The coach ran the athletes around the track* [accomplishment]

Variation in the expression of arguments is related to variation in meaning. For example, verbs that refer to Surface Contact through Motion display the pattern in (21), while verbs that refer to Manner of Motion display the pattern in (22). For example, since *wipe* is a verb of Surface Contact through Motion, it behaves like *sweep* in (21):

23. a. *Terry wiped* [activity]

b. *Terry wiped the table* [activity/accomplishment]

c. *Terry wiped the crumbs into the sink* [accomplishment]

d. *Terry wiped the slate clean* [accomplishment]

Rather than having one lexical entry for each of the possible structures in (21) - (22), the verb class model seeks to develop principles that use the meaning of a verb to predict ways in which it can express its arguments.

Variability in verb meaning is related to event structure. Verbs with highly variable meaning all specify the *manner* in which the action denoted by the verb is carried out. Verbs whose meaning is less variable specify the *result* of the action denoted by the verb. *Sweep* and *run* are manner (atelic) verbs, while *break* and *open* are result (telic) verbs that specify an end state without specifying the manner of achieving it. Thus, variability in syntactic behavior is related to the aspectual properties of a verb such as whether it specifies an end state.

As noted above, the verbs within a semantic class share syntactic properties. The *structural*

meaning of a verb captures the syntactic properties that verbs within a semantic class share. The differences in meaning between verbs within a class appear in their *idiosyncratic meaning*. It is only the structural meaning that is relevant to a verb's syntactic behavior. Event structure templates such as the following express a verb's structural meaning:

[[x ACT] CAUSE [BECOME [y <*STATE*>]]]

Kelly broke the window.

In this template for a result verb, the idiosyncratic meaning appears in the *STATE.*

In contrast to result verbs, manner verbs have a wider variety of event structure templates:

[[x ACT]]

Terry swept [activity]

[[x ACT] CAUSE [BECOME [y <*STATE*>]]]

Terry swept the leaves off the sidewalk [accomplishment, state change]

[[x ACT] CAUSE [BECOME [y <*PLACE*>]]]

Terry swept the crumbs into the corner [accomplishment, location change]

The verb class model partly explains variations in syntactic structure by maintaining that result templates are less flexible than other templates. The variations in meaning for manner verbs like *sweep* and *run* involve 'expansion' of an activity to yield various kinds of accomplishments. For example, the various meanings of *sweep* in (21) all involve adding a resulting state with a change of location, a change of state, or something coming into existence. In each case, an element in the syntax signals the addition of the resulting state. In contrast, the rigidity of result verbs is due to the fact that their event structure template is fully specified. These verbs cannot take on an activity reading without eliminating part of their structural meaning (i.e., the resulting state). Furthermore, no additional expansion of their representation is

possible because the accomplishment representation is the most complex representation available. Event structure templates that are not fully-specified lexically may be "augmented" through expansion or contraction, but those that are fully-specified lexically cannot be expanded and resist contraction.

In addition, manner verbs with a two-argument template more readily allow omission of their direct object, compared to two-argument result verbs:

24. a. *Leslie swept the floor* → *Leslie swept*

b. *Kelly broke the window* → **Kelly broke*

That is, compared to telic verbs, atelic verbs are more likely to appear as null object verbs.

To summarize, the verb class model maintains that the event structure template of a telic verb projects a resulting state. This model predicts that telic verbs will be less flexible both in the meanings they take on and in the structures in which they appear, compared to atelic verbs. This difference in flexibility follows from the fact that telic event structure templates are fully specified. In contrast, atelic verbs are associated with a broader range of event structure templates; since some of their event structure templates specify no state change, they are more likely to appear as null object verbs.

Derivational Models

A second approach claims that telicity is represented in the form of a particular syntactic or semantic configuration. On this view, event structure is primarily a derived property. Some models within the derivational approach propose that event structure is a semantic property while others propose that it is represented syntactically. There are large differences between semantic vs. syntactic derivational approaches. However, these approaches broadly claim that event structure is derivationally assigned to a predicate, a sentence, or a stretch of discourse on the

basis of information that includes more than just the verb.

Linguists who adopt the derivational approach suggest that there is evidence against the verb class model. For example, in contrast to the verb class model, Ritter & Rosen (1996) suggest that variability of meaning is independent of verb event structure. They note that both *run* and *walk* are manner of motion verbs that take a single external argument. However, the meaning and syntactic frame of *run* is much more variable than that of *walk*:

25. a. *Martha ran/walked to the store*

b. *Tears ran/*walked down the child's face*

c. *Martha ran/walked Fred to the station*

d. *Martha ran/*walked a successful campaign*

e. *Fred knows how to run/*walk the fax machine*.

f. *Floris ran/walked over to the dean's office, but she didn't run/*walk there*

g. *Floris ran/walked the letter to the dean's office, but she didn't run/*walk there*.

h. *The Kansas River runs into the Missouri River, but it doesn't run there; that would be silly*.

The fact that the Collins COBUILD dictionary has more than 9 times as many entries for *run* as for *walk* is an indication of the greater flexibility of *run*. These results cast some doubt on the verb class model.

The Generative Lexicon Model. The *generative lexicon model* proposes that word meanings combine according to a limited set of generative rules to obtain the meaning of a sentence (Pustejovsky, 1991a, 1995). Thus, the meaning of a verb in a particular sentence depends on the phrases that appear in the verb phrase, and also on the meanings of the arguments of the verb. The meaning of a word includes its argument structure, event structure, *inheritance structure*,

and *qualia structure*. The inheritance structure of a word describes how it is related semantically to other concepts. The qualia structure specifies four aspects of meaning: its constitutive role, its formal role, its telic role (i.e., purpose and function), and its agentive role (i.e., how it comes into being). These are the aspects of the meaning of words that combine to produce new meanings. For example, the event structure of (26a) and (26b) differ even though their verbs and syntactic arguments are similar.

26. a. *John baked the potato.*

    b. *John baked the cake.*

    c. *Mary enjoyed reading the book.*

    d. *Mary enjoyed the book.*

Sentence (26a) is an (atelic) activity, whereas (26b) is a (telic) accomplishment. There are not two different senses for the verb *bake*. Instead, there is a single meaning that shifts from the activity meaning in (26a) to the accomplishment meaning in (26b) because the agentive role of *cake* includes the fact that it is an artifact that comes into existence because of the activity of baking. Thus, the fact that *bake* is an activity is part of its lexical representation, but the phrases and meanings of other words in the sentence may change its event structure interpretation. The process by which this change in meaning occurs is called *co-composition*. This shift in meaning does not occur with (26a) because part of the agentive role of *potato* is that it is a natural kind.

A somewhat different shift in meaning occurs in (26c)-(26d). In (26d) the verb induces a change in meaning of the object from an entity to an event. Pustejovsky (1995) refers to this phenomenon as *coercion*. Coercion occurs in (26d) because *enjoy* requires an event complement, and the telic role or typical function of *book* is that it is used for reading. The process of coercion therefore shifts the semantic type of the direct object in (26d) from an entity to a reading event.

An attractive feature of the generative lexicon model is that, rather than simply listing that *enjoy* can appear with a noun phrase object or with a sentential object, it explains the existence of these alternative argument structures.

A sentence has a lexical conceptual structure that identifies its propositions in terms of the core meaning of the verb plus predicates such as BECOME, CAUSE, and ACT (Pustejovsky, 1991b). This lexical conceptual structure is based on a representation of event structure. According to the generative lexicon model, Vendler's activity consists of a sequence of events that are identical, as in *John ran*, and Vendler's accomplishment consists of an activity plus a change of state. This approach allows Pustejovsky to explain why phrases such as *in an hour* occur only with accomplishments such as *John built the house in an hour*: The adverbial phrase describes the temporal distance between onset of the activity and the change of state.

Pustejovsky (1995) proposes that the inherent meaning of a verb may denote a bounded or an unbounded event, but that an appropriate context can easily modify this meaning. The ease with which the inherent telicity of a verb is modified and the naturalness of the resulting sentences leads Pustejovsky, Folli (2001), and others to consider telicity to be derived from lexical and other information.

There is evidence for on-line processes of coercion and co-composition. For example, processing load increases after an adverbial phrase that changes the aspectual meaning from a punctual event to an iterative event, as in *The man kicked the little bundle of fur for a long time…* (Pinango, Zurif, & Jackendoff, 1999). In addition, reading times increase when a verb that requires a propositional event as its object actually has a noun phrase as object, as in *The author was starting the book*, compared to a verb that generally takes a noun phrase object, as in *The author was writing the book* (McElree, Traxler, Pickering, Sealy, & Jackendoff (2001; Traxler,

Pickering, & McElree, 2002). Some of these results may be due to argument structure preferences, or to plausibility (see de Almeida, 2004). Nevertheless, these studies suggest that aspectual shifts occur at some point during sentence comprehension (see General Discussion).

Others have argued that processes such as coercion are pragmatic inferences that encompass discourse context. Fodor & Lepore (1998) have argued that shifts in meaning as in (26) are due to inferences based on knowledge of the world rather than to the semantics of the lexicon. They argue, for example, that the typical function of a book is part of our knowledge about the world rather than part of lexical knowledge. Lascarides & Copestake (1998) have argued that shifts in aspectual meaning depend on context. For example, in the sequence *My goat eats anything. He really enjoyed your book* the interpretation that *your book* refers to the event of eating your book depends on context, not on the telic role of *book.*

The Predicate-Driven Model. The *predicate-driven model* is an example of a syntactic derivational approach (Borer, 1994). In the predicate-driven model the expression of arguments as internal direct, external, etc. depends on a combination of the verb and aspectual functional projections (i.e., nodes in a phrase structure or X' tree). The position of arguments depends on aspectual constraints on specifiers that are associated with particular interpretations and specific grammatical functions. Thus, lexical entries do not specify arguments as external or internal, and there are no rules in lexical entries that govern the projection of arguments. For example, the lexical entry for *derive* indicates that it requires two NP arguments, while that for *wilt* indicates that it takes only one NP argument. It is the movement of arguments to specifiers of functional projections that creates the hierarchical representation of arguments as internal vs. external. The predicate-driven model suggests that event structure properties depend on syntactic mechanisms.

Recall that a justification for a relation between event structure and syntactic structure is the

difference between unergative verbs, which have no object at any level, and unaccusative verbs, which take a subject that is an underlying object. In the predicate-driven model, unergative and unaccusative verbs differ according to whether they project a specifier in the aspect phrase. It is this specifier that determines whether there is a MEASURE/DELIMITER.

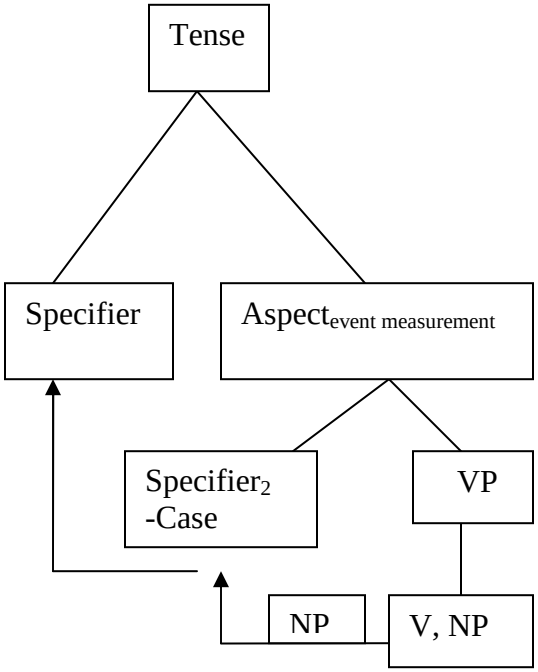
Figure 1 shows how the difference between unaccusative and unergative arises syntactically. The specifier in the Aspect phrase is optional, but if it is present it must be filled. If it is filled, there is a MEASURE/DELIMITER. Accusative case assignment in the specifier of the Aspect phrase is optional as well, while nominative case assignment in the specifier of the Tense phrase is obligatory (i.e., every sentence must have a subject and tense). Thus, an unaccusative verb projects a specifier under an Aspect node but this specifier does not assign accusative case. So, in the derivation of an unaccusative sentence, the single NP moves to the nearest specifier to receive case. In the case of unaccusative, the specifier under the Aspect node gives rise to MEASURE/DELIMITER, which measures the event, but the specifier does not assign case. Since all NPs require case, the NP must move to the higher specifier in the Tense phrase, where it receives nominative case. Thus, the single argument for an unaccusative verb receives MEASURE/DELIMITER but not accusative case from the Aspect phrase, and it ends up as the subject.

In contrast, an unergative verb does not project a specifier in the Aspect phrase. Since there is no specifier in an Aspect phrase of an unergative verb, the NP moves directly to the specifier under the Tense node, where it receives nominative case. Like the argument for an unaccusative verb, the argument for an unergative verb appears as the subject; but unlike the argument for an unaccusative verb, it does not receive MEASURE/DELIMITER.

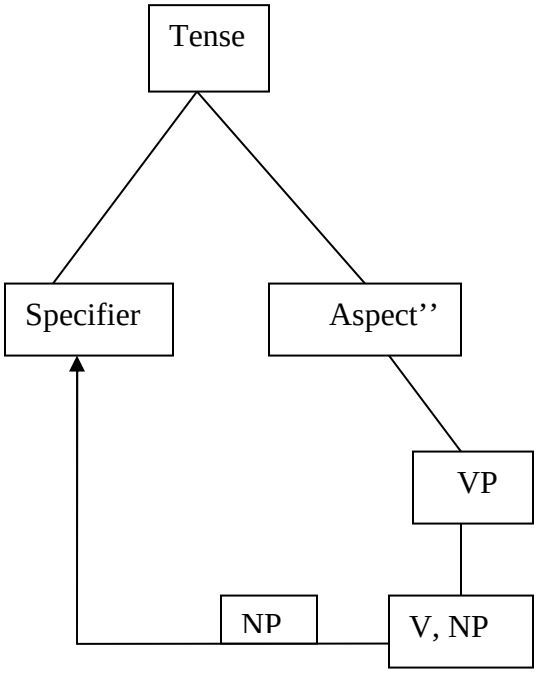
An attractive characteristic of the predicate-driven model is that it predicts different event

Figure 1. Predicate-driven derivation of unaccusative and unergative sentences

Unaccusative Derivation:



Unergative Derivation:



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structure depending on the context in which the verb occurs, for example, specific vs. non-specific objects. Borer observes that the direct object is a MEASURE/DELIMITER in (27a) but not in (27b)

27. a. *Robin climbed the staircase (in an hour/*for an hour).*

b. *Robin climbed staircases (*in an hour/for an hour).*

This difference follows from the fact that *staircase* in (27a) has a specifier (*the*) but *staircases* in (27b) does not. Hence, *staircases* in (27b) remains in the verb phrase and therefore cannot receive MEASURE/DELIMITER. The predicate-driven model maintains that syntactic properties of the predicate, such as object specificity, influence the aspectual role of predicates.

Sanz (2000) proposed that the processing system uses the requirement for a delimiter to assign the role of syntactic object. Factors such as verb telicity and specificity, as in (27), influence how readily the parser assigns noun phrases to the role of object. In particular, the parser more readily assigns noun phrases to the role of object/MEASURE/DELIMITER for telic verbs since these verbs require a delimiter. Since specific noun phrases are better delimiters than non-specific noun phrases, the processing system more readily assigns specific noun phrases to the role object/MEASURE/DELIMITER. For example, among the following sentences, the garden path should be smallest for (28a):

28. a. *The dog found in the alley is a poodle.*

b. *Dogs found in the alley are poodles.*

c. *The dog chased in the alley is a poodle*.

d. *Dogs chased in the alley are poodles.*

This prediction follows from the claim that a telic verb (found) seeks a delimiter whereas an atelic verb (*chased*) does not, and that a specific noun phrase (*the dog*) is a better delimiter than a

non-specific noun phrase (*Dogs*). This proposal also predicts that processing the post verbal determiner *a* will be harder for *The dog found a squirrel in the alley* than for each of the following: *Dogs found a squirrel in the alley; The dog chased a squirrel in the alley;* and *Dogs chased a squirrel in the alley.* In the first of these sentences, the telic verb *found* immediately initiates a search for a delimiter and *the dog* is a better delimiter than *Dogs*. Thus, the initial noun phrase tends to be assigned the role of MEASURE/DELIMITER/object. Since the parser has assigned the initial noun phrase to the role of MEASURE/DELIMITER/object, a true post-verbal object, as signaled by *a*, will be relatively unanticipated and harder to process.

O'Bryan, Harley, Folli, & Bever (2002, 2003, 2004) reported that reduced relative garden paths are smaller for telic verbs than for atelic verbs (see Experiment 1 below for further discussion). There also is evidence that comprehenders are sensitive to the aspectual effects of specifiers. Slabakova (1999) found that speakers judge coordinate sentences such as *Antonia worked in a bakery and [made cakes/made a cake]*, which begins with a durative event (*Antonia worked in a bakery*, more acceptable when the second conjunct contains a non-specific object (*cakes)* rather than a specific object (*a cake*). Todorova, Straub, Badecker, & Frank (2000) found that the shift from punctual to iterative interpretation that is caused by a non-specific object increases self-paced reading times. For example, they found that the non-specific object *large checks* increased reading times on the adverbial phrase *for many years* in *Even though Howard sent [a large check/large checks] to his daughter for many years…*

To summarize, derivational approaches maintain that the event structure of a sentence depends on syntactic or semantic properties of arguments of the verb. These properties include the purpose, function, origin, and specificity of objects. Various processes combine these properties with the meaning of the verb to obtain the event structure of the sentence.

