2

The Syntax of Event Structure*

JAMES PUSTEJOVSKY

I INTRODUCTION

Recent work in linguistic theory has stressed the important role that structured lexical representations can play in natural language, for example, the emergence of argument structure as a distinct level of representation (Grimshaw, 1990; Williams, 1981) and the importance of semantic representations such as f-structure (Bresnan, 1982) and lexical conceptual structure (LCS) (Jackendoff, 1983; Rappaport & Levin, 1988). Similarly, we will explore what advantages there are in positing a separate level indicating the event structures associated with predicates and their arguments.

The conventional view of argument structure is that a verb is given a set of arguments and associated diacritics indicating how they are realized. Some authors, however, have argued that argument structure is a structured representation over which prominence relations are defined (Grimshaw, 1990; Williams, 1981). This structure has profound effects on the behavior of the predicates in the language. Similarly, the conventional view of events (e.g., whether a sentence denotes an activity, a state, etc.) within much of linguistic theory has been that of a single, existentially quantified event variable for sentences in the language (Higginbotham, 1985; Parsons, 1985).[1] Extending this view, we will argue that grammatical phenomena do in fact make reference to the internal structure of events, and that a subeventual analysis for predicates is able to system-atically capture these effects. The basic assumptions of the theory are as follows:

(I)   A subeventual structure for predicates provides a template for verbal decomposition and lexical semantics. Following Vendler (1967), Dowty (1979), and others, we distinguish three basic event types: states, processes, and transitions, where a predicate in the language by default denotes one particular event type. Unlike previous analyses, however, we assume a more complex subeventual structure of event types, where event types make reference to other embedded types.

(II) By examining the substructure of events, one can describe much of the behavior of adverbial modification in terms of scope assignment within an event structure.

[1] This is assuming that events are represented at all. There are many who still argue that events are not a necessary addition to the ontology of types (see Cresswell, 1985).

(III) The semantic arguments within an event structure expression can be mapped onto argument structure in systematic and predictable ways. The event structure proposed here should be seen as a further refinement of the semantic responsibilities within an LCS (Jackendoff, 1983; Rappaport & Levin, 1988).

We should point out one caveat about the analysis presented below. This paper is not the proper forum for specifying the formal semantics of the event structure proposed here. Rather, what we attempt to show, in broad outline, is the relevance of event structure to lexical semantics and linguistic theory in general. Where appropriate, we will briefly point out the technical details of the analysis, as well as the limitations and shortcomings of the proposal. Details of the formal interpretation of the event semantics presented here can be found in Pustejovsky (1991) and other work in progress.

2   EVENT TYPES

Temporal aspect can be viewed as the behavior of sets of periods involving the concepts of *initial*, *internal*, and *final* temporal subperiods, as they relate to the semantic roles associated with the arguments of predicates.[2] To make this clear, let us examine the meanings of the sentences below:

(1) a. Mary walked.
     b. Mary walked to the store.
     c. Mary walked for 30 minutes.

It is normally assumed that there are at least three aspectual types: *state, process*, and *events*, sometimes distinguishing between *accomplishment* and *achievement* events. The verb *walk* as used in (1a) denotes an activity of indefinite length. That is, the sentence itself does not convey information regarding the temporal extent of the activity. Such a sentence is said to denote a *process* (Dowty, 1979; Kenny, 1963; Mourelatos, 1978; Ryle, 1949; Vendler, 1967; Verkuyl, 1989). Sentence (1b) conveys at least as much information as (1a), with the additional constraint, however, that Mary terminated her activity of walking at the store. Although not making explicit reference to the temporal duration of the activity, (1b) does assert that the process has a logical culmination or duration, such that the activity is over when Mary is at the store. This type of sentence is said to denote an event, or *accomplishment*.

Sentence (1c) also conveys information about a specific activity of walking and its termination. In this sentence, however, there is no explicit mention of a logical culmination to the activity, but rather a durative adverbial is used to impose a temporal specification on the activity's boundedness. Such a sentence denotes a *bounded process*. These examples illustrate the same verb being used for three different aspectual types: process, accomplishment, and bounded process. When the verb *walk* appears alone structurally, it assumes a process interpretation—it is lexically "process-like". The presence of prepositional and adverbial phrases, however, causes the aspectual class of the sentence to change.