Lexical and derivational approaches to event structure make different claims about how telicity is related to meaning flexibility and direct objects. In the next section we test these predictions with off-line studies of sentence acceptability and corpus analysis. We will see that the behavior of atelic verbs is less flexible than that of telic verbs, and that there is a weak association between verb telicity and direct objects. Following these off-line studies we will examine the implications of event structure for sentence comprehension.

Sentence Acceptability and Corpus Analysis of Telicity

The verb class model proposes that the event structure template of a telic verb projects a resulting state, which appears as a direct object. Since the event structure template of a telic verb is fully specified, telic verbs are less flexible in the meanings they take on. According to derivational models the meaning of a verb is easily modified by properties of the object, such as its specificity. We tested these predictions in several ways. We examined judgments about the acceptability of sentences with in- vs. for-temporal phrases. We analyzed a corpus for the frequency of shifts in telicity and the frequency with which telic vs. atelic verbs appear in different types of intransitive sentences. We compared telic vs. atelic verbs in the number of meaning senses they have in their dictionary entries. We tested the acceptability of sentences in null object vs. unaccusative sentence frames.

The materials consisted of a set of verbs that differed in telicity and argument structure preferences. The verbs consisted of 16 sets of four verbs each; within each set there was a telic potentially intransitive verb, a telic transitive-only verb, an atelic potentially intransitive verb, and an atelic transitive-only verb.

In/For Acceptability

In *John drew a circle in an hour* we are asserting that it took an hour to complete the event of

drawing a circle. This implies that the event of drawing a circle has a natural end-point. The phrase *in an hour* provides a "frame" for the event. Since atelic verbs refer to an event that has natural end-point, it is awkward to say *?John pushed a cart in an hour*. In *John pushed a cart for an hour* we are asserting that the activity of pushing the cart lasted an hour. In this case there is no implication of a natural end-point of the pushing event, but the event ended arbitrarily after an hour. A phrase like *for an hour* provides a "duration" during which the event occurs. Since telic verbs refer to an event with a natural end-point, it is awkward to say ?*John drew a circle for an hour.*

Quantifying the object phrase influences telicity. As discussed earlier, *John built a house* is judged telic because it is more natural with an *in*-phrase than with a *for*-phrase:

John built a house in 6 months

?John built a house for 6 months.

If the object refers to an unknown quantity, however, the sentence is no longer telic:

?*John built houses in 6 months.*

John built houses for 6 months.

If verb telicity determines an inherent end-point, then the acceptability of sentences with *in*- vs. *for*-temporal phrases will depend on verb telicity. If a non-specific object decreases temporal boundedness, judgments of acceptability with *in*-phrases will be smaller for non-specific objects than for specific objects. To test these hypotheses, we administered a forced choice acceptability test of sentences containing a telic vs. atelic verb, a specific vs. non-specific object, and an *in*- vs. *for*-temporal phrase.

Method. Participants received each critical verb with an *in*-phrase and a *for*-phrase, as in *The orderly arrested the patient in 6 minutes* vs. *The orderly arrested the patient for 6 minutes.* The

arguments in these sentences were identical to those that we used in self-paced reading experiments (see Experiments 1 and 2). The participants' instruction was to indicate which sentence sounded better, or if they sounded equally good, or if neither sounded good. There were 16 sets of verbs. Each set had one of each combination of telic/atelic and potentially intransitive/transitive-only. Telic vs. atelic verbs were selected on the basis of the homogeneity test. The sentences were presented with either a singular or bare plural object noun as in *The orderly arrested the patient in 6 minutes* and *The orderly arrested patients in 6 minutes.*

The materials were presented in booklets. Participants read instructions that illustrated acceptable vs. unacceptable sentences. They were asked to circle "a" if sentence a was more acceptable than sentence b, and to circle "b" if sentence b was more acceptable. If the two sentences were both acceptable, they were to circle "both." If neither sentence was acceptable, they were to circle "neither."

The participants were 55 native English speaking undergraduates at Montclair State University. Some participated to fulfill a course requirement and some received a cash payment.

Results and Discussion. Table 3 shows the proportion of responses on the *in/for* forced choice test depending on telicity, sub-categorization, and specificity.

Analysis of the *in*-responses over the 16 sets of verbs indicates that participants prefer *in*-phrases when

- the verb is telic rather than atelic (.31 vs. .05), F (1, 15) = 28.3, $p < .001$, $MS_e = .074$.
- the verb is transitive-only rather than potentially intransitive (.24 vs. .13), F (1, 15) = 9.30, $p < .01$, $MS_e = .040$.
- the object noun is singular rather than bare plural (.24 vs. .12), F (1, 15) = 12.1, $p < .01$, $MS_e = .035$.

Table 3

Proportion of Preferred Sentences on Forced Choice In/For Acceptability Test for 64 Verbs Depending on Verb Telicity, Verb Argument Structure, and Object Specificity (N=55)

			Response on Forced Choice Test			
Verb	Argument	Object	Only	Only		
Telicity	Structure	Specificity	*In*	*For*	Both	Neither
Telic	PI	Singular	.27	.35	.18	.20
		Bare plural	.16	.46	.17	.21
	TO	Singular	.52	.20	.09	.18
		Bare Plural	.29	.28	.18	.25
	Singular Mean		.40	.28	.14	.19
	Overall Mean		.31	.32	.16	.21
Atelic	PI	Singular	.07	.68	.19	.05
		Bare Plural	.02	.66	.18	.14
	TO	Singular	.09	.68	.16	.07
		Bare Plural	.04	.74	.15	.08
	Singular Mean		.08	.68	.18	.06
	Overall Mean		.05	.69	.17	.09

Notes: PI = potentially intransitive TO = transitive-only

The proportion of *in*-responses depended on an interaction between telicity and sub-categorization, F (1, 15) = 7.66, $p < .05$, $MS_e = .030$; this interaction was due to a larger sub-categorization effect for telic verbs (the proportion of *in*-responses was larger for transitive-only verbs by .20) than for atelic verbs (the proportion of *in*-responses was larger for transitive-only verbs by .03). The proportion of *in*-responses also depended on an interaction between telicity and specificity, F (1, 15) = 7.98, $p < .01$, $MS_e = .018$; the proportion of *in*-responses was larger for singular object nouns when the verb was telic (.18) rather than atelic (.05). There were no other significant effects in the analysis of *in*-responses.

Analysis of the *for*-responses indicates that participants prefer *for*-phrases when the verb is atelic rather than telic (.69 vs. .32), F (1, 15) = 35.4, $p < .001$, $MS_e = .125$. There were no other significant effects in the analysis of *for*-responses.

Analysis of "both" responses showed no significant effects.

"Neither" responses were more frequent when the verb was telic rather than atelic (.21 vs. .08), F (1, 15) = 12.4, $p < .01$, $MS_e = .041$, and when the object was bare plural than when it was singular (.17 vs. .13), F (1, 15) = 4.52, $p = .05$, $MS_e = .013$. There were no other significant effects in the analysis of "neither" responses.

A separate analysis within the set of telic verbs showed no difference in preferences for *in*-phrases vs. *for*-phrases (.31 vs. .32), $F < 1$. There was an interaction between preferred preposition and sub-categorization, F (1, 15) = 12.2, $p < .01$, $MS_e = .080$, that was due to more *in*-responses for transitive-only verbs than for potentially intransitive verbs (.41 vs. .21) and more *for*-responses for potentially intransitive verbs than for transitive-only verbs (.40 vs. .24). There also was an interaction between preference for *in*- vs. *for*-phrases and object specificity, F (1, 15) = 11.5, $p < .01$, $MS_e = .059$, that was due to more *in*-responses for singular objects than

for bare plural objects (.40 vs. .22) and more *for*-responses for bare plural objects than for singular objects (.37 vs. .27).

A separate analysis within the set of atelic verbs showed a strong preference for *for*-phrases over *in*-phrases (.69 vs. .05), F (1, 15) = 152.7, $p < .001$, $MS_e = .085$. No other effects were significant.

The fact that *in*- vs. *for*-responses did not differ for telic verbs suggests that these verbs can take on a wide range of meanings, while atelic verbs are more consistently interpreted as referring to an unbounded event. This result does not support the claim from the verb class model, that atelic verbs are more flexible in their meaning and structure.

The surprising result on the *in/for* test was the relatively low proportion of preferences for *in*-phrases with telic verbs. We wondered if our verbs differed in this respect from the classic examples of telic predicates. To test this, we administered the *in/for* test with four telic and four atelic predicates from Vendler (1957), Dowty (1979), and Tenny (1994). The results appear in Table 4.

The results for the two sets in Tables 3 and 4 are similar, particularly when we compare *in/for* preferences in Table 3 and *in/for* preferences for singular object nouns in Table 4.

Table 4 suggests that *in*-responses are more frequent for telic verbs than for atelic verbs (.34 vs. .06) while *for*-responses are more frequent for atelic verbs than for telic verbs (.75 vs. .18). Separate analyses of the percentage of *in*-, *for*-, "both"-, and "neither"-responses showed that *in*-responses are more frequent with telic than with atelic verbs, F (1, 6) = 6.32, $p < .05$, $MS_e = 240$; that *for*-responses are more frequent with atelic verbs than with telic verbs, F (1, 6) = 35.1, $p < .001$, $MS_e = 185$, and that "both"-responses are more frequent with telic verbs than with atelic verbs, F (1, 6) = 6.93, $p < .05$, $MS_e = 191$. A separate analysis of telic verbs comparing the

Table 4

Proportion of Preferred Sentences on Forced Choice In/For Acceptability Test for 8 Classic Predicates (N=21)

	Response on Forced Choice Test			
Telicity	Only *In*	Only *For*	Both	Neither
Telic	.34	.18	.45	.04
Atelic	.06	.75	.19	.00

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frequency of choices of *in*- vs. *for*-phrases showed no effect of preposition, F (1, 6) = 1.11, p > .05, MS_e = 448.

We draw three conclusions from our *in/for* tests. First, our verbs behave similarly to those that are discussed in the literature on event structure. The two sets of telic vs. atelic verbs produce similar patterns of preferences. Second, the *in/for* test is not as definitive a measure of event structure as we had anticipated. As expected, atelic verbs show a large preference for *for*-phrases over *in*-phrases, while telic verbs show a weaker preference for *in*-phrases over *for*-phrases. Third, the behavior of atelic verbs on the *in/for* test is more rigid compared to that of telic verbs. Atelic verbs are more consistently associated with *for*-phrases, whereas telic verbs frequently are judged acceptable in either *in*- or *for*-phrases.

Argument Structure Frequency

We tested the hypothesis that direct objects are more likely to occur with telic verbs than with atelic verbs. Depending on how we define direct object, several predictions follow from the view that telic verbs require a direct object delimiter. We can rank these predictions from strongest to weakest:

- Telic verbs appear only in transitive sentences, which have an underlying direct object and an explicit direct object.
- If telic verbs appear in intransitive sentences, they will be null object verbs in which there is an implied object.
- If telic verbs appear in intransitive sentences, they will be unaccusative verbs in which the internal direct argument appears in subject position.
- Telic verbs will not appear as unergative verbs, in which there is no object at any level.

To test these predictions we analyzed sentences from the Collins Cobuild corpus (2004).

Method. We searched the Collins Cobuild corpus for four types of verbs: telic potentially intransitive, telic transitive-only, atelic potentially intransitive, and atelic transitive-only. There were 16 verbs of each type. Collins Cobuild provided a random selection of 40 sentences for each of our 64 verbs. We analyzed each of these 2,560 sentences to determine whether the verb appeared as transitive, null object, unaccusative, or unergative.

Results and Discussion. Table 5 shows the proportion of uses of verbs in various sentence types depending on verb telicity and verb sub-categorization. Table 5 shows that transitive uses tend to be more common for transitive-only verbs for both telic (.94 vs. .48) and atelic verbs (.78 vs. .54), whereas intransitive uses tend to be more common for potentially intransitive verbs than for transitive-only verbs (telic, .38 vs. .02; atelic, .29 vs. .11). Inspection of Table 5 shows that transitive uses are slightly more common for telic verbs (.71 vs. .66) than for atelic verbs. However, among the intransitive sentences, telic verbs are also used more often than atelic verbs in the “least” transitive unergative sentences, which do not have an explicit or implicit object at any level. We analyzed the differences in proportions of various sentence uses across 16 sets of verbs with verb telicity and verb sub-categorization as within item variables.

Table 5

Proportion of Transitive, Null Object, Unaccusative, and Unergative Uses in Collins Cobuild Corpus Depending on Verb Telicity and Verb Argument Structure

	Telic		Atelic	
Sentence Use	PI	TO	PI	TO
Transitive	.48	.94	.54	.78
Intransitive	.38	.02	.29	.11
Null Object	.05	.01	.14	.05
Unaccusative	.24	.00	.09	.00
Unergative	.08	.01	.05	.00

Notes: PI = potentially intransitive TO = transitive-only

Transitive uses were more common for transitive-only verbs than for potentially intransitive verbs (.86 vs. .51), F (1, 15) = 37.2, $p < .001$, MSe = .053. The transitive-only advantage was greater for telic verbs (.94 vs. .48) than for atelic verbs (.78 vs. .54), F (1, 15) = 6.70, $p < .05$, MSe = .029.

Overall, intransitive uses were more common for potentially intransitive verbs than for transitive-only verbs (.34 vs. .07), F(1, 15) = 29.4, $p < .001$, MSe = .039. The potentially intransitive advantage for intransitive uses was greater for telic verbs (.38 vs. .02) than for atelic verbs (.29 vs. .11), F (1, 15) = 5.97, , $p < .05$, MSe = .021.

Null object uses were more common

- for potentially intransitive verbs than for transitive-only verbs (.09 vs. .03), F (1, 15) = 4.82, $p < .001$, MSe = .012, and

- for atelic verbs than for telic verbs (.09 vs. .03), $F(1, 15) = 52.5$, $p < .001$, $MSe = .001$.

  Unaccusative uses were more common

- for potentially intransitive verbs than for transitive-only verbs (.17 vs. .002), $F(1, 15) = 14.6$, $p < .01$, $MSe = .029$, and
- marginally for telic verbs than for atelic verbs (.12 vs. .05), $F(1, 15) = 3.96$, $p = .065$, $MSe = .022$.

The potentially intransitive advantage for unaccusative uses tended to be greater for telic verbs (.24 vs. .003) than for atelic verbs (.09 vs. .000), $F(1, 15) = 3.54$, $p < .10$, $MSe = .022$.

Unergative uses were more common

- for potentially intransitive verbs than for transitive-only verbs (.07 vs. .007), $F(1, 15) = 8.68$, $p = .01$, $MSe = .006$, and
- marginally for telic verbs than for atelic verbs (.046 vs. .026), $F(1, 15) = 4.14$, $p = .06$, $MSe = .002$.

No other effects were significant for any of the four types of sentence use.

These results show an association between telicity and transitivity, but this association is neither perfect nor uniform. Note that if telic verbs required a direct object delimiter, we would expect telic verbs to appear only in transitive sentences. Table 5 shows that telic verbs were used intransitively (.38 uses for potentially intransitive verbs and .02 intransitive uses for transitive-only verbs).

Furthermore, if there were intransitive uses of telic verbs, we would expect these uses to be of the null object type, in which there is an implied object, or at least unaccusative, in which the internal direct argument occupies the subject position. The data in Table 5 show that null object uses were less common for telic verbs than for atelic verbs (.05 and .01 null object uses for telic

verbs vs. .14 and .05 null object uses for atelic verbs).

In addition, we would expect that telic verbs would not be used as unergative, in which there is no object at any level. Instead, unergative uses tended to be more common for telic verbs than for atelic verbs (.08 and .01 for telic verbs vs. .05 and .00 for atelic verbs). The corpus search revealed examples of telic unergative uses such as *Karen awakened at 6:00 so she could see the sunrise, Fred undressed and got into bed, Agnes reluctantly moved,* and *The pioneers settled in the desert.* Since these sentences pass the tests for both unergativity and telicity (Tables 1 and 2), they indicate that the association between telicity and transitivity is not perfect.

Acceptability of Intransitive Sentences

We tested the association between telicity and direct objects by collecting judgments about sentence acceptability. If telic verbs require a direct object delimiter, they will be more acceptable in transitive sentences than in intransitive sentences. In addition, in intransitive sentences telic verbs will be more acceptable in null object sentence frames than in unaccusative sentence frames.

Method. We conducted forced-choice acceptability studies to determine whether participants agree with our judgments about the use of telic vs. atelic verbs as intransitives. We presented a verb in two sentences that contained the same arguments as our experimental sentences (see Experiments 1-3). We asked participants to indicate which sentence was better. If the two sentences were equally acceptable or equally unacceptable, they were to indicate that instead. Within each pair of sentences, there was one sentence in a transitive frame and one in an intransitive frame. In one version of this test, the intransitive “null object frame” retained the subject of the transitive frame, and in another version the intransitive “unaccusative frame” used the transitive object as the intransitive subject. Table 6 shows examples of the materials in these

Table 6

Sample Materials for Acceptability of Null Object/Unaccusative Sentences

(1)	a. *The cartoonist sketched a scene.*	a	b	both	Neither
	b. *The cartoonist sketched.*				
(2)	a. *The cartoonist sketched a scene.*	a	b	both	Neither
	b. *A scene sketched.*				
(3)	a. *Bob scattered a team.*	a	b	both	Neither
	b. *Bob scattered.*				
(4)	a. *Bob scattered a team.*	a	b	both	Neither
	b. *A team scattered.*				
(5)	a. *The doctor healed a wound*.	a	b	both	Neither
	b. *The doctor healed.*				
(6)	a. *The doctor healed a wound.*	a	b	both	Neither
	b. *A wound healed.*				

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two tests. In the null object version participants saw odd-numbered pairs like those in Table 6, in the unaccusative version they saw even-numbered pairs.

Notice that for *sketched*, both sentences are acceptable in (1) of Table 6 but in (2) only the transitive sentence (a) is acceptable, suggesting that as an intransitive *sketched* is primarily a null object verb. But for *scattered*, both sentences are acceptable in (4) while in (3) only the transitive sentence (a) is acceptable, suggesting that as an intransitive *scattered* is primarily an unaccusative verb. For *healed*, both sentences are acceptable in (5) and (6), suggesting that as an intransitive *healed* may be used either as a null object verb or as an unaccusative verb.

If argument structure is derived from event structure, we expect that in the null object test choices of “both” will be more common for telic verbs than for atelic verbs. This is because null object sentences have an implied object, which a telic event must have to delimit the event, but an atelic event need not have since it does not require delimitation. Under the assumption that an implied object is a better delimiter than an underlying object that occupies surface subject position, we expect that in the unaccusative test, the advantage in choices of “both” for atelic verbs will be greater for null object than for unaccusative sentences. This is because unaccusative sentences have an underlying object but not a surface object, whereas null object sentences have an implicit surface object.

There were 63 native English speaking participants. Fifty-five took the null object test and eight took the unaccusative test.

There were 74 critical pairs and 42 filler pairs. Among the filler pairs were four pairs in which both sentences were acceptable and ten in which neither was acceptable. The materials were presented in booklets. Participants read instructions that illustrated acceptable vs. unacceptable sentences. They were asked to circle "a" if sentence a was more acceptable than sentence b, and to circle "b" if sentence b was more acceptable. If the two sentences were both acceptable, they were to circle “both.” If neither sentence was acceptable, they were to circle “neither.”

Results. Table 7 shows the proportion of responses on the acceptability test depending on the type of intransitive sentence. When the intransitive sentence fit the null object pattern, the proportion of choices of “both” transitive and intransitive sentences was larger for atelic verbs than for telic verbs (.44 vs. .31). When the intransitive sentence fit the unaccusative pattern, the proportion of choices of “both” sentences was larger for telic verbs than for atelic verbs (.39 vs.

Table 7

Proportion of Responses on Transitive vs. Intransitive Forced Choice Acceptability Test Depending on Verb Telicity, Verb Argument Structure, and Type of Intransitive

			Response on Forced Choice Test			
Type of Intransitive	Verb Telicity	Argument Structure	Only Transitive	Only Intransitive	Both	Neither
Null Object (N=55)	Telic	PI	.41	.02	.55	.01
		TO	.90	.01	.07	.01
		Mean	.66	.02	.31	.01
	Atelic	PI	.35	.05	.58	.01
		TO	.67	.02	.30	.01
		Mean	.51	.04	.44	.01
Unaccusative (N=8)	Telic	PI	.23	.06	.67	.05
		TO	.86	.02	.11	.02
		Mean	.55	.04	.39	.07
	Atelic	PI	.51	.12	.35	.02
		TO	.90	.02	.07	.02
		Mean	.71	.07	.21	.02

Notes: PI = potentially intransitive TO = transitive-only

.21).

Data from each of the two acceptability tests were analyzed with four separate analyses of variance using proportion of choices of transitive, intransitive, both, and neither as dependent

variables. In all analyses, the independent variables were verb telicity and verb sub-categorization.

Null Object Frames. When the intransitive form fit a null object frame, judgments that both transitive and intransitive sentences are equally acceptable were more common

- for potentially intransitive verbs than for transitive-only verbs (.57 vs. .19), F (1, 15) = 72.6, $p < .001$, $MS_e = .032$.
- for atelic verbs than for telic verbs (.44 vs. .31), F (1, 15) = 5.59, $p < .05$, $MS_e = .049$.

The advantage of potentially intransitive verbs in choices of both was larger for telic verbs (.55 vs. .07) than for atelic verbs (.58 vs. .30), F (1, 15) = 6.01, $p < .05$, $MS_e = .027$.

Judgments that only the transitive sentence is acceptable were more common

- for transitive-only verbs than for potentially intransitive verbs (.79 vs. .38), F(1, 15) = 77.0, $p < .001$, $MS_e = .034$.
- for telic verbs than with atelic verbs, (.66 vs. .51), F (1, 15) = 6.26, $p < .05$, $MS_e = .056$.

The advantage of transitive-only verbs in transitive frames was larger for telic verbs (.91 vs. .41) than for atelic verbs (.67 vs. .35), F(1, 15) = 5.18, $p < .05$, $MS_e = .024$.

No other differences were significant in the null object test.

Unaccusative Frames. When the intransitive form fit an unaccusative frame, judgments that both transitive and intransitive sentences are equally acceptable were more common

- for potentially intransitive verbs than for transitive-only verbs (.51 vs. .09), F (1, 15) = 35.0, $p < .001$, $MS_e = .082$.
- for telic verbs than for atelic verbs (.39 vs. .21), F(1, 15) = 6.08, $p < .05$, $MS_e = .085$.

The advantage of potentially intransitive verbs in choices of both was larger for telic verbs (.67 vs. .11) than for atelic verbs (. 35 vs. .07), F (1, 15) = 11.0, $p < .01$, $MS_e = .029$.

Judgments that only the transitive sentence is acceptable were more common

- for atelic verbs than for telic verbs (.71 vs. .55), F (1,15) = 4.14, p = .06, MS_e = .099, and
- for transitive-only verbs than for potentially intransitive verbs (.88 vs. .37), F (1, 15) = 48.2, p < .001, MS_e = .087.

The advantage of transitive-only verbs was larger for telic verbs (.86 vs. .23) than for atelic verbs (.90 vs. .51), F (1, 15) = 6.18, p < .05, MS_e = .038.

Judgments that only the intransitive sentence is acceptable were more common for potentially intransitive verbs than for transitive-only verbs (.09 vs. .02), F (1, 15) = 15.6, p < .001, MS_e = .052.

No other differences were significant in the unaccusative test.

Discussion. The results of these two acceptability tests show that null object sentences are more acceptable for atelic verbs than for telic verbs, while unaccusative sentences show the opposite pattern. These results are similar to those of the corpus study on argument structure frequency, which showed that atelic verbs appear more often in null object sentences while telic verbs appear more often in unaccusative sentences. Under the assumption that the object is more accessible in a null object sentence than in an unaccusative sentence, these results do not confirm the prediction that telic verbs require an object to delimit the event to which they refer.

Dictionary Meanings

The verb class model predicts that the range of meanings for telic verbs is smaller than that of atelic verbs. If meaning variability is smaller for telic verbs, they will have fewer meaning senses. We tested this hypothesis by counting the number of dictionary entries for telic vs. atelic verbs.

Method. We used the same set of 64 verbs as in the earlier off-line studies. For each verb we

Table 8

Mean Number of Meaning Senses Depending on Verb Telicity and Verb Argument Structure

	Verb Telicity	
Argument Structure	Telic	Atelic
Potentially intransitive	6.29	5.14
Transitive-only	4.13	5.07

---

counted the number of different meaning senses in the Random House Dictionary entry.

Results and Discussion. The mean number of senses appears in Table 8. Since the distributions were skewed, we used a $\log_{10}$ transformation of the number of senses. Telicity was unrelated to number of senses, F (1,15) < 1, but there was an interactionbetween verb telicity and argument structure, F (1, 15) = 5.57, MS_e = .0114, p < .05. This interaction appears to be due to the fact that for potentially intransitive verbs, the number of senses was greater for telic verbs than for atelic verbs (6.29 vs. 5.14), but for transitive-only verbs the number of senses was greater for atelic verbs than for telic verbs (5.07 vs. 4.13).

For transitive-only verbs the results support the prediction that meaning variability is smaller for telic verbs. For potentially-intransitive verbs, meaning variability is greater for telic verbs than for atelic verbs.

Shifts in Telicity

If telic verbs are more fixed in their meaning, they will be less likely to change their meaning within sentences. We tested this hypothesis by analyzing the telicity of sentences that contain one of our 64 verbs.

Method. We searched the Collins Cobuild corpus (2004) for our 64 verbs. The Collins

Cobuild corpus automatically produces for each verb a random selection of 40 sentences that contain the verb. We analyzed the event structure of the 40 sentences for each of our verbs.

Results and Discussion. Of the 2,722 sentences, 2,343 had the same event structure classification as the verbs they contained. The remaining 379 sentences, or 13.9%, had a different event structure. Figure 2 shows the distribution of sentences that differed from their verb in event structure, depending on our classification of verb telicity and sub-categorization. Figure 2 shows that the proportion of shifts in event structure from verb to sentence is greater for telic potentially intransitive verbs (.21) and for atelic transitive-only verbs (.20) than for telic transitive-only verbs (.13) and atelic potentially intransitive verbs (.12). Analysis of variance of the proportion of event structure switches with verb telicity and sub-categorization as within-item variables showed a significant interaction between verb telicity and sub-categorization, $F(1, 15) = 6.32$, $p < .05$, $MS_e = .011$.

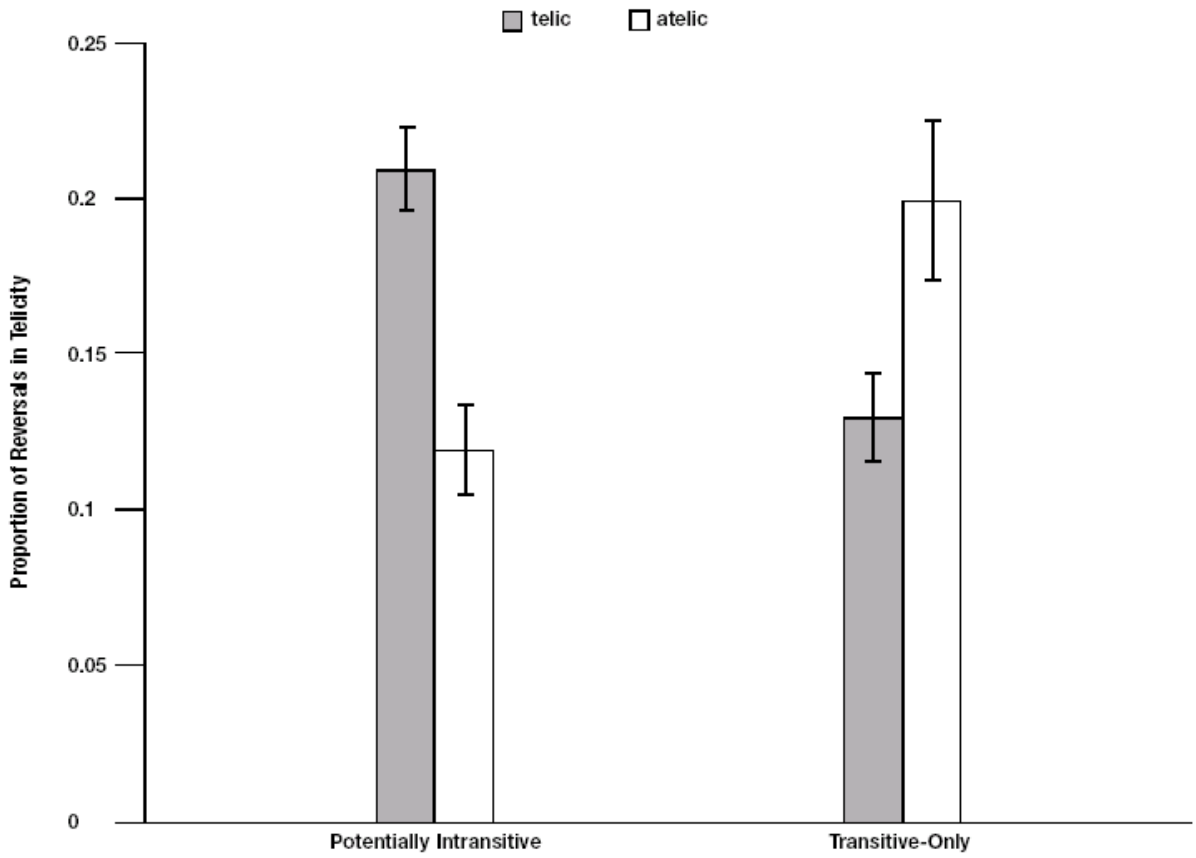

Figure 2. Proportion of Sentences that Differ in Verb and Sentence Telicity Depending on Argument Structure Preferences

These results suggest that event structure is not fixed by the verb, but rather is dependent on the context within the sentence. In addition, flexibility in event structure is related to argument structure. Atelic verbs that tend to occur with an object are more likely to appear in telic sentences. On the other hand, telic verbs that do not strongly require an object are more likely to appear in atelic sentences.

Conclusion

The *in/for* acceptability study shows that the meaning of telic verbs is more flexible than that of atelic verbs. Corpus analysis and acceptability judgments show that null object intransitives are common and more acceptable for atelic verbs than for telic verbs, whereas unaccusative

intransitives are more common and more acceptable for telic verbs than for atelic verbs. In addition, unergative intransitives tend to be more common for telic verbs than for atelic verbs. Our sample of verbs shows that telic potentially intransitive verbs have the greatest number of dictionary senses and shifts in telicity between the verb and the sentence, whereas telic transitive-only verbs have the fewest number of dictionary senses and shifts in telicity between the verb and the sentence. These results seem to favor linguistic approaches to event structure in which properties of the verb combine extensively with structural and semantic properties of phrases within the sentence.

We will now examine the implications of linguistic theories of event structure for sentence comprehension. We first will review major approaches to comprehension, and then use theories of linguistic representation to develop some hypotheses about sentence processing.

Three Theories of Comprehension

In this section we examine three major theories of comprehension: the garden path model, the constraint-based model, and the situation model.

The Garden Path Model. Structural models of sentence comprehension maintain that comprehenders obtain sentence meaning by first building a syntactic structure. The *garden path model* proposes that the parser initially adopts the one interpretation that corresponds to the simplest syntactic structure (Frazier, 1987; Frazier & Clifton, 1996). When the parser recognizes a word, it determines the lexical category of the word. This lexical category elicits one set of syntactic rules for each interpretation that is possible up to that point. The structure that requires application of the fewest number of rules becomes available soonest. For example, encountering the verb in Bever's (1970) classic sentence *The horse raced …*, the parser selects the structure in which the verb is expanded as verb plus prepositional phrase:

((The horse)$_{NP}$ ((raced)$_{V}$ (…)$_{PP}$)$_{I'}$)$_{IP}$

rather than a structure in which it is expanded as a reduced relative clause that modifies the initial noun:

(((The horse)$_{NP}$ ((raced)$_{V}$)$_{CP}$)$_{NP}$ (…)$_{I'}$)$_{IP}$

The garden path theory makes two basic assumptions about the process of combining words into phrases. First, processing resources are limited. This limitation means that the parser attempts to minimize complexity in order to preserve resources. Second, to generate candidate structures for a sentence, the parser uses only lexical category information, such as whether a word is a noun, verb, or adjective. Thus, the garden path theory proposes that, as each word is received, the parser selects the structure that integrates the word into the previous structure with minimal structure change. Because of limitations on processing resources, only the analysis that becomes available first is maintained. The first available analysis is the “minimal attachment" structure. Other analyses that are possible but not preferred are called “non-minimal attachment." In cases in which the first available analysis ultimately does not prove to be correct, there is a garden path, and the parser must perform relatively costly reanalysis.

Basic evidence for initial computation of only the simpler, minimal attachment structure comes from the existence of garden-path sentences (Frazier & Rayner, 1982), such as

29. *The horse raced past the barn fell.*

This sentence is difficult because the active structure for *the horse raced past the barn* is initially adopted as soon as *raced* is received. At the point of receiving *raced*, the only X’ rule needed is

VP → V’ + (NP) + (PP)

When *fell* is processed, it is apparent that *raced past the barn* is a relative clause reduced from

30. *The horse that was raced past the barn fell.*

The reduced relative structure requires more elaborate X' structure compared to the active structure, and so is not initially followed:

N' → N' + CP

This type of sentence is called an MC/RR garden path because the initial structural assignment of the verb incorrectly places it in a main clause rather than in a reduced relative clause.

According to the garden path model, semantic and syntactic properties of verbs, such as event structure and argument structure, have no immediate effect on the strength of the garden path. However, since structural models maintain that the meaning of a sentence depends on its phrases, the garden path theory aligns more naturally with derivational models of event structure such as the predicate-driven model.

The Constraint-based Model. The *constraint-based model* (Boland, 1997; MacDonald et al., 1994; Trueswell, Tanenhaus, & Garnsey, 1994) proposes that comprehenders use a variety of types of information to obtain an immediate interpretation that is as complete as possible. Various types of information influence the strength of an interpretation according to their relevance. Furthermore, much of syntactic ambiguity depends on the ambiguity of words.

MacDonald et al. (1994) illustrate the formation of syntactic structure from lexical information with the sequence

31. *John cooked.*

MacDonald et al. (1994) assume a distributed representation of lexical information, so that a lexical item is "activated" when the units that correspond to its properties are activated. Reading the word *John* activates the semantic features associated with "John," including the fact that "John" is animate, human, male, and so on. It also activates the lexical category information associated with John, including the fact that it is a noun and appears in a noun phrase. The

various thematic roles in which *John* can appear are activated, and since “John” is animate, the AGENT role is strongly activated. Other factors, such as how frequently *John* appears in different roles, discourse constraints, and so on, will influence the activation of the thematic role.