Just as the verb *walk* seems to be lexically process-like, there are lexical accomplishments as well. For example, the verbs *build* and *destroy*, in their typical transitive use in (2),

---

[2] Carlson (1981) presents the issues in these terms, and we adopt this statement of the problem.

denote accomplishment events, because there is a logical culmination to the activity performed by Mary:

(2) a. Mary built a house.
    b. Mary destroyed the table.

In (2a) the existence of the house is the culmination of Mary's act, while in (2b) the non-existence of something denotable as a table is the direct culmination of her act. One useful test for whether a sentence denotes an accomplishment is the ability to be modified by temporal adverbials such as *in an hour*, that is, the so-called frame adverbials. Notice in (3) that both "derived" and lexical accomplishments license such modification:

(3) a. Mary walked to the store in an hour.
    b. Mary built a house in a year.

Even though *build* seems lexically to be an accomplishment, observe how it can be used in a context where it appears to denote a process:

(4) Mary built houses for four years.

Sentence (4) means that Mary engaged in the activity of house building for a bounded period of time. The durative adverbial indicates that the sentence has been reinterpreted as a process due to the bare plural in object position (see Bach, 1986; Krifka, 1987).

Another aspectual type mentioned earlier is that of achievement. An achievement is an event that results in a change of some sort, just as an accomplishment does, but where the change is thought of as occurring instantaneously. For example, in sentences (5a), (5b), and (5c) the change is not a gradual one, but something that has a "point-like" quality to it. In fact, modification by *point adverbials* such as *at noon* is a diagnostic that a sentence denotes an achievement (Dowty, 1979):

(5) a. John died at 3 p.m.
    b. John found his wallet at 3 p.m.
    c. Mary arrived at noon.

What are apparently lexical properties of the verb can be affected by factors that could not possibly be lexical. For instance, consider the sentences in (6), where one sees a shift in the meaning of *drink* from an accomplishment as in (6a) to a process as in (6b):

(6) a. Mary drank a beer.
    b. Mary drank beer.

The presence of a bare plural object shifts the interpretation of a logically culminating event to an unbounded process (see Pelletier & Schubert (1989) and Krifka (1987) for details).

Finally, let us consider the behavior of *states*, such as those sentences in (7):

(7) a. Mary is sick.
    b. Mary believes that John loves her.

There is no change occurring in either sentence and no reference to initial or final periods. In fact, it is the homogeneity of states that distinguishes them from the other aspectual types. States are identified by several diagnostics. First, they allow modification

by durative adverbials (8a), and secondly, they do not appear as imperatives (8b) (Dowty, 1979):

(8) a.   Mary was sick for two months.
    b. *Be sick!

Because of the sometimes elusive nature of aspectual classification, it is useful to consider a few more diagnostics. One well-known test for distinguishing activities from accomplishments, known as the "imperfective paradox" (Bach, 1986; Dowty, 1979), involves the possible entailments from the progressive aspect. To illustrate the nature of this paradox, consider the sentences in (9):

(9) a.   John is running. *Entails* John has run.
    b.   John is building a house. *Does not entail* John has built a house.

What this difference in entailment indicates is whether an action is homogeneous in nature or has a culmination of some sort. Sentence (9a) is an activity and entails the statement *John has run*. That is, John has already engaged in some running. Sentence (9b), on the other hand, does not allow the entailment *John has built a house* because building is not a homogeneous process, but rather culminates in a changed state, i.e. it is an accomplishment. Thus, if *x is V-ing* entails *x has V-ed*, then either the verb or the predicate is a process. A theory of aspect should be able to account for this behavior, and not just use it to classify propositions into aspectual types.

Finally, there is an important distinction between accomplishments and non-accomplishments based on their interaction with scalar adverbials such as *almost*. Consider the sentences in (10) and the possible interpretations associated with each:

(10) a.   John almost swam.
     b.   John almost painted a picture.
     c.   John almost arrived.
     d.   John almost left.

In sentence (10a), what is being expressed is that John almost performed an activity of swimming, but did not even begin it. Sentence (10b), on the other hand, allows for two interpretations. One is similar to (10a), where John almost engaged himself in painting, but then did not. The other interpretation is that John was painting but did not quite complete the picture. The interpretation of (10c), like (10a) is unambiguous, while (10d) permits two readings along the same lines as (10b). Why should there be such a difference? Dowty (1979) claims that an ambiguity arises with *almost* just in case the predicate is an accomplishment. If this ambiguity does not arise, the predicate is not an accomplishment.

Summarizing, we have considered the following categorization of aspectual types for verbs and verb phrases:

(11) a.   *Processes:* walk, run
     b.   *Accomplishments:* build, destroy
     c.   *Achievements:* die, find, arrive
     d.   *States:* sick, know, love, resemble

If membership in one of these aspectual classes is viewed as a projection of the lexical properties of the verb, then how is it that the aspectual properties of a sentence may change as the result of other factors, such as adverbials (both durative and frame), the structure of the noun phrase (NP) in an argument position (e.g. definite vs. bare plural),

or the presence of a prepositional phrase? In the sections that follow, we will explain these behaviors, which have come to be known as "type-shifting" phenomena (Bach, 1986), in terms of a configurational theory of event structure. We show how the tests normally used as diagnostics for membership in one class or another fall out as the principled consequence of different event structures. Thus, we are able to abandon the feature-based approach to aspect which is generally assumed (e.g., Verkuyl, 1972) in favor of a highly restricted, topological theory of how events are structured.

3   TOWARDS A MODEL OF LEXICAL KNOWLEDGE

In this section, we will outline generally what the basic requirements for a theory of lexical semantics should be. We present a conservative approach to decomposition, where lexical items are minimally decomposed into structured forms (or templates) rather than sets of features. We will provide a generative framework for the *composition* of lexical meanings, thereby defining the well-formedness conditions for semantic expressions in a language.

One can distinguish between two distinct approaches to the study of word meaning: *primitive-based* theories and *relation-based* theories. Those advocating primitives assume that word meaning can be exhaustively defined in terms of a fixed set of primitive elements (e.g., Jackendoff, 1972; Katz, 1972; Lakoff, 1971; Schank, 1975; Wilks, 1975). Inferences are made through the primitives into which a word is decomposed. In contrast to this view, a relation-based theory of word meaning claims that there is no need for the decomposition of word meaning into primitives if words are associated through a network of explicitly defined links (e.g., Brachman, 1979; Carnap, 1956; Collins & Quillian, 1969; Fodor, 1975; Quillian, 1968). Sometimes referred to as *meaning postulates*, these links establish any inference between words as an explicit part of a network of word concepts.[3] What we would like to do is to propose a new way of viewing primitives, looking more at the generative or *compositional* aspects of lexical semantics, rather than the decomposition of words into a specified number of primitives.

Most approaches to lexical semantics making use of primitives can be characterized as using some form of *feature-based* semantics, since the meaning of a word is essentially decomposable into a set of features (e.g., Katz, 1972; Katz and Fodor, 1963; Schank, 1975; Wilks, 1975). Even those theories that rely on some internal structure for word meaning (e.g., Dowty, 1979; Fillmore, 1988) do not provide a complete characterization for all of the well-formed expressions in the language. Jackendoff (1983) comes closest, but falls short of a comprehensive semantics for *all* categories in language. No existing framework, in my view, provides a *method for the decomposition of all lexical categories*.

What, exactly, would a method for lexical decomposition give us? Instead of a taxonomy of the concepts in a language, categorized by sets of features, such a method would tell us the minimal semantic behavior of a lexical item. Furthermore, it should tell us the compositional properties of a word, just as a grammar informs us of the specific syntactic behavior of a certain category. What one is led to, therefore, is a *generative* theory of word meaning, but one very different from the generative semantics of the 1970s (Pustejovsky, 1991). In order to explain why we are suggesting that lexical decomposition proceed in a *generative* fashion rather than the traditional

---

[3] For further discussion on the advantages and disadvantages to both approaches, see Jackendoff (1983).

exhaustive approach, let me take as a classic example the word *closed* as used in (12) (see Lakoff, 1970):

(12) a. The door is **closed**.
     b. The door **closed**.
     c. John **closed** the door.