When *cooked* is read, information about its meaning, lexical category (V), voice (active/passive), argument structures (one NP as internal direct argument/one NP as external argument and one as internal direct argument), and possible thematic structures (AGENT / PATIENT / AGENT,PATIENT) are activated. In each case, the level of activation of alternative interpretations is related to their frequency of use. If we assume that *John* most frequently appears with an <AGENT, PATIENT> thematic structure, the corresponding argument structure, providing syntactic slots for an AGENT and a PATIENT, will be activated most strongly. When the most strongly activated structures for *John* and *cooked* correspond, as in this case, they are linked, and *John* is assigned the AGENT role, with the PATIENT role needing to be filled. This example illustrates how syntactic structure emerges from lexical information.

Table 9 summarizes some of the factors that may influence the strength of the garden path in sentences with a reduced relative clause. These factors include verb form, argument structure, frequency of passive use, unergativity, post-verbal cues, animacy, conceptual fit, initial noun specificity, referential context, and tense. According to constraint-based models, the parser weighs all possible interpretations according to the strength with which various factors support each interpretation. As the parser receives more information, the strength of competing interpretations changes until one interpretation acquires a clear advantage in strength.

Constraint-based models fit naturally with lexical approaches to event structure: If event structure is represented in verbs, then comprehenders will use it immediately to arrive at an interpretation.

The Situation Model. A third major theory of comprehension focuses on processing at the text and discourse level. Zwaan (1999) proposes that comprehension involves constructing a mental representation of what a text is about, i.e., a *situation model*. Situation models are representations of the people, objects, locations, events and actions that are described in a text. According to this approach comprehenders assume that events appear in narratives in their chronological order as a continuous flow with nothing left out, just as in the world.

Zwaan (1999) reports three kinds of evidence that support the view that temporal information is a part of the discourse-level representation of text. First, language allows speakers to deviate from chronological order. If comprehenders construct a situation model that includes the temporal sequence of events, it should be harder to process (33a) compared to (33b):

32. a. *Before the psychologist submitted the manuscript, the journal changed its policy*

b. *After the psychologist submitted the manuscript, the journal changed its policy.*

ERP evidence supports this prediction (Munte, Schiltz, & Kutas 1998), as do several kinds of behavioral evidence (e.g., Clark & Clark, 1968; Townsend, 1983; Townsend 1997). Second, in real life events follow each other without pause or transition, but in narratives events can have temporal discontinuities. Since these temporal gaps differ from everyday experience, time shifts should disrupt the comprehension process. Zwaan (1996) found that reading times for sentences with *a few days later* are longer than for sentences that do not introduce a time shift. Third, comprehenders access more readily recent events compared to events that happened a while ago. Zwaan (1996) reports that probe recognition times for *enter* are slower in (34a) than in (34b):

33. a. *An hour ago John entered the building*

b. *A moment ago John entered the building.*

Madden & Zwaan (2003) note that comprehenders represent an event in the perfective aspect as

Table 9

Factors that May Influence the MC/RR Garden Path

Factor	Study
Argument structure	MacDonald, 1994; Pritchett, 1992; Townsend & Bever, 2001
Frequency of passive use	Trueswell, 1996
Unergativity	Stevenson & Merlo, 1997
Post-verbal cues	MacDonald, 1994; Clarke, Townsend, & Bever, 2000
Animacy/Agenthood	Ferriera & Clifton, 1986; Filip, Tanenhaus, Carlson, Allopenna, & Blatt, 1997; MacDonald, 1994; Trueswell, Tanenhaus, & Garnsey, 1994
Conceptual fit	McRae, Spivey-Knowlton, & Tanenhaus, 1998; Pearlmuter & MacDonald, 1992; Tabossi, Spivey-Knowlton, McRae, & Tanenhaus, 1994; Trueswell, Tanenhaus, & Garnsey, 1994
Initial noun specificity	Crain & Steedman, 1985; Sanz, 2000
Referential context	Crain & Steedman, 1985; Ferreira & Clifton, 1986; Britt, Perfetti, Garrod, & Rayner, 1992; Murray & Liversedge, 1994; Spivey, Trueswell, & Tanenhaus, 1993
Discourse/sentence tense	Trueswell & Tanenhaus, 1991

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having been completed, as in *John entered the building*. This representation foregrounds the event and its completion. On the other hand, imperfective aspect, as in *John was entering the building,* foregrounds the agent and his/her efforts to accomplish the task. The representation of

an event in the imperfective, however, concerns the event in progress. In this case, the emphasis is on information about the internal structure of the event and the agent's progress at intermediate states. Studies have shown that several thematic roles (location, agent, and instrument) are more available when events are described in the imperfective rather than the perfective (Carreiras, Carriedo, Alonso, & Fernandez, 1997; Madden & Zwaan, 2003; Magliano & Schleich, 2000). Thus, the imperfective acts as a cue for constructing an event representation that foregrounds the location, agent, and instrument of the ongoing event. On the other hand, the perfective aspect directs the reader to construct an event representation that foregrounds the resultant state of the completed event. Magliano & Schleich (2000) assessed the role of grammatical aspect (whether the verb is perfective (*-ed)* or imperfective (*was …-ing*)) in discourse comprehension. They found that comprehenders interpret events described with imperfective aspect as ongoing in narrative time whereas they interpret events described with perfective aspect as completed.

Since the situation model makes no assumption about how event structure is represented at lower levels such as words and sentences, it is consistent with either the garden path model or the constraint-based model. We can summarize the situation model of event structure in terms of the discourse integration hypothesis: If sentences that present events with a definite temporal boundary move a narrative forward in time, processing will be easier for telic events than for atelic events.

Implications for Sentence Processing

Lexical and derivational models of the representation of event structure make different predictions about the point at which information about event structure comes into play. In this research we examine when comprehenders access information about telicity. Lexical views

predict that comprehenders access telicity immediately upon recognizing the verb, whereas derivational views suggest that such access is tenuous at best. However, derivational views of the representation of event structure, as well as situation models of text comprehension, predict that comprehenders access information about telicity in terms of the entire predicate or sentence. We address these issues by conducting single word self-paced reading studies of ambiguous sentences and probe recognition studies of text comprehension.

If comprehenders access lexical information about event structure immediately, this information will influence the extent to which they experience a garden path. We test this notion with garden path sentences such as *The woman healed at the clinic rejoined the demonstration*, in which readers often misinterpret *healed* as the main verb with *woman* as its subject. The correct analysis is that *woman* is the direct object of *healed*, which is part of the reduced relative clause *healed at the clinic*. The broader question is what kind of lexical information comprehenders use to form their initial representation of structure. In particular, do they correctly assign *woman* to the role of internal direct argument more readily when the initial verb is telic (*healed*) rather than atelic (*assisted*)? This prediction follows from lexical representation of event structure, and it is consistent with constraint-based models, but not with the garden path model. On the other hand, constraint-based models predict that the parser uses argument structure preferences immediately; hence, garden paths will be greater for verbs that may be used transitively or intransitively (e.g., *healed*), compared to verbs that are only used transitively (e.g., *identified*). The prediction from the garden path theory is that the parser uses only lexical category information, and so garden paths will not vary depending on differences in the properties of verbs.

Constraint-based models predict that the parser may also use specificity of the initial noun

phrase immediately to guide assignment of the delimiter role (Sanz, 2000). Therefore, garden path effects should be smaller for specific initial nouns and telic initial verbs. If comprehenders use event structure later during comprehension when they integrate sentence meaning into a mental model, verb telicity and object specificity should have effects at that point.

Table 10 summarizes the predictions of the various approaches to the representation of event structure. Levin & Rappaport's verb class model maintains that the event structure templates of verbs are easier to modify for atelic verbs than for telic verbs. Since the meaning and structure of atelic verbs is less fixed, end of clause processing times will be greater for atelic verbs than for telic verbs. We refer to this prediction as the *template augmentation hypothesis*.

The *delimiter search hypothesis* follows from lexical representation of event structure. It also predicts that the garden path effect is smaller for telic verbs than for atelic verbs. However, it attributes differences in garden path effects to the requirement of telic verbs that there be something to delimit the event (O'Bryan et al., 2002, 2003, 2004; Sanz, 2000). Thus, as soon as

Table 10

Summary of Processing Hypotheses Derived from Models of the Representation of Event Structure

Lexical Model

1. *Template augmentation hypothesis:* Telic verbs constrain syntax more than atelic verbs → End-of-clause processing times are greater for atelic verbs than for telic verbs.
2. *Delimiter search hypothesis:* Recognition of a telic verb initiates search for a delimiter, and therefore facilitates assignment of an NP to internal direct object →
   A constraint-based implementation predicts that the garden path is smaller for telic verbs.
3. *Specificity constraint hypothesis:* A telic sentence cannot have a non-specific object phrase →
   A constraint-based implementation predicts that the garden path is smallest for the combination of specific initial noun phrase plus telic verb.
4. *Preposition constraint hypothesis:* The preposition *by* is a strong cue that the verb is a passive participle →
   A constraint-based implementation predicts that the garden path is smallest for the combination of telic verb plus *by*.

Derivational Model

Derived event structure hypothesis: Event structure depends on specificity of the object NP →
Processing is faster for sentences when the verb is telic and the object is specific.

Situation Model

Discourse integration hypothesis: Telic events move a narrative forward in time →
Processing is faster for telic than for atelic sentences.

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the verb is recognized as telic, the parser searches for a delimiter, and finds it in the initial noun. Since the delimiter is the direct object, and this is the correct structural assignment for an initial noun phrase that is modified by an embedded relative clause, garden path effects will be smaller for telic verbs than for atelic verbs.

Further predictions follow from the delimiter search hypothesis. The *specificity constraint hypothesis* maintains that specific objects can delimit events but non-specific objects cannot. This hypothesis predicts that the garden path is smaller for telic verbs with specific initial nouns.

The *preposition constraint hypothesis* maintains that *by* is a strong cue that the verb is a passive participle in a reduced relative clause rather than a past tense in a main clause. This hypothesis leads to the prediction that the garden path is smaller when *by* follows a telic verb.

Borer's predicate-driven model maintains that verbs specify the number of arguments they require, but they do not specify event roles, thematic roles, or type of argument. A constraint-based implementation of this model predicts no effect of verb in immediate processing. Since event structure depends on properties of the predicate, including the specificity of the object, it does predict a late effect of object specificity. This is the *derived event structure hypothesis.*

Zwaan's situation model maintains that comprehenders construct a mental model of the situation that a text describes. Since this mental model organizes events in chronological order, events that advance time will be integrated into the mental model more readily. This leads to the prediction that processing times at the end of a sentence will be faster for telic events than for atelic events (the discourse integration hypothesis). Since object specificity influences sentence telicity, the telicity effect will be limited to sentences with a specific object (the derived event structure hypothesis).

We tested these hypotheses in three experiments.

Experiment 1

In their review of the comprehension of garden path sentences, Townsend and Bever (2001) differentiated verbs in terms of whether they are *agent-seeking* or *patient-seeking*. Agent-seeking verbs minimally require an agent, whereas patient-seeking verbs minimally require a patient. If the initial verb in a sentence with an embedded reduced relative clause were patient-seeking, the garden path would be relatively small because the patient-seeking property of the verb would lead comprehenders to assign the initial noun to the role of patient of the verb rather than the more common agent role.

Following Townsend & Bever (2001), Bever, Sanz, and Townsend (1998), and Sanz (2000), O'Bryan et al. (2002, 2003, 2004) developed the notion of patient-seeking verbs in the context of event structure. They proposed that comprehenders use verb telicity to assign NPs to the role of direct object. Their reasoning was that since a telic verb requires a delimiter for the event it denotes, comprehenders fill this event role with any noun that is available. Since this assignment is correct in the case of sentences with a reduced relative, the garden path effect should be smaller for telic verbs than for atelic verbs.

To test the delimiter search hypothesis, O'Bryan et al. (2002, 2003, 2004) re-analyzed data from two studies (McRae, Spivey-Knowlton, & Tanenhaus, 1998; Tabossi, Spivey-Knowlton, McRae, & Tanenhaus, 1994) that examined the processing of sentences with reduced relative clauses by classifying the verbs as telic vs. atelic. The materials in McRae et al. and Tabossi et al. contained the preposition *by* immediately after the verb, and in both studies two-word self paced reading times were recorded. O'Bryan et al. reported that the garden path effects were smaller on the frame containing the verb + *by* when the verb was telic rather than atelic. The argument structure effect fell short of significant (cf., MacDonald, 1994). O'Bryan et al. (2004)

assert that comprehenders have immediate access to verb telicity and use it to assign the initial NP in a reduced relative sentence the role of object of the verb.

Examination of the procedures in O'Bryan et al. (2002, 2003, 2004) raises questions about their classification of the verbs and their analysis of the materials. First, O'Bryan et al. reported that there were 71 items across the two studies. However, 23 of the items were identical in the McRae et al. and Tabossi et al. studies, so that O'Bryan et al. actually analyzed data from 48 different items. This fact causes difficulties in interpreting the statistical analyses: the data from some items are counted twice (e.g., *fired*), while the data from other items are counted only once (e.g., *graded*). To see why counting some items more than others creates interpretative problems, suppose that verb telicity has no effect at all, so that as a group telic and atelic verbs actually have exactly the same effect on resolving ambiguity. If so, randomly selecting telic vs. atelic verbs usually will produce a set of verbs in which half of both telic and atelic subsets shows a smaller than average garden path effect. But suppose we counted data from some verbs twice and the telic verbs that we counted twice happen to produce a relatively small garden path effect. In this case, the estimate of the garden path effect for telic verbs will not accurately assess the true garden path effect for the entire set of telic verbs. Thus, it is difficult to assess the validity of the statistically significant difference between telic and atelic verbs that O'Bryan et al. report. Because of this problem of verb selection, we cannot be confident that we will be able to replicate the results (unless we use exactly the same set of verbs and count twice the same subset of verbs).

Second, as we have noted, the behavior of verbs is quite variable (e.g., Moens & Steedman, 1988; Pulman, 1997; Rappaport & Levin, 1998; Ritter & Rosen, 1998). Inspection of the verbs in O'Bryan et al. confirms this observation. Consider their classification of verbs into the telic

potentially intransitive group. They claim 6 different verbs in this group (*fired, graded, kicked, shot, selected,* and *visited*). Applying *in/for,* homogeneity, and intransitive acceptability tests, however, none of these verbs is clearly both telic and potentially intransitive (see Tables 1 and 2). Perhaps the clearest example of a telic potentially intransitive verb in their group is *fire* as in *the hunter fired the gun* and *the gun fired*. However, another sense of *fire* occurs in *the employer fired the worker*; this sense of *fire* is telic but it does not allow intransitive use, as shown by the unacceptable **the employer fired* and **the worker fired*. A further difficulty with the O'Bryan et al. classification of *fire* as telic potentially intransitive is that McRae et al. and Tabossi et al. used *fire* in sentences like *the employer fired by the owner was jobless for several months,* where it is telic transitive-only. Similar problems exist with *kick,* whose event structure depends at least on the context preceding the verb. In *The punter kicked the ball in 3 seconds, kicked* is a telic achievement that may appear as a null object intransitive (*The punter kicked on fourth down).* In *The bronco kicked the cowboy, kicked* is a transitive telic achievement, but in *The bronco kicked for 3 seconds* it is an atelic (unergative) activity. The variability in the uses of these verbs suggested that it would be useful to conduct a careful investigation of the role of verb telicity in assigning structure during sentence comprehension.

We conducted a self-paced reading task with sentences like *The woman healed at the clinic rejoined the demonstration* to test the delimiter search hypothesis. This hypothesis states that comprehenders use verb telicity as a cue to assign a noun phrase as delimiter. This hypothesis predicts that garden path effects in reduced relative clauses will be smaller when the initial verb is telic rather than atelic (O'Bryan et al., 2002, 2003, 2004).

We also tested a corollary of the delimiter search hypothesis. The specificity constraint hypothesis states that comprehenders use verb telicity in combination with noun phrase

specificity to assign the role of delimiter. This hypothesis predicts that garden path effects with an initial telic verb will be smaller when the initial noun phrase is specific, since specific noun phrases are better delimiters (e.g., Verkuyl, 1989, 1993).

We also tested the *argument structure hypothesis*, which states that the frequency of verb uses as transitive vs. intransitive guides initial hypotheses about structure. This hypothesis predicts that garden path effects on the preposition *at* will be smaller when the initial verb is potentially intransitive rather than transitive-only. Since a potentially intransitive verb may be interpreted as intransitive, the word following the verb need not be part of a direct object noun phrase. For a transitive-only verb, however, the post-verbal word is generally part of a noun phrase (MacDonald, 1994; Townsend & Bever, 2001). However, the garden path effects on the main verb *rejoined* will be larger when the initial verb is potentially intransitive because the sequence of words up to the main verb constitutes a complete sentence if the initial verb is intransitive.

Participants read sentences in a one word self-paced reading task. The critical sentences contained a relative clause as in {*The woman/Women} {that was, 0} {healed/identified/assisted/ridiculed} at the clinic rejoined the demonstration.* Curly brackets indicate alternatives in experimental materials. The initial verb was either telic (*healed, identified*) or atelic (*assisted, ridiculed*) and either potentially intransitive (*healed, assisted*) or transitive-only (*identified, ridiculed).* The initial noun was either specific or non-specific (*The woman/Women).*

Method

Participants. The participants were 64 native English speaking college students at Montclair State University.

Materials. We used 16 sets of verbs. Within each set, there was one verb in each combination of verb telicity and verb argument structure. Pre-testing showed the following:

- Telic verbs produced a larger preference for *in*-phrases compared to atelic verbs, whereas atelic verbs produced a larger preference for *for*-phrases compared to telic verbs (see Off-Line Studies).
- In the corpus analysis, telic and atelic verbs did not differ in overall frequency of occurrence. Telic and atelic verbs did not differ in frequency of occurrence in the Collins corpus, F (1,15) < 1, MS_e = 27096. The mean frequency of occurrence for telic verbs in the 56 million word corpus was 111, and that for atelic verbs was 104, with standard errors of 38 and 21 respectively. Verb telicity and argument structure did not interact, F (1,15) < 1, MS_e = 23408.
- In the corpus analysis, transitive-only verbs appeared more frequently in transitive sentences compared to potentially intransitive verbs, whereas potentially intransitive verbs appeared more frequently in intransitive sentences compared to transitive-only verbs (see Off-Line Studies).
- In the corpus analysis, null object uses were more common for atelic verbs than for telic verbs, and both unaccusative and unergative uses were marginally more common for telic verbs than for atelic verbs (see Off-Line Studies).
- Acceptability judgments confirmed the classification of verbs into argument structure preferences (see Off-Line Studies).
- Telic and atelic verbs did not differ overall in number of dictionary meanings. However, for potentially intransitive verbs, the number of senses was greater for telic verbs than for atelic verbs, but for transitive-only verbs the number of senses was greater for atelic verbs than for telic verbs (see Off-Line Studies).

- In the corpus analysis, shifts between the telicity of the verb and the sentence in which it appeared did not differ overall for telic vs. atelic verbs. However, for potentially intransitive verbs these shifts were more common for telic verbs than for atelic verbs, whereas for transitive-only verbs aspectual shifts were more common for atelic verbs than for telic verbs (see Off-Line Studies).

For each set of verbs, we wrote a sentence with an embedded relative clause, using one of the verbs from the set. We chose initial noun phrases that could appear as singular or as bare plural. The preposition following the verb was never *by.*

The sets were arranged in a random order, and each set appeared with a different combination of variables across 16 lists. The lists contained 60 filler sentences that varied in structure.

Plausibility Pre-Test. Pre-testing showed that telic vs. atelic verbs did not differ in their plausibility in simple sentences that contained the same arguments of the verb. However, for potentially intransitive verbs, sentences with telic verbs were more plausible than sentences with atelic verbs; for transitive-only verbs, sentences with atelic verbs were more plausible than sentences with telic verbs.

We presented our verbs in either transitive or unaccusative frames, as in *Somebody healed the woman at the clinic* vs. *The woman healed at the clinic.* Except for *somebody*, the arguments were the same as those in our experimental sentences (see Experiments 1-3). College students (N=24) rated the plausibility of the sentence on a scale from 1 to 6, in which 1 = very implausible and 6 = very plausible. Table 11 shows the mean plausibility ratings (standard errors in parentheses). Telic and atelic verbs did not differ in plausibility, 3.89 vs. 4.11, $F < 1$. Verb telicity and argument structure interacted, F (1, 15) = 9.41, MS_e = .801, $p < .01$, indicating a

Table 11

Mean Plausibility Ratings Depending on Verb Telicity and Verb Argument Structure (standard errors in parentheses) (N=24)

	Verb Telicity	
Argument Structure	Telic	Atelic
Potentially intransitive	4.45 (.25)	4.19 (.20)
Transitive-only	3.33 (.16)	4.04 (.14)

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larger plausibility advantage for potentially intransitive verbs when the verb was telic (a difference of 1.12) rather than atelic (a difference of 0.15).

Procedure. Participants read the sentences one word at a time with the word centered on the screen. Comprehension questions about the content of the sentence followed 33 of the trials. The dmdx software controlled the experiment (Forster, 1999).

Design. The design was 2 (Relative Clause Structure: reduced/unreduced) x 2 (Verb Telicity: telic/atelic) x 2 (Argument Structure: potentially intransitive/transitive-only) x 2 (Object Specificity: singular/bare plural). All variables varied within participants and within items. Since one verb was used three times by mistake, the value of the degrees of freedom for the error term in item analyses was reduced by two.

Results

Reading times that were greater than two standard deviations from the cell mean were replaced with the value of the mean plus two standard deviations. These long response times occurred at a rate of 5.0%. Table 12 shows the mean word reading times depending on verb telicity, argument structure, and relative clause structure. Figures 3 and 4 show the garden path

Table 12

Mean Word Reading Times (ms) and Standard Errors depending on Verb Argument Structure, Verb Telicity, and Clause Structure in Experiment 1 (N=64)

	Argument Structure				Verb Telicity				Overall	
	PI		TO		Telic		Atelic			
	RT	SE	RT	SE	RT	SE	RT	SE	RT	SE
…Initial Verb:										
Reduced Relative	548	30	541	28	532	28	557	30	544	26
Unreduced Relative	620	41	565	39	585	38	601	41	593	37
Preposition (*at*):										
Reduced Relative	493	15	519	17	510	16	502	17	506	14
Unreduced Relative	494	19	458	14	471	17	482	17	476	15
Determiner (*the*):										
Reduced Relative	444	15	463	15	445	15	462	16	453	14
Unreduced Relative	439	17	437	19	427	16	449	19	438	15
Noun *(clinic)*:										
Reduced Relative	512	20	595	29	548	21	559	25	554	20
Unreduced Relative	587	27	550	26	559	26	578	27	568	24
Main Verb (*rejoined…*):										
Reduced Relative	697	42	732	49	661	45	767	51	714	42
Unreduced Relative	560	26	566	26	537	20	589	34	563	23

Notes: PI = potentially intransitive TO = transitive-only

RT = reading time SE = standard error

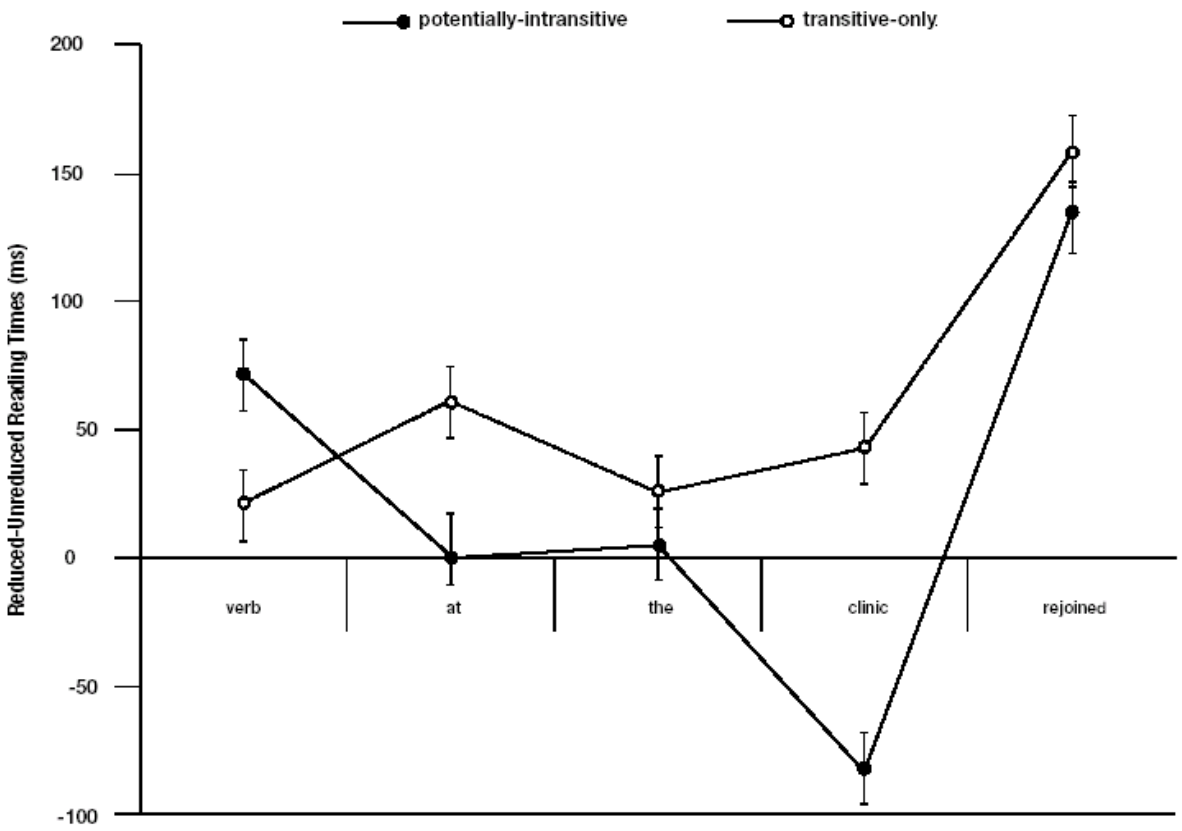

Figure 3. Garden Path Effects for Potentially Intransitive vs. Transitive-Only Verbs Depending on Word Position in Experiment 1.

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effects depending on verb telicity and argument structure.

Initial Verb. Transitive-only verbs were read more quickly than potentially intransitive verbs (551 vs. 590 ms), F_1 (1, 63) = 3.11, $p < .10$, MS_e = 54664, F_2 (1, 13) = 4.69, $p < .05$, MS_e = 21023. No other main effects or interactions were significant.

Preposition. The preposition was read more quickly in unreduced relative clauses than in reduced relative clauses (476 vs. 506 ms), F_1 (1, 63) = 6.57, $p < .05$, MS_e = 34571, F_2 (1, 13) = 8.48, $p < .05$, MS_e = 8699. This result demonstrates the general garden path effect.

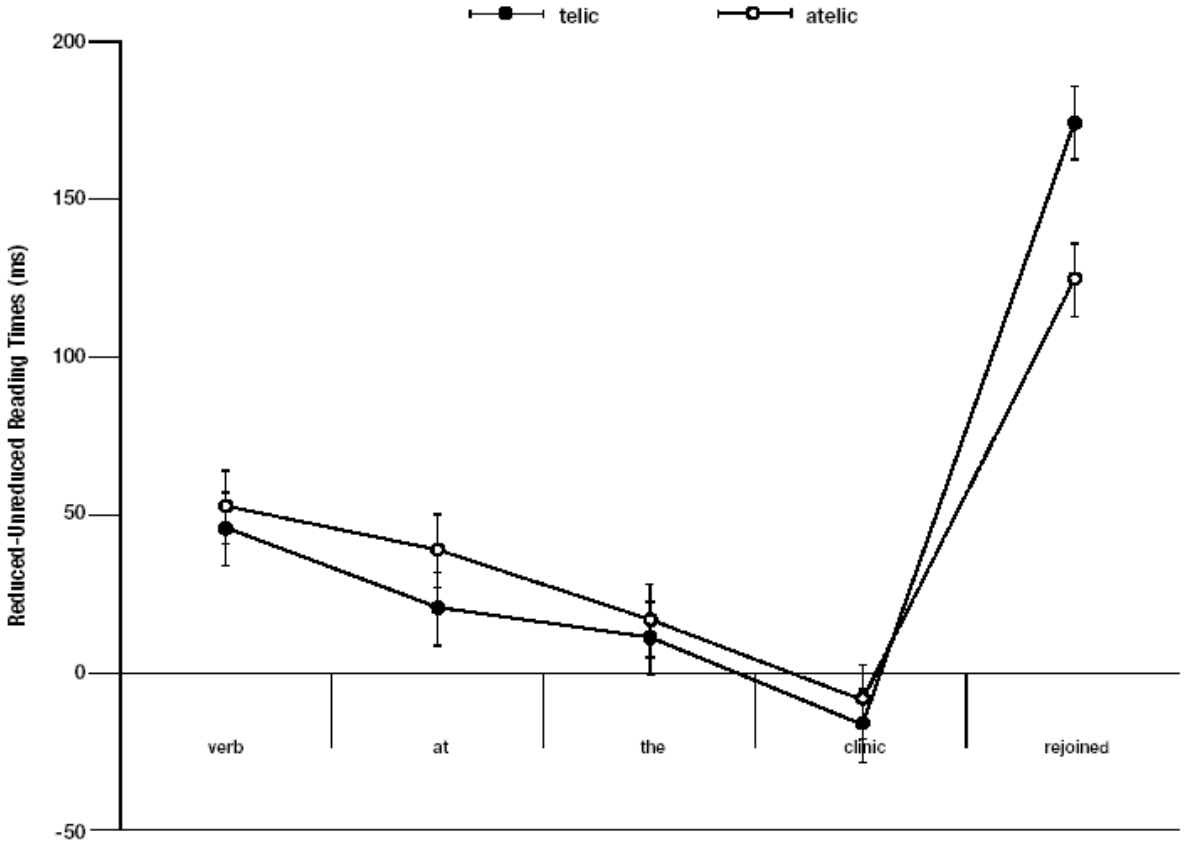

Figure 4. Garden Path Effects for Telic vs. Atelic Verbs Depending on Word Position in Experiment 1.

The effect of relative clause structure was larger for transitive-only verbs (61 ms advantage in unreduced relative clauses) than for potentially intransitive verbs (1 ms advantage in reduced relative clauses). The interaction between argument structure and relative clause structure was significant, F_1 (1, 63) = 8.20, $p < .01$, MS_e = 29630, F_2 (1, 13) = 7.50, MS_e = 14505, $p < .05$.

The interaction between telicity and relative clause structure was not significant, F_1 (1, 63) < 1, $p < .01$, MS_e = 34896, F_2 (1, 13) < 1, MS_e = 16422.

The only other significant effect on the preposition was the interaction between argument structure and object specificity, F (1, 63) = 4.29, $p < .05$, MS_e = 29793, F_2 (1, 13) = 2.07, $p > .05$,

MS_e = 20884.

Determiner. The interaction between telicity and relative clause structure was not significant, F_1 (1, 63) < 1, MS_e = 24272, F_2 (1, 13) < 1, MS_e = 16491.

The interaction between argument structure and relative clause structure was not significant, F_1 (1, 63) < 1, MS_e = 31958, F_2 (1, 13) < 1, MS_e = 18078.

The only significant effect on the determiner was that reading times were faster when the initial noun was a bare plural than when it was singular (429 vs. 462 ms), F (1, 63) = 10.9, p <.01, MS_e = 24667, F_2 (1, 13) = 7.36, p < .05, MS_e = 17917.

Noun. There was an interaction between argument structure and relative clause structure, F_1 (1, 63) = 8.19, p < .01, MS_e = 114760, F_2 (1, 13) = 5.59, p < .05, MS_e = 53218, and between argument structure, structure, and object specificity, F_1 (1, 63) = 5.19, p < .05, MS_e = 34122, F_2 (1, 13) = 3.56, p < .10, MS_e = 14203.

The main effect of telicity was not significant, F_1 (1, 63) < 1, MS_e = 68083, F_2 (1, 13) 1.10, p > .10, MS_e = 17333.

The interaction between telicity and relative clause structure was not significant, F_1 (1, 63) < 1, MS_e = 48121, F_2 (1, 13) < 1, MS_e = 17333.

No other effects were significant on the noun.

Main Verb. Main verb reading times were faster for unreduced relatives than for reduced relatives (563 vs. 714 ms), F_1 (1, 63) = 20.8, p < .001, MS_e = 280641, F_2 (1, 13) = 48.9, p < .001, MS_e = 39454, and faster for telic verbs than for atelic verbs (599 vs. 678 ms), F_1 (1, 63) = 10.7, p < .01, MS_e = 149653, F_2 (1, 13) = 5.72, p < .05, MS_e = 102222.

The interaction between telicity and relative clause structure was not significant, F_1 (1, 63) < 1, MS_e = 242715, F_2 (1, 13) = 1.54, p > .05, MS_e = 46831.

The interaction between argument structure and relative clause structure was not significant, F_1 (1, 63) < 1, MS_e = 113805, F_2 (1, 13) < 1, MS_e = 64909.

No other effects were significant.

Correlations. As a further test of the delimiter search hypothesis, we calculated the correlation between preferences for *in*- vs. *for*-phrases and the size of the garden path. For each verb we subtracted the percentage of judgments that a sentence sounds better with a *for*-phrase from the percentage of judgments that it sounds better with an *in*-phrase. This difference score provides an estimate of strength of a telic interpretation: a more positive difference score indicates a strong preference for a telic interpretation, whereas a more negative difference score indicates a strong preference for an atelic interpretation. For each verb we also estimated the strength of the garden path by subtracting reading times for unreduced relatives from reading times for reduced relatives. The reading time data included reading times for both specific and non-specific initial nouns. A more positive difference indicates a stronger garden path. The delimiter search hypothesis predicts a negative correlation between these two differences scores: as strength of a telic interpretation increases, the size of the garden path decreases.

Table 13 shows the correlations between *in/for* preference and size of the garden path at each of the underlined words in *The N Verb at the clinic rejoined the demonstration*. There was a significant correlation between size of the difference in preference for *in* vs. *for* preference on the initial verb and size of the garden path when the participant was reading the preposition, r = +.27, $p < .05$. This result indicates that as the strength of a telic interpretation increases, the garden path effect also increases. These results do not confirm the prediction that a telic interpretation decreases the garden path effect.