Lakoff (1970), Jackendoff (1972), and others have suggested that the sense in (12c) must incorporate something like *cause-to-become-not-open* for its meaning. Similarly, a verb such as *give* specifies a transfer from one person to another, e.g. *cause-to-have*. Most decomposition theories of word meaning assume a set of primitives and then operate within this set to capture the meanings of all the words in the language. These approaches can be called *exhaustive* since they assume that with a fixed number of primitives complete definitions of lexical meaning can be given. In the sentences in (12), for example, *closed* is defined in terms of the negation of a primitive, *open*. Any method assuming a fixed number of primitives, however, runs into some well-known problems with being able to capture the full expressiveness of natural language.[4]

These problems are not, however, endemic to all decomposition approaches. We would like to suggest that lexical (and conceptual) decomposition is possible if it is performed *generatively*. Rather than assuming a fixed set of *primitives*, let us assume a fixed number of *generative devices* that can be seen as constructing semantic expressions. Just as a formal language is described in terms of the productions in the grammar rather than its accompanying vocabulary, a semantic language should be defined by the rules generating the structures for expressions rather than the vocabulary of primitives itself.[5]

How might this be done? Consider the sentences in (12) again, A minimal decomposition of the word *closed* is that it introduces an *opposition* of terms: *closed* and *not-closed*. For the verbal forms in (12b) and (12c), both terms in this opposition are predicated of different subevents denoted by the sentences. In (12a), this opposition is left implicit, since the sentence refers to a single state. Any minimal analysis of the semantics of a lexical item can be termed a *generative* operation, since it operates on the predicate(s) already literally provided by the word. This type of analysis draws on Aristotle's *species of opposition* (see Categories, 11b17; Lloyd, 1968), and it will form the basis of one level of representation for a lexical item. Rather than decomposing such a word into primitive terms, evaluate it relative to an opposition.[6]

The essential opposition denoted by a predicate forms part of what we will call the *qualia structure* of that lexical item (Pustejovsky, 1989a, 1991). Briefly, the qualia structure of a word specifies four aspects of its meaning:

- the relation between it and its constituent parts;
- that which distinguishes it within a larger domain;

---

[4] For example, Weinreich (1972) faults Katz and Fodor (1963) for the inability to distinguish between word senses of polysemous elements without requiring an unlimited number of differentiating features.

[5] In my opinion, this approach is also better suited to the way people write systems in computational linguistics. Different people have distinct primitives for their own domains, and rather than committing a designer to a particular vocabulary of primitives, a lexical semantics should provide a method for the decomposition and composition of the meanings of possible lexical items.

[6] Aristotle identifies four species of term opposition:

(a) Correlation: e.g., "double" vs. "half".
(b) Contrariety: e.g., "good" vs. "bad".
(c) Privation: e.g., "blind" vs. "sighted".
(d) Contradiction: e.g., "sit" vs. "not sit".

See Horn (1989) for discussion of the logic of negation. See Modrak (1987) and Graham (1987) for discussion of Aristotle's theory of explanation and its relation to perception.

- its purpose and function;
- whatever brings it about.

We call these aspects of a word's meaning its *constitutive role*, its *formal role*, its *telic role*, and its *agentive role*, respectively.[7] For example, the telic role of the noun *book* is the predicate *read*, while the agentive role might be *write*.

The minimal semantic distinctions of the qualia structure are given expressive force when combined with a theory of aspectual (or event) types. For example, the predicate in (12a) denotes the *state* of the door being closed. No opposition is expressed by this predicate. In (12b) and (12c), however, the opposition is explicitly part of the meaning of the predicate. Both these predicates denote what we call *transitions*. The intransitive use of *close* in (12b) makes no mention of the causer, yet the transition from *not-closed* to *closed* is still entailed. In (12c), the event that brings about the *closed* state of the door is made more explicit by specifying the actor involved. These differences constitute the *event structure* of a lexical item. Both the opposition of predicates and the specification of causation are part of a verb's semantics, and are structurally associated with slots in the event template for the word. In this case, for example, the *formal* role for the verb *close* is specified as a transition, denoting an opposition. The *constitutive* role specifies the exact content of the event, in terms of what the predicates engaged in opposition actually are (see below). As will be seen in the next section, there are different inferences associated with each event type, as well as different syntactic behaviors (Grimshaw, 1990; Pustejovsky, 1989b).