We can explain the positive correlations between preference for an *in* adverbial and the size

Table 13

Correlations between Linguistic Properties and Overall Garden Path Effects

	Word Position				
	..Verb	*at*	*the*	*clinic*	*rejoined..*
Measures of Transitivity (*identified, ridiculed*)					
Preference for transitive vs. null object	0.05	0.47**	0.29*	0.24	-0.35**
Preference for transitive vs. unaccusative	0.07	0.29*	-0.04	0.29*	-0.05
Frequency of transitive sentence in BNC	0	0.43**	0.11	0.29*	-0.24
Measures of Intransitivity (*healed, assisted*)					
Preference for both transitive and null object	-0.05	-0.47**	-0.29*	-0.22	0.32*
Preference for both transitive and unaccusative	-0.06	-0.23	0.06	-0.24	0
Frequency of null object sentence in BNC	0.14	-0.44**	-0.13	-0.03	0.24
Frequency of unaccusative sentence in BNC	-0.23	-0.24	-0.01	-0.43**	-0.01
Measures of Telicity (*healed, identified*)					
Preference for *in*-phrase over *for*-phrase	-0.01	0.24	0.26	0.22	-0.08
Difference between *in*- and *for*-phrase preference	0.01	0.27*	0.22	0.18	-0.18
Frequency of telic sentence in BNC	-0.05	0.15	0.1	0.04	-0.22
Measures of Atelicity (*assisted, ridiculed*)					
Preference for *for*-phrase over *in*-phrase	0.02	-0.31*	-0.15	-0.12	0.25
Other Measures					
Frequency of Initial Verb	-0.05	0.13	0.01	0.1	0.03
Number of Senses	-0.19	-0.25	-0.34**	-0.15	0.21

Notes: *$p < .05$ **$p < .01$

of the garden path in terms of the correlation between transitivity and telicity: The more telic a verb is, the more likely it is to be transitive. The correlation between transitive and *in*-preferences was $r = .35$, $p < .01$. The more likely a verb is to be used as transitive, the greater the expectation of a post-verbal object and the larger the garden path.

As a further test of the role of argument structure preferences in the garden path, we calculated the correlations between preferences for transitive vs. null object/unaccusative intransitive frames and the size of the garden path effect as measured by the difference in reading times for reduced vs. unreduced relatives. A positive correlation indicates that the garden path is stronger as the preference for using the initial verb in a particular sentence frame increases. A negative correlation indicates that the garden path effect is weaker as preference for a particular sentence frame increases. For preferences between transitive vs. both null object and unaccusative frames, these correlations are significant on the preposition, $r = .41$, $p < .01$ and $r = .29$, $p < .05$ respectively. Thus, the garden path effect becomes greater as preference for a transitive frame increases. Because of the expectation that a direct object follows the verb when it is highly transitive, reading times on the preposition are greater in reduced clauses.

Table 13 shows the correlation between the size of the garden path and the number of dictionary entries for each verb. As the number of dictionary entries increased, the size of the garden path became smaller for words within the relative clause. This correlation was significant on the determiner, $r = -.34$, $p < .01$. This result suggests that within the relative clause, comprehenders entertain more possible structures when the verb is more polysemous. Consequently, evidence that suggests that there is a reduced relative clause does not disrupt reading times.

Regression Analysis. We conducted multiple regressions to predict the size of garden path

effects from several verb properties. As two measures of preference for usage in transitive sentences, we used as predictors the percentage of preferences of the transitive form in the null object and the unaccusative forced choice acceptability tests. As measures of telicity, we used as predictors the difference in percentage of preferences for *in* vs. *for* temporal adjuncts and percentage of British National Corpus sentences that are telic. As a measure of verb strength, we used as a predictor the number of dictionary senses for the verb. We used stepwise regression with $p < .05$ to enter a variable and $p > .10$ to remove a variable. The only significant predictors were as follows:

- On the preposition, preference for the transitive form on the null object test, $R = .46$, $p < .001$;
- On the determiner, number of dictionary senses, $R = .29$, $p < .05$;
- On the noun, preference for the transitive on the unaccusative test, $R = .29$, $p < .05$;
- On the main verb, preference for the transitive form on the null object test, $R = .36$, $p < .01$.

The properties that predict the garden path were preferences for transitive usage and number of dictionary senses; measures of verb telicity were unrelated to the garden path.

Discussion

Experiment 1 confirmed the general finding that reduced relative clauses lead to increased reading times (see Table 9). Experiment 1 extends this finding to show that the range of structures and meanings that a verb has influences the size of the garden path effect. However, verb telicity does not influence the garden path.

The argument structure hypothesis stated that the frequency with which a verb is used as transitive vs. intransitive influences the initial hypothesis about sentence structure. Experiment 1 showed that garden path effects on the preposition were limited to cases in which the initial verb

is only used transitively. This result confirms MacDonald (1994) and follows from the view that after a transitive-only verb, comprehenders anticipate a direct object noun phrase. Since a preposition is inconsistent with a direct object noun phrase, reading times for reduced relative sentences increase compared to reading times for unreduced relatives. Correlation analysis confirmed that as the preference for transitive usage of a verb increases, the greater the garden path effect on the preposition. These results confirm the argument structure hypothesis.

The delimiter search hypothesis stated that, since a telic verb "seeks" an object that can delimit the event it refers to, the garden path effect will be smaller for telic verbs than for atelic verbs. Experiment 1 showed that verb telicity was unrelated to the size of the garden path effect. Correlation analysis showed that the strength of a telic interpretation for a verb was related to *larger* garden path effects, rather than to smaller effects as predicted by the delimiter search hypothesis. These results do not confirm the delimiter search hypothesis.

The specificity constraint hypothesis stated that comprehenders use cues to the specificity of the initial noun phrase in combination with verb telicity to assign objects. The results showed that noun specificity did not influence the size of the garden path by itself or in combination with verb telicity. These results do not confirm the specificity constraint hypothesis.

The template augmentation hypothesis stated that atelic verbs are less constrained in the syntactic structures in which they can appear, compared to telic verbs. This hypothesis leads to the prediction that atelic verbs require relatively more processing at the end of the clause, and so will show longer reading times at the end of the clause. The results, however, showed no difference in self-paced reading times for the final word of the embedded clause, failing to support the template augmentation hypothesis. The results did show that the size of the garden path was related to number of dictionary senses for the initial verb. As the number of senses

increased, the size of the garden path within the relative clause decreased. Thus, comprehenders are sensitive to patterns of usage, and when a verb is used in a variety of contexts, comprehenders appear to be less committed to any single interpretation.

Experiment 2

It is possible that verb telicity is a weak cue to structure whose effect on the garden path may appear only when combined with cues other than noun specificity. The preposition *by* is strong cue that the verb is a transitive. *By* may signal a locative phrase, as in *The hiker rested by the river*, but more often it is used to introduce the AGENT in a passive, as in *The cowboy was kicked by the bronco*. To determine whether verb telicity might influence the garden path when other strong cues to structure are available, we conducted a self-paced reading experiment in which we varied the preposition that follows the verb.

We tested the delimiter search hypothesis, which states that comprehenders use verb telicity as a cue to assign a noun phrase as PATIENT/delimiter/direct object. This hypothesis predicts that garden path effects will be smaller in sentences with a reduced relative clause when the initial verb is telic rather than atelic (O'Bryan et al., 2002, 2003, 2004).

We also tested the preposition constraint hypothesis, which states that comprehenders use the preposition *by* to determine that the initial verb is a passive participle rather than a past tense. This hypothesis predicts that garden path effects will be smaller in reduced relative sentences when the preposition is *by*. If verb telicity reduces the garden path in combination with other information that supports a reduced relative structure, garden path effects will be smaller when the verb is telic and the preposition is *by*.

We tested again the argument structure hypothesis, which states that comprehenders use frequency of use information to assign a noun phrase as direct object. This hypothesis predicts

that garden path effects will be smaller in reduced relative sentences when the initial verb is transitive-only rather than potentially intransitive (MacDonald, 1994).

Participants read sentences in a one word self-paced reading task. The critical sentences contained a relative clause as in *The woman {that was, 0} {healed/identified/assisted/ridiculed} {by/at} the clinic rejoined the demonstration.* Curly brackets indicate alternatives in experimental materials. The initial verb was either telic (*healed, identified*) or atelic (*assisted, ridiculed*) and either 'potentially intransitive' (*healed, assisted*) or 'transitive-only' (*identified, ridiculed).* The preposition was either *by* or some other preposition (e.g., *by/at)*. We collected single word reading times using the Dmdx software (Forster, 1999).

Method

Participants. The participants were 32 native English speaking college students at Montclair State University.

Materials. We used 16 sets of four verbs from the same pool as those in Experiment 1. We replaced 13 of the 64 verbs in Experiment 1 so that the four categories defined by telicity and sub-categorization were more sharply defined. Sentences were written in the same way as in Experiment 1 except that Preposition replaced Object Specificity as a variable. The initial noun phrase was always in the singular. The preposition was either *by* or some other preposition. The sets were arranged in a random order, and each set appeared with a different combination of variables across 16 lists. The lists contained 60 filler sentences that varied in structure.

Procedure. Participants read the sentences one word at a time in a moving window paradigm. Comprehension questions about the content of the sentence followed 33 of the trials.

Design. The design was 2 (Relative Clause Structure: reduced/unreduced) x 2 (Verb Telicity: telic/atelic) x 2 (Argument Structure: potentially intransitive/transitive-only) x 2 (Preposition:

by/other preposition). All variables varied within participants and within items.

Results

The mean word reading times depending on verb telicity, argument structure, and relative clause structure appear in Table 14. Response times in a cell that were two standard deviations greater than the mean for the cell were replaced with the mean plus two standard deviations. The percentage of long response times replaced was 5.3% ranging from 0-9% within cells. Analysis of variance of response times treated participants as a random variable.

Initial Verb. There was an interaction between preposition and relative clause structure, F_1 (1, 31) = 3.78, $p < .10$, MS_e = 2086921, F_2 (1, 15) = 5.91, $p < .05$, MS_e = 323230. There were no other significant main or interaction effects.

Preposition. The interaction between telicity and relative clause structure was not significant, F_1 (1, 31) < 1, MS_e = 17329, F_2 (1, 15) < 1, MS_e = 11288.

There was a significant four-way interaction between telicity, argument structure, preposition, and relative clause structure, F_1 (1, 31) = 7.10, $p < .05$, MS_e = 634874, F_2 (1, 15) = 3.93, $p < .10$, MS_e = 18493. Figure 5 displays this interaction. For the combination of telic verb and "other" preposition, reduction effects appeared greater for transitive-only verbs than for potentially intransitive verbs (107 vs. -43). For the combination of telic verb and *by*, however, reduction effects appeared greater for potentially intransitive verbs than for transitive-only verbs (54 vs. -74). Atelic verbs showed no apparent reduction effects (potentially intransitive: -13 with *by*, -24 with other preposition; transitive only: 12 with *by*, 9 with other preposition).

There was a significant effect three-way interaction between telicity, argument structure, and preposition, F_1 (1, 31) = 5.72, $p < .05$, MS_e = 610098, F_2 (1, 15) = 2.53, $p > .10$, MS_e = 22292.

No other effects were significant on the preposition.

Table 14

Mean Word Reading Times (ms) and Standard Errors depending on Verb Argument Structure, Verb Telicity, and Clause Structure in Experiment 2 (N=64)

	Argument Structure				Verb Telicity				Overall	
	PI		TO		Telic		Atelic			
The Preposition By	RT	SE	RT	SE	RT	SE	RT	SE	RT	SE
…Initial Verb:										
Reduced Relative	478	34	498	30	477	29	499	34	488	29
Unreduced Relative	546	48	570	42	547	44	569	44	558	38
Preposition (*by*):										
Reduced Relative	477	28	467	27	490	30	454	25	472	24
Unreduced Relative	456	21	498	38	500	35	455	25	477	25
Determiner (*the*):										
Reduced Relative	439	27	425	15	425	20	440	23	432	19
Unreduced Relative	423	19	422	22	414	16	431	23	422	17
Noun *(clinic)*:										
Reduced Relative	515	32	553	40	514	34	555	44	534	31
Unreduced Relative	560	32	579	41	535	25	604	45	569	31
Main Verb (*rejoined…*):										
Reduced Relative	660	57	600	43	641	46	620	54	630	39
Unreduced Relative	615	47	698	57	634	51	679	57	657	45

Table 14 (continued)

	Argument Structure				Verb Telicity				Overall	
	PI		TO		Telic		Atelic			
"Other" Preposition	RT	SE	RT	SE	RT	SE	RT	SE	RT	SE
…Initial Verb:										
Reduced Relative	523	39	524	40	538	42	509	37	523	34
Unreduced Relative	504	38	505	38	505	36	504	37	504	33
Preposition (*at*):										
Reduced Relative	441	18	495	26	471	22	466	23	468	20
Unreduced Relative	475	34	437	15	439	16	473	33	456	21
Determiner (*the*):										
Reduced Relative	396	13	438	22	407	15	426	20	417	14
Unreduced Relative	422	21	408	19	400	16	429	24	415	17
Noun (*clinic*):										
Reduced Relative	500	25	518	36	487	27	531	33	509	28
Unreduced Relative	538	32	535	27	534	29	539	28	536	25
Main Verb (*rejoined*…):										
Reduced Relative	635	48	579	44	642	44	571	49	606	37
Unreduced Relative	528	24	518	31	520	24	527	26	523	22

Notes: PI = potentially intransitive TO = transitive-only

RT = reading time SE = standard error

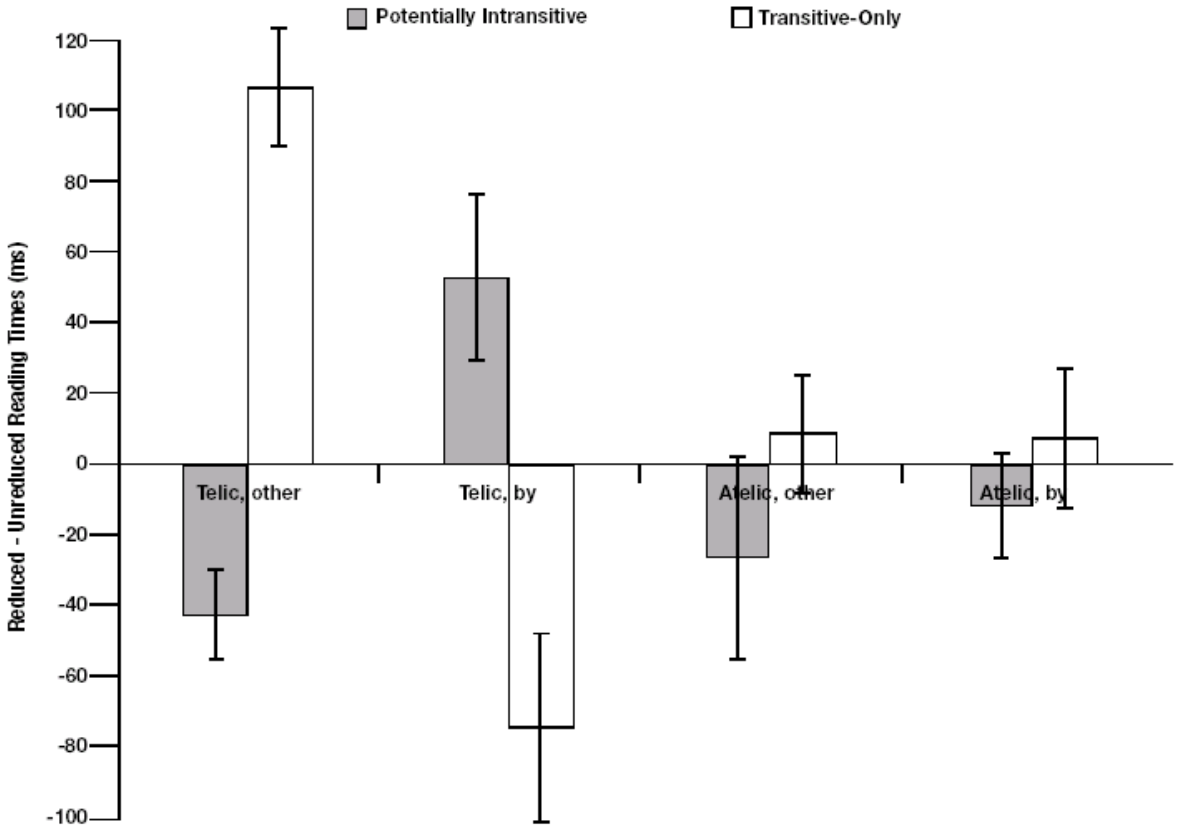

Figure 5. Garden Path Effects on the Preposition Depending on Verb Telicity, Argument Structure, and Preposition in Experiment 2

Determiner. The interaction between telicity and relative clause structure was not significant, F_1 (1, 31) < 1, MS_e = 15289, F_2 (1, 15) = < 1, MS_e = 11300.

Reading times were faster when the initial verb was telic rather than atelic (412 vs. 432 ms), F_1 (1, 31) = 4.94, $p < .05$, MS_e = 314749, F_2 (1, 15) = 2.72, $p > .10$, MS_e = 138459.

No other effects were significant on the determiner.

Noun. The interaction between telicity and relative clause structure was not significant, F_1 (1, 31) < 1, MS_e = 25020, F_2 (1, 15) = < 1, MS_e = 20834.

Reading times were faster when the initial verb was telic rather than atelic (518 vs. 557 ms),

F_1 (1, 31) = 5.05, $p < .05$, MS_e = 36196, F_2 (1, 15) = 7.17, $p < .05$, MS_e = 99599.

Reading times were faster in reduced relative clauses than in unreduced relative clauses (522 vs. 553 ms), F_1 (1, 31) = 4.56, $p < .05$, MS_e = 27642, F_2 (1, 15) = 1.55, $p > .10$, MS_e = 40602.

Reading times were faster for "other" prepositions than for *by* (523 vs. 552 ms), F_1 (1, 31) = 3.16, $p < .10$, MS_e = 34070, F_2 (1, 15) = 5.17, $p < .05$, MS_e = 156284.

No other effects were significant on the noun.

Main Verb. The interaction between telicity and relative clause structure was not significant, F_1 (1, 31) = 2.59, MS_e = 1964198, p > .10, F_2 (1, 15) = 1.65, p > .10, MS_e = 49881.

For the first word of the main verb phrase, reading times were faster for "other" prepositions than for *by* (565 vs. 643 ms), F_1 (1, 31) = 8.33, $p < .01$, MS_e = 2928328, F_2 (1, 15) = 10.7, $p < .01$, MS_e = 36630.

The four-way interaction between telicity, argument structure, preposition, and relative clause structure was significant, F_1 (1, 31) = 10.3, $p < .01$, MS_e = 44622, F_2 (1, 15) = 3.21, $p < .10$, MS_e = 71292. Figure 6 displays this interaction. For telic verbs, reduction effects appeared to be greater for "other" prepositions than for *by* (175 ms for potentially intransitive verb with "other" preposition, 70 ms for transitive-only verb and "other" preposition" vs. -12 ms for potentially intransitive verb and *by*, 24 ms for transitive-only verb and *by*). For atelic verbs with *by*, the reduction effect was greater for potentially intransitive verbs than for transitive-only verbs (102 vs. -220 ms). For atelic verbs with "other" prepositions, the reduction effects were similar for potentially intransitive and transitive-only verbs (37 and 51 ms respectively).

No other effects were significant.

Main Verb Phrase, Word 2. We analyzed response times for the word following the main verb to check on the possibility of delayed effects of verb telicity. The interaction between

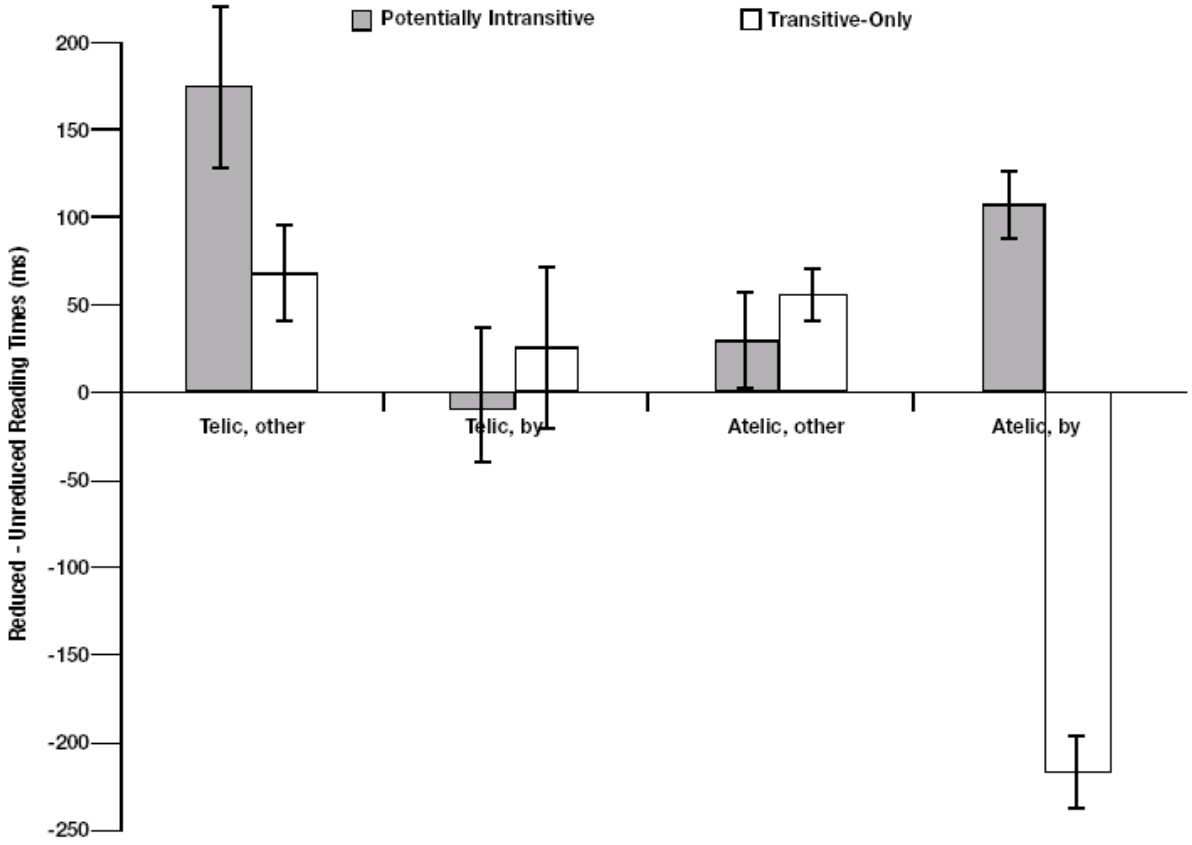

Figure 6. Garden Path Effects on the Main Verb Depending on Verb Telicity, Argument Structure, and Preposition in Experiment 2

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telicity and relative clause structure was not significant, F_1 (1, 31) < 1, MS_e = 57689, F_2 (1, 15) < 1, MS_e = 47465.

Reading times were faster for unreduced relative clauses than for reduced relative clauses (554 vs. 623 ms), F_1 (1, 31) = 10.0, p < .01, MS_e = 60666, F_2 (1, 15) = 5.37, p < .05, MS_e = 56484.

There was an interaction between telicity and argument structure, F_1 (1, 31) = 4.07, p < .10, MS_e = 103938, F_2 (1, 15) = 16.5, p < .001, MS_e = 192803.

No other effects were significant.

Discussion

The results do not support the delimiter search hypothesis, that verb telicity reduces the garden path, or the preposition constraint hypothesis, that *by* combined with a telic verb reduces the garden path. Instead, they suggest that both argument structure and preposition mediate the effect of verb telicity on the garden path. On the preposition, the only significant effect involving telicity and relative clause structure was the four-way interaction with argument structure and preposition. In no combination of the variables was there a sizable garden path effect on the preposition for atelic verbs. In addition, the garden path effects on the preposition for telic verbs depend on the type of preposition and argument structure preferences. For potentially intransitive verbs a garden path effect occurred with *by* (54 ms), but for transitive-only verbs a garden path effect occurred with prepositions other than *by* (107 ms). Thus, for telic verbs, argument structure preferences and preposition influence the size of the garden path. When a telic verb is potentially intransitive, comprehenders are surprised when the preposition is *by*. When a telic verb is transitive-only, comprehenders are surprised only when the preposition is not *by.*

While these results do not support the view that a lexical category of verb telicity influences immediate processing, the class of telic verbs does have an immediate indirect effect on processing via argument structure. One interpretation of the results is that the relevant processing factors are not verb telicity but rather, verb strength and argument structure preferences. Verbs that are more flexible in their meaning and structure are less susceptible to an immediate garden path.

In contrast to Experiment 1, there was support for the template augmentation hypothesis. On the final word of the embedded clause, reading times overall were faster when the initial verb was telic rather than atelic. This result is consistent with the view that atelic verbs are more

flexible in their meaning and structure.

Experiment 3

Do comprehenders integrate inherently bounded events more readily into a conceptual representation of discourse? Experiment 3 examined the role of event structure in discourse comprehension. We used a probe recognition task in which participants read a story one sentence at a time until a probe appeared. The participants' task was to indicate whether the probe is consistent with what they had read before. We measured the time between the onset of the probe and the participant's response. We assumed that rapid response times indicate that comprehenders access the target easily. A sample story follows (Magliano & Schleich, 2000):

The tornado struck the school with little warning.

It was destroyed.

The firemen didn't think there would be many survivors.

Suddenly, one of the men heard voices in the wreckage.

The firemen rescued a survivor.

<T1> (Target Probe: RESCUE SURVIVOR)

Many of the bystanders helped.

Some people brought food.

They were all anxious for the children.

<T2> (Target Probe: RESCUE SURVIVOR)

When the firemen got to the kids, they found them safe in the basement of the school.

A probe such as RESCUE SURVIVOR appeared every 2-4 sentences. The critical test points were immediately after the target sentence (<T1>) vs. three sentences later (<T2>). Our materials used 16 sentences that differed in preference for *in*- vs. *for*-temporal phrases. The independent

variables were verb telicity (telic/atelic), object specificity (*a survivor*/*survivors*), viewpoint (*did*/*was doing*), and probe location (immediate/3 sentences later). If comprehenders use inherently bounded events as "anchors" around which to integrate the content of a story, response times will be faster for telic sentences than for atelic sentences.

We tested the discourse integration hypothesis, which states that comprehenders use the event structure of a sentence to integrate its meaning into a discourse-level representation. This hypothesis predicts that comprehenders will respond more quickly to probes following a sentence with a telic rather than an atelic verb. We also tested the derived event structure hypothesis, which states that sentence telicity depends on both verb telicity and arguments that appear in the sentence. This hypothesis predicts that probe recognition times will be faster when the verb is telic and the direct object is specific. However, object specificity will have no effect on probe recognition times when the verb is atelic.

Method

Participants. The participants were 50 native-English speaking college students at Montclair State University.

Materials. The materials were 16 stories from Magliano & Schleich (2000). The predicates from eighteen of Magliano & Schleich's target sentences were presented to 27 undergraduate students in the *in/for* forced choice acceptability test using procedures that appear in the Appendix. Eight predicates that showed a preference for *in*-phrases were used as telic verbs; eight that showed a preference for *for*-phrases were used as atelic verbs.

Pre-Test. The predicates from eighteen of Magliano & Schleich's target sentences were presented to 27 undergraduate students in the *in/for* forced choice acceptability test. Based on the results of the acceptability test, we selected sixteen of these predicates. The set of 16 selected

predicates showed the pattern of preferences that appear in Table 15.

Statistical analysis of the acceptability data show that telic and atelic predicates differed on the *in/for* test. The percentage of *in*-responses was greater when the predicate is atelic rather than telic (.42 vs. .12), F (1, 13) = 57.8, $p < .001$, $MS_e = 123.6$, and when the object is singular rather than bare plural (.42 vs. .12), F (1, 13) = 116.3, $p < .001$, $MS_e = 63.0$. The effect of object specificity on frequency of preferences for *in*-phrases appeared to be greater for telic predicates than for atelic predicates. When the predicate was telic, the proportion of preferences for *in*-phrases was .44 greater for singular objects than for bare plural objects, but when the predicate was atelic, this difference was .13. The interaction between telicity and object specificity was significant, F (1, 13) = 39.5, $p < .001$, $MS_e = 63.0$.

Analysis of the *for*-responses indicates that *for*-phrases are preferred when the predicate is

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Table 15

Proportion of Preferred Sentences on Forced Choice In/For Acceptability Test Depending on Telicity and Object Specificity in Probe Recognition Study (N=27)

		Response on Forced Choice Test			
Telicity	Specificity	Only *In*	Only *For*	Both	Neither
Telic	Singular	.66	.03	.26	.05
	Bare plural	.18	.28	.37	.17
	Mean	.42	.16	.32	.11
Atelic	Singular	.19	.27	.54	.01
	Bare Plural	.06	.56	.33	.04
	Mean	.13	.42	.44	.03

atelic rather than telic (.42 vs. .16), F (1, 13) = 16.3, $p < .01$, $MS_e = 330.6$, and when the object was bare plural rather than singular (.42 vs. .15), F (1, 13) = 43.3, $p < .001$, $MS_e = 135.5$. There were no other significant effects in the analysis of *for*-responses.

Analysis of "both" responses indicates that choices of both *in*- and *for*-phrases were more frequent when the predicate is atelic rather than telic (.43 vs. .32), F (1, 13) = 5.81, $p < .05$, $MS_e = 196.3$. The effect of telicity on choices of both *in*- and *for*-phrases was greater for singular objects than for bare plural objects. When the object was singular, the proportion of choices of both was .28 greater for atelic predicates than for telic predicates, but when the object was bare plural, choices of both was .04 greater for telic predicates than for atelic predicates. The interaction between telicity and object specificity was significant, F (1, 13) = 9.21, $p < .01$, $MS_e = 217.1$. There were no other significant effects in the analysis of "both" responses.

"Neither" responses were more frequent when the predicate was telic rather than atelic (.11 vs. .03), F (1, 13) = 8.15, $p < .05$, $MS_e = 64.8$, and when the object was bare plural than when it was singular (.11 vs. .03), F (1, 13) = 7.61, $p < .05$, $MS_e = 63.1$. There were no other significant effects in the analysis of "neither" responses.

Design. The design was 2 (telicity of predicate: telic/atelic) x 2 (perfectivity: perfective/imperfective) x 2 (object specificity: singular/bare plural) x 2 (target position: immediate/3 sentences later). All variables varied within participants. Telicity of the predicate varied between stories, while the other three variables varied within stories. Since one verb was used twice by mistake, the value of the degrees of freedom for the error term in item analyses was reduced by one.

Procedure. Participants read sixteen stories one sentence at a time on a computer screen. For each story, the participant was periodically probed as to whether a specific phrase (untensed verb

plus unmarked noun) had appeared in the story. Each story contained a target probe that appeared either immediately after the aspect sentence or after the third post-aspect sentence. Each story contained 2-4 filler probe trials to provide balance between positive and negative trials. For each probe presented to the participant, he/she pressed one key to indicate a "yes" response (that the phrase did appear in the story) or another key to indicate a "no" response (that the phrase did not appear in the story). Dmdx recorded the participant's response times for each probe (Forster, 1999).

Results

The overall error rate on probe recognition was 13.6%. The percentage of errors was smaller for atelic verbs than for telic verbs (.088 vs. .18), F (1, 49) = 16.6, $p < .001$, smaller for specific object noun phrases than for non-specific object noun phrases (.098 vs. .17), F (1, 49) = 11.0, $p < .01$, and smaller for probes immediately after the target than for probes three sentences later (.095 vs. .18), F (1, 49) = 8.0, $p < .01$. There was an interaction between verb telicity and object specificity such that errors were more frequent for telic verbs, particularly when the object was specific, F (1, 49) = 4.78, $p < .05$. The basis of the interaction is that specificity appeared to have a larger effect when the verb was telic rather than atelic (telic: .25 for specific, .12 for non-specific; atelic: .10 for specific, .08 for non-specific).

Response times for incorrect responses were replaced with the mean response time for correct responses in the same cell, as were response times for trials that were two standard deviations greater than each participant's mean response time. Table 16 shows mean response times for correct probe recognition responses depending on telicity of predicate, object specificity, and probe position.

Analysis of adjusted response times showed that probe recognition times were faster for

sentences with telic rather than atelic predicates (1435 vs. 1569 ms), F_1 (1, 49) = 13.6, MS_e = 270728, $p < .001$, F_2 (1, 13) = 1.32, MS_e = 575799, $p > .10$.

There was an interaction between verb telicity, object specificity, and probe position, F_1 (1, 49) = 4.3, MS_e = 180388, $p < .05$, F_2 (1, 14 = 3.60, MS_e = 131777, $p < .10$. Immediately after the target sentence, response times for telic predicates were faster with specific object noun phrases than with non-specific object noun phrases (1242 vs. 1385 ms). Three sentences after the target sentence, response times were faster for telic predicates regardless of object specificity (1661 and 1446 ms for telic predicates vs. 1734 and 1747 ms for atelic predicates).

The only other significant effects were probe position, F_1 (1, 49) = 50.8, MS_e = 334371, $p < .001$, F_2 (1, 13) = 14.9, MS_e = 184281, $p > .01$; the interaction between object specificity and probe position, F_1 (1, 49) = 11.1, MS_e = 244346, $p < .01$, F_2 (1, 13) = 12.7, MS_e = 36599, $p < .01$;

Table 16

Mean Probe Recognition Times (ms) depending on Probe Location, Telicity, and Object Specificity (Standard Errors are in parentheses) (N=50)

	Telicity	
	Telic	Atelic
Immediate Probe:		
Singular	1242 (50)	1338 (65)
Bare Plural	1385 (67)	1458 (79)
Probe 3 Sentences Later:		
Singular	1661 (66)	1734 (73)
Bare Plural	1446 (61)	1747 (90)

and the interaction between verb telicity, object specificity, perfectivity, and probe position, F_1 (1, 49) = 5.12, MS_e = 226776, $p < .05$, F_2 (1, 13) = 4.14, MS_e = 45404, $p = .061$. Perfectivity did not have an independent effect, both Fs < 1.

Discussion

The fact that probe recognition times are faster when the predicate is telic rather than atelic supports the discourse integration hypothesis. This hypothesis states that the event structure of a sentence influences its integration into a discourse representation. The fact that this effect is limited to sentences that contained a telic predicate and a specific direct object supports the derived event structure hypothesis. This hypothesis maintains that event structure is derived from properties of the entire sentence, including the verb and object phrase.

The error data on the probe recognition task suggest that telic events are relatively inaccessible, perhaps because comprehenders have integrated the content of the sentence into a conceptual representation of discourse. The response time data, however, suggest the opposite: telic events are accessed faster than atelic events. This pattern of results indicates a speed-accuracy tradeoff: When participants favored accuracy their response times were slow, but when they favored speed their errors increased.

The fact that probe recognition times are faster for telic predicates than for atelic predicates differs from the results of Experiments 1 and 2, in which verb telicity had no effect on the garden path. One might suppose that the failure to find an effect of verb telicity on the garden path occurs because the *in/for* difference between telic and atelic predicates is smaller for the materials in Experiments 1 and 2 than in Experiment 3. However, correlations between the size of the *in/for* difference and the size of the garden path in Experiment 1 are positive. Thus, increased verb telicity increases the size of the garden path. This suggests that we cannot

attribute the different effects of telicity in Experiments 1 and 2 vs. Experiment 3 to differences in materials. Instead, the differences appear to depend on the nature of the task. If we assume that single-word self-paced reading assesses on-line parsing processes and probe recognition assesses post-sentence integrative processes, the results suggest that telicity influences integrative processes but not parsing.

General Discussion

Comprehenders access verb strength and argument structure preferences early and event structure relatively late. In the processing of sentences with an embedded reduced relative clause, stronger verbs, which are more restricted in the range of meanings they have, produce a larger garden path. In contrast, weaker verbs, which are restricted in meaning and enter into a wider variety of syntactic frames (Ritter & Rosen, 1996), produce a smaller garden path.