4 A LEVEL OF EVENT STRUCTURE

As mentioned above, the theory of decomposition being outlined here is based on the central idea that word meaning is highly structured, and not simply a set of semantic features. Let us assume this is the case. We will argue that one level of semantic description involves an event-based interpretation of a word or phrase, that is, the *event structure* mentioned above. Event structure is just one level of the semantic specification for a lexical item, along with subcategorization, argument structure, and qualia structure. Because an event structure is recursively defined in the syntax, "event-type" is also a property of phrases and sentences.[8] There are three primary components to event structure:

- the primitive *event type* of the lexical item;
- the rules of *event composition*;
- the *mapping rules* to lexical structure.

Any verb in natural language can be characterized as belonging to one of three basic event types: *states*, *processes*, or *transitions* (see Bach, 1986; Dowty, 1979; Vendler, 1967).[9] Except where otherwise indicated, the event structure will be interpreted as representing both temporal precedence and exhaustive event inclusion. That is, for an event e, represented as $[e_1\ e_2]$, the intended interpretation is that e is an event containing

---

[7] To a large extent, we follow Moravcsik (1975), who distinguishes the different "aitia" associated with a proposition. For details, see Pustejovsky (1991).

[8] See Tenny (1987) for a proposal on how aspectual distinctions are mapped to the syntax.

[9] Above we distinguished between four aspectual classes. These classes, we argue, collapse to three distinct structural configurations, where transitions subsume both accomplishments and achievements.

two subevents, e_1 and e_2, where the first temporally precedes the second, and there are no other events locally contained in event e.[10] We will distinguish these event types as follows (where E is a variable for any event type):[11]

(13) a. State (S): a single event, which is evaluated relative to no other event
Examples: *be sick, love, know*
Structural representation:.

$$S$$
$$|$$
$$e$$

b. Process (P): a sequence of events identifying the same semantic expression
Examples: *run, push, drag*
Structural representation:

$$P$$
$$e_1 \ldots e_n$$

Following Dowty (1979) and others, we will assume that when P is a process verb, then if the semantic expression P' identified with P is true at an interval I, then P' is true for all subintervals of I larger than a moment:

c. Transition (T): an event identifying a semantic expression, which is eva-luated relative to its opposition (Jackendoff, 1972; Lakoff, 1970; von Wright, 1963)[12]
Examples: *give, open, build, destroy*
Structural representation (where E is a variable for any event type):

$$T$$
$$E_1 \qquad \neg E_2$$
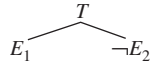
To illustrate the basic distinction in event types, consider the sentences in (12) from the previous section, repeated below:

(12) a. The door is **closed**.
b. The door **closed**.
c. John **closed** the door.

We assume a level of lexical representation similar to that of Dowty (1979), Jackendoff (1983), and Levin and Rappaport (1988), in that verb class distinctions are character-ized in terms of an LCS-like structure, which we call LCS′. An LCS is a lexical semantic representation which takes the form of a predicate decomposition. Here we will not assume any fixed set of primitive terms, but rather assume a minimal decomposition of verbs and sentences in terms of the principles of event structure outlined here. This level, using predicates such as $act(x, y)$, $at(x, y)$, and $on(x, y)$, constitutes the LCS′. Thus, the trees represent LCS-like information partitioned according to event structure. Furthermore, we will assume that the LCS representations assumed by Levin and Rappaport (1988) can be constructed by interpreting the event structure together with the LCS′, as we will illustrate below. Let us begin with the
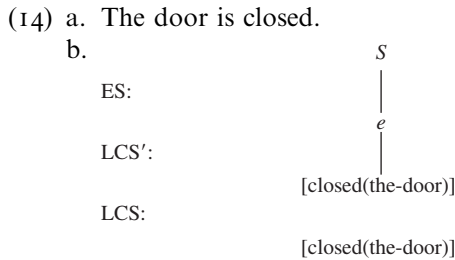
---

[10] This does not mean that there is no subeventual structure to these events (see below).
[11] The tree structures are given to illustrate the configurational nature of event structures and their combinations. See Pustejovsky (to appear) for discussion of their formal interpretation; cf. Croft (1990) for an alternative suggestion on how lexical items may structure their internal events.
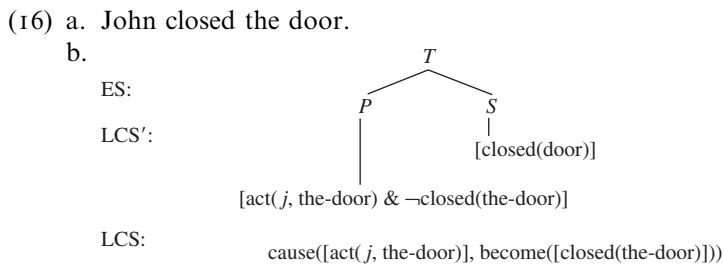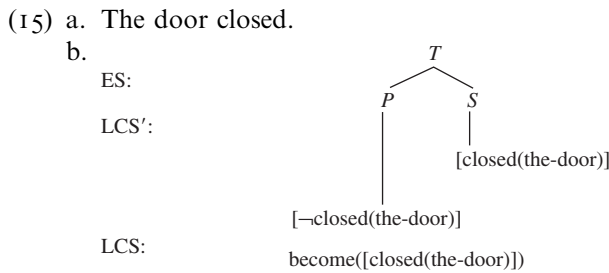[12] As mentioned in the previous section, Aristotle's *Categories* (194b) makes the same point.

sentence in (12a) above. The adjectival form *closed* denotes a state where the event structure is that shown in (14b):

(14) a. The door is closed.

b.

ES:
                                     S

LCS′:
                                     e

                          [closed(the-door)]

LCS:

                          [closed(the-door)]

As mentioned in the previous section, a lexical transition, such as *close* in (12b) and (12c), expresses the opposition of a predicate, as illustrated in (15) and (16) below. Here we are assuming that one can interpret the expression of a term opposition as logically equivalent to Dowty's *become* operator (Dowty, 1979, p. 140). Similarly the operator *cause* can be seen as a derivative relation between events, structurally interpreted from an agentive predicate within the initial subevent of an event structure. Furthermore, the conjunction of predicates (&) indicates the simultaneity of the expressions:

(15) a. The door closed.

b.

ES:
                                                T

LCS′:
                                   P   *S*

                                           [closed(the-door)]

                          [¬closed(the-door)]

LCS:
                          become([closed(the-door)])

(16) a. John closed the door.

b.

ES:
                                           T

LCS′:
                             P   *S*

                                       [closed(door)]

                    [act(*j*, the-door) & ¬closed(the-door)]

LCS:
   cause([act(*j*, the-door)], become([closed(the-door)]))

These two structures suggest that *close*, in both the *inchoative* (as in (15)) and *causative* (as in (16)) forms, is a transition from one state to its opposition.[13] Their LCS′ representations differ only in the further specification of an action being performed for the causative cases; that is, the expression and indicates simultaneity of the two expressions within this subevent. But notice that the LCS representations do differ significantly because of the explicit reference to a causal agent. Thus, while the verb *close* is semantically ambiguous at one level (LCS), the logical relatedness of the verb's senses is captured at another (ES and LCS′).

---

[13] Hale and Keyser (1986) provide independent motivations for treating the inchoative and causative forms of a verb as essentially identical at some level of representation. In our analysis, they differ only in their LCS, but not in their event structures.
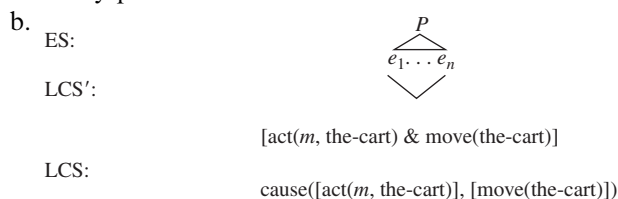
Sentence (17) illustrates how a process verb differs structurally from states and transitions:

(17) a. Mary ran.

    b.

        ES:

$$P$$
$$e_1 \ldots e_n$$

        LCS′:

$$[\mathrm{run}(m)]$$

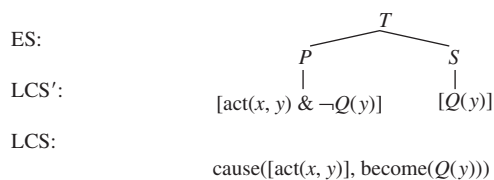   LCS:

$$[\mathrm{run}(m)]$$
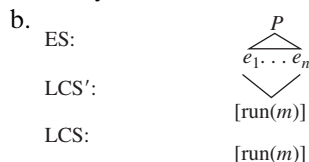
The sentence in (18) illustrates how a causative process is represented and subsequently mapped onto an LCS representation:

(18) a. Mary pushed the cart.

    b.

        ES:

$$P$$
$$e_1 \ldots e_n$$

        LCS′:

$$[\mathrm{act}(m, \text{the-cart}) \ \& \ \mathrm{move}(\text{the-cart})]$$

        LCS:

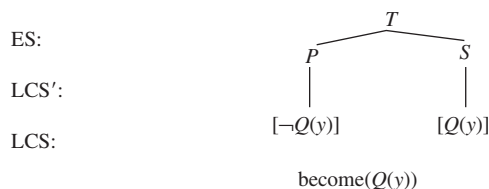$$\mathrm{cause}([\mathrm{act}(m, \text{the-cart})], [\mathrm{move}(\text{the-cart})])$$

The aspectual distinctions made by the above trichotomy do not distinguish between achievements and accomplishments in any structural way, as illustrated above with the inchoative *close* and causative *close*, an achievement and accomplishment, respectively. In fact, we will argue that there is no further distinction necessary in terms of event structure for classifying these two aspectual types. Rather, achievements and accomplishments can be distinguished solely in terms of an agentive/non-agentive distinction. We will characterize the difference as follows. When a verb makes reference both to a predicate opposition and the activity bringing about this change, then the resulting aspectual type is an accomplishment (as in (16)). When the verb makes no explicit reference to the activity being performed, the resulting aspectual type is an achievement (as in (15)). This distinction is illustrated in (19) below:
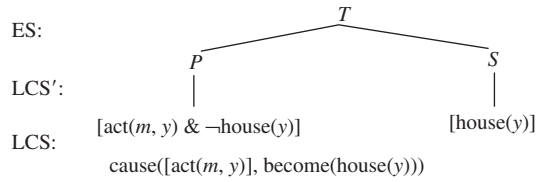
(19) a. Accomplishment:

        ES:

$$T$$
$$P \qquad S$$

        LCS′:

$$[\mathrm{act}(x, y) \ \& \ \neg Q(y)] \qquad [Q(y)]$$

        LCS:

$$\mathrm{cause}([\mathrm{act}(x, y)], \mathrm{become}(Q(y)))$$

    b. Achievement:

        ES:

$$T$$
$$P \qquad S$$

        LCS′:

        LCS:

$$[\neg Q(y)] \qquad [Q(y)]$$
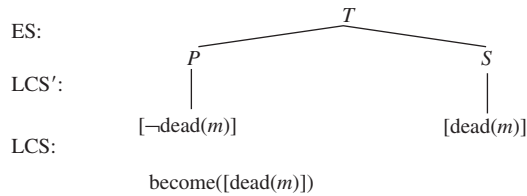
$$\mathrm{become}(Q(y))$$

The role of agentivity for distinguishing event types, explored in Dowty (1979), replaces the notion of "event headedness" introduced in Pustejovsky (1989b). As an example of

this difference, notice how the transition verbs *build*, *draw*, and *leave* differ in their event structures from *arrive* and *die*, illustrated with *build* and *die*.

(20) a. Mary built a house.

ES:

```
                              T
                    P                    S
LCS':               |                    |
        [act(m, y) & ¬house(y)]      [house(y)]
LCS:
        cause([act(m, y)], become(house(y)))
```

b. Mary died.

ES:

```
                          T
                 P                   S
LCS':            |                   |
             [¬