Argument structure preferences also influence the size of the garden path (MacDonald, 1994). For telic verbs, argument structure preferences and post-verbal preposition jointly influence the size of the garden path. When *by* follows a telic potentially intransitive verb, garden path effects are large. This result suggests that a potentially intransitive telic verb leads to the expectation that there is no direct object. However, since the presence of *by* is a strong cue that the verb is a passive participle and therefore requires a direct object, the intransitive interpretation of the verb and the preposition *by* lead to conflicting structural expectations, producing an increase in reading time. In contrast, when a preposition other than *by* follows a telic transitive-only verb, garden paths are large. In the case of a transitive-only verb, the parser expects a direct object. A preposition other than *by* is a strong cue that there is no direct object.

There is support for the discourse integration and derived event structure hypotheses. The discourse integration hypothesis maintains that comprehenders use the event structure of a

sentence to organize sentences into a discourse-level representation, while the derived event structure hypothesis maintains that event structure depends on both verb meanings and the arguments that appear in the sentence. Supporting the discourse integration hypothesis, the probe recognition experiment shows that probe recognition times are faster when the verb is telic rather than atelic, particularly when the direct object contained a specific noun phrase. These results show that comprehenders determine the event structure of a sentence relatively late, and that they maintain telic sentences in a more accessible form in active memory, as predicted by situation models of comprehension. These results also suggest that derivational factors are important in the representation of event structure. The fact that verb telicity has an effect on probe recognition times suggests that verbs may be categorized, at least roughly, in terms of their preferred event structure.

Verb telicity, however, does not reduce the size of the garden path effect in sentences with a reduced relative clause. Instead, garden path effects generally are *larger* for telic than for atelic verbs. The lack of an immediate effect of verb telicity is consistent with derivational models of the linguistic representation of event structure, including Borer's predicate-driven model, which maintains that verbs do not project syntactic or aspectual structure, but rather, simply project the number of arguments they require. If event structure is represented in individual verbs and if comprehension involves constraint-based processing, verb telicity conceivably could be a useful immediate cue to structure. From a processing perspective the failure to find that telic verbs reduce the size of the garden path suggests one of the following: (a) the association between verb telicity and direct objects is not categorically correct, (b) constraint-based processing is incorrect, or (c) verb telicity is not a sufficiently strong cue to guide constraint-based processing. In any case, the results do not support the delimiter search hypothesis.

Even when there are additional cues that strengthen assignment of the initial noun to the role of DELIMITER, there is no support for the delimiter search hypothesis. Verb telicity does not interact with either object specificity or preposition to influence the size of the garden path. This result suggests that the parser is unable to take advantage of verb telicity even when there are supportive cues such as a specific initial noun phrase, which should be a good delimiter, or a preposition such as *by,* which should be a cue to a transitive argument structure. Both of these cues when combined with verb telicity could favor a reduced relative structure for sequences such as *The woman healed by…* The failure to find an interaction of verb telicity with object specificity, therefore, does not support the specificity constraint hypothesis, which states that comprehenders use object specificity as a cue to assign an NP to the event role of delimiter and the syntactic role of internal direct object. The absence of an interaction of verb telicity and preposition does not support the preposition constraint hypothesis, which states that the combination of the preposition *by* and a telic verb reduces the size of the garden path.

Processing Models

The major findings about processing are that argument structure and verb strength have an early effect on processing, while derivationally-based event structure has a late effect on processing. Let us refer to argument structure preferences as a "habit-based property," verb strength as a "lexical property," and event structure as a "derived property." Since the parser is able to retrieve rapidly lexical or habit-based properties, these factors have an immediate effect on processing. Since the parser must combine information from different lexical items and phrases to obtain event structure, this factor has a late effect on processing.

The two factors that influence the garden path both indicate that information other than lexical category influences immediate hypotheses about structure, contradicting the garden path

model. The garden path model maintains that the parser initially adopts the one structure that is syntactically simplest based on the lexical category of a word.

On the other hand, constraint-based models maintain that the parser uses any reliable information as soon as it becomes available to determine the most likely structure and meaning. These models emphasize lexical representation of grammatical information rather than an independent syntax (e.g., MacDonald et al., 1994).

Two results support constraint based processing over the garden path model. First, argument structure interacted with verb telicity and preposition to determine garden path effects, though not in the way predicted by the delimiter search or preposition constraint hypotheses. Second, the size of the garden path was related to verb strength: stronger verbs showed a larger garden path. The effects of verb strength on processing depend on argument structure preferences and verb telicity. In particular, the weakest verbs were potentially intransitive telic verbs, while the strongest were transitive-only telic verbs. Atelic verbs were of moderate strength, with no difference depending on argument structure preferences. While the present research has demonstrated that the lexical property of verb strength may set limits on the modifiability of meaning and the structural possibilities of verbs, further work is needed to isolate the principles that underlie differences in verb strength.

Situation models explain the late interaction between verb telicity and object specificity in the probe recognition task. Since discourse comprehension involves the construction of a model of the events and their temporal order, events that have a clear temporal boundary are highly focused immediately after the sentence. However, situations models do not address issues of lexical or syntactic processing.

Constraint-based models are able to account for more of the results than either garden path or

situation models. Constraint-based models can explain the late effects of sentence telicity by noting that the comprehension system develops as complete an interpretation as possible as information becomes available to it. Since sentence telicity depends on both verb meaning and other phrases in the sentence, its effects appear relatively late. Constraint-based models can explain the early effects of argument structure preferences and verb strength, and the late effects of event structure, entirely in terms of when the relevant information becomes available to the processor. According to these models there is no need to distinguish alternative sources of knowledge, such as "fixed" lexical representations vs. syntactic representations.

In contrast to constraint-based models, we could distinguish the early vs. late effects precisely in terms of whether they are due to memorized and rapidly-retrieved information vs. derived, rule-based information (Chi, Skoutelakis, Seegmiller, & Townsend, 2004; Townsend & Bever, 2001). Memorized information includes how frequently a particular verb has appeared with particular sentence frames. Derived information includes rules that govern how the meanings of words in different phrases modify interpretations (Pustejovsky, 1995) or that govern how words are combined into phrases (Borer, 1998). Since the domain over which these rules apply is the sentence, it is natural that event structure effects appear only at the end of the sentence. Thus, an alternative to constraint-based models is a *two-stage model* along the lines of Townsend & Bever (2001). The first stage is a constraint-based integration of easily accessed information that allows an initial hypothesis about meaning and structure. The second stage applies generative rules to this initial meaning to obtain a detailed syntactic/semantic representation. Once this derived representation is checked for accuracy against the input, it is integrated into a conceptual representation.

What distinguishes the two-stage model from the constraint-based model is that the two stage

model maintains that the most natural point to integrate meanings that depend on the combination of phrases in the sentence is at the end of the sentence. In contrast, the constraint-based model proposes that such integration occurs at the earliest point possible. The presence of object specificity effects after the sentence but not within the sentence to influence the garden path would appear to be evidence against the constraint-based model. However, constraint-based models explain the lack of such effects on the garden path by asserting that object specificity is simply a weak a cue to structure at that point.

Earlier studies demonstrate evidence for on-line effects of aspectual properties. However, these studies do not conclusively show that these effects occur within a clause. Object specificity influences reading times on a clause-final adverbial modifier, but it does not influence reading times prior to the clause-final phrase, as in *Even though Howard sent [a large check/large checks] to his daughter for many years…*(Todorova et al., 2000). Aspectual shift effects on lexical decision times appear 250 ms after the end of the clause, as in *The man kicked the little bundle of fur for a long time…*(Pinango et al., 1999). Aspectual type-shifting in *The secretary began the memo about the new office policy* occurs only in total reading times, not in first pass reading times, or on the next (post-boundary) word in self-paced reading (Traxler et al., 2002). The type-shifting effect on self-paced reading of the object does not differ from the effect of a non-preferred verb (de Almeida, 2004).

These studies and the present one demonstrate substantial evidence for a derived event structure. Is this derived event structure represented at the syntactic level or at the syntax/semantic interface?

The Locus of Telicity in a Linguistic Representation

If telicity were represented at the lexical level, modifications of telicity through syntactic

means would be limited. As we have noted, this does not appear to be the case. For example, the basic semantic category of *hop* is an achievement, but it takes on an iterative interpretation in *John hopped for several minutes* (Pinango et al., 1999). Similarly, the basic semantic category of *play* is an activity, but several phrases change its aspectual interpretation in *It took me two days to play the Minute Waltz in less than sixty seconds for more than an hour* (Moens & Steedman, 1988).

If telicity is syntactic, it will not be possible to modify its value through discourse context. This does not seem to be the case either, since the context outside the clause in *Walter hopped and he hopped and he hopped* changes the meaning of *hop* into an iterative activity. Hay, Kennedy, & Levin (1999) have noted that non-syntactic processes of conversational implicature play a role in determining telicity (see also Fodor & Lepore, 1998). They point out that sentences like *The soup cooled* are ambiguous in their telicity. Such a sentence is telic when there is a salient bound to the endpoint of the change of state, such as room temperature, as in *The soup cooled in an hour,* but a durative adverbial can cancel this conversational implicature and make the event atelic as in *The soup cooled for an hour.* This ambiguity arises when an endpoint can be inferred. These observations suggest that factors that are outside the syntax as well as outside the lexicon influence event structure (see Bever et al., 1998). These facts suggest that telicity is represented at the syntax/semantics interface, rather than in the syntax.

Comparing telicity with other linguistic phenomena that are uncontroversially located at one or the other level, that is, in the syntax or the semantics, also leads to the conclusion that telicity is represented at the level of the syntax/semantics interface.

The Syntactic Level. Tense is a syntactic category that also has semantic consequences. The evidence for the syntactic status of tense is that it plays a role in a variety of syntactic processes,

such as subject-verb agreement. In English, for example, only present-tense verbs show overt subject-verb agreement (*she runs* and *they run*), except that forms of *be* show number agreement in the past tense as well (*she is fast; they are fast; she was fast; they were fast*). It is generally assumed that tense is a functional category that is explicitly represented in the syntax of a sentence in the form of a category T(ense).

It is also obvious that tense has a semantic value in addition to its syntactic role. In English, for example, verbs in the past tense almost always denote events, states, etc., that occurred at a time before the time of their reporting. It is interesting to note, however, that so-called present-tense forms often do not refer to present time, as the following examples show:

34. *I leave for Paris next Thursday.* [future time]

35. *So I'm sitting on the subway this morning and this guy starts shouting at me.* [past time]

36. *Fred works at Pathmark.* [“general" time]

In the first two sentences, the context forces an interpretation other than the present-time one. The third sentence illustrates one of the most common uses of the present tense, to refer to "general" time, and to describe a sort of state rather than an action or an event. Note that the following sentence is not contradictory because the first clause does not refer to present time.

37. *Fred works at Pathmark, but today is his day off.*

Because the so-called present-tense forms are so frequently used to refer to something other than present time, many linguists prefer to call it the “non-past” form.

Thus tense is a syntactic category that also contributes, in a complex way, to the semantic interpretation of a sentence.

The Semantic Level. Causation is a semantic category, not a syntactic one. While there are clearly lexical items that include causative meaning inherently (e.g., verbs like *cause, make,* and

have, conjunctions like *because*), the usual case is that causation is an inference based on a sentential or discourse context. Consider the following example:

38. *Lucy kicked the television set and it started playing.*

There is nothing in either of the conjoined sentences in (39) that expresses causative meaning, nor is the conjunction *and* one that inherently means "causes". Nevertheless, the normal interpretation of this sentence (perhaps incorrectly) is that Lucy's kicking of the TV was the cause of its playing.

On the other hand, there are no instances in which a syntactic process such as agreement or movement refers to a feature CAUSE, so there is no reason to suppose that causation is a syntactic category -- it is strictly semantic.

Telicity. The question we now ask is whether telicity behaves more like tense or more like causation. While interpretations of events are subject to a sentential or discourse context, like both tense and causation, there are no known instances in which a syntactic process like movement or agreement makes reference to telicity. Even the selection of PP adjuncts, which might seem to depend on the telicity of the verb is not strictly limited by telicity (recall the *in/for* + NP studies reported earlier). For example, compare the following sentences:

39. *Jane pushed the cart in/for an hour*.

40. *Joan drew a circle in/for ten minutes.*

We have used the expressions *push the cart* and *draw a circle* as examples of atelic and telic events, respectively. Note, however, that both *for + NP* and *in + NP* phrases can occur with both (39) and (40), with semantic consequences. Thus even the standard test for telicity is not rigidly enforced at the selectional level. We conclude that there is no evidence for a syntactic representation of telicity and that telicity is therefore a semantic category, and that the late effects

of event structure occur because of a generative semantic system such as proposed by Pustejovsky (1995).

Conclusion

We have presented experimental and linguistic data that have theoretical implications for the representation and processing of event structure. The linguistic data show that it is rarely the case that a verb is always telic or atelic. Sentence telicity depends nearly always on phrases that appear in the sentence. Thus, most verbs can occur in either telic or atelic sentences. It is therefore hard to maintain the view that properties of the verb project event structure. In light of the linguistic evidence, it is perhaps not surprising that the experimental data suggest that telicity does not have an immediate, independent effect on processing.

The *in-for* acceptability data showed that telic verbs are judged, at best, only slightly more acceptable with *in*-temporal phrases than with *for*-temporal phrases. Atelic verbs, on the other hand, show a greater preference for *for*-phrases than for *in*-phrases. One conclusion from these results is that meaning flexibility is greater for telic verbs than for atelic verbs, contrary to the prediction of the verb class model. A second conclusion is that the telicity of verbs in general is not as fixed as has been assumed.

The association between telicity and transitivity is not perfect, since corpus analysis reveals telic sentences that contain unergative verbs, which do not have an object at any level. Furthermore, if telic verbs required a direct object delimiter we would expect that they would be judged more acceptable in null object sentence frames than in unaccusative sentence frames, since the object is more accessible in a null object frame. In contrast, our data show that intransitive atelic verbs prefer null object frames whereas intransitive telic verbs prefer unaccusative frames.

The theoretical issue we have considered is whether event structure is a property of verbs, or whether it is represented at a higher level. Our data show that event structure is not primarily lexical, but rather is a property of the entire predicate. Verbs do have meaning that influences event structure, but the effect of verb meaning on event structure is not straightforward.

We examined the processing implications of theories of the linguistic representation of telicity. The delimiter search hypothesis follows from the view that telic verbs project an object to delimit the event. If the delimiter search hypothesis were true, the effect of a reduced relative garden path would be smaller for telic verbs than for atelic verbs. Our results contradict the delimiter search hypothesis on the word immediately following the embedded verb and on the main verb. Correlations between measures of telicity and the size of the garden path show that atelicity is related to an immediate decreased garden path.

The specificity constraint hypothesis predicts that delimiter search effects are limited to sentences in which the initial noun phrase was specific, since these phrases are better delimiters than non-specific phrases. The preposition constraint hypothesis predicted that the verb telicity effect are limited to sentences in which the post-verbal preposition was *by*, since this is a strong cue that the initial verb is a passive participle and therefore requires an object. Our results do not support either the specificity constraint hypothesis or the preposition constraint hypothesis.

Argument structure preferences of verbs, on the other hand, have clear effects on the garden path. The garden path effect is greater for transitive-only verbs than for potentially intransitive verbs (Experiment 1). Correlations between various measures of verb transitivity and the size of the garden path confirms that transitivity is related to an immediate increased garden path, and, on the main verb, a decreased garden path. Garden path effects are limited to telic verbs (Experiment 2). For these verbs, transitive-only verbs produce an immediate garden path when

the preposition was not *by*, but potentially intransitive verbs produce an immediate garden path when the preposition was *by*. These results support the view that, compared to atelic verbs, telic verbs are more constrained in the range of structures in which they appear.

The template augmentation hypothesis follows from the view that telic verbs constrain syntax more than atelic verbs. This hypothesis predicts that end of clause processing times are greater for atelic verbs than for telic verbs, since the syntactic flexibility of atelic verbs requires more integration at the end of the clause. Reading time data from Experiment 2 support his prediction. Negative correlations between number of dictionary senses and the size of the garden path within the embedded clause show that verbs that have more meanings produce a smaller garden path.

The derived event structure hypothesis predicts that processing is faster for sentences when the verb is telic and the object is specific. The discourse integration hypothesis predicts that processing is faster when the sentence contains a telic verb than when it contains an atelic verb, since telic events move a narrative forward in time. Probe recognition data support both of these hypotheses.

The results therefore suggest some variant of constraint-based processing in which sub-categorization preferences and verb strength influence initial hypotheses about meaning and structure. While constraint-based models do allow for immediate effects of lexical meaning, our results suggest that these meanings are not sufficiently strong to be effective cues for assigning structure. Instead, the parser uses other information along with verb meaning, including the structure and meaning of phrases and discourse context, to assemble the event structure of the sentence. The parser integrates this assembled event structure into a conceptual representation of the sentence relatively late during sentence processing. The sentence boundary is a natural point for integrating this information into a conceptual representation of discourse.

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Errata

Townsend, D. J., & Seegmiller, M. S. (2004). The linguistic representation and processing of event structure. *Journal of Cognitive Science, 5*, 157-244.

Figures 3 and 4 incorrectly depict the results for the verb position. As Table 12 shows, mean reading times for the initial verb numerically are *shorter* in the reduced relative condition than in the unreduced relative condition. Figures 3 and 4 have reversed the direction of these differences in the verb position.

In Figure 4 the labels on the lines are reversed. The line with filled circles actually refers to the atelic condition. The line with unfilled circles actually refers to the telic condition.

The key to Figure 4 assigns these labels incorrectly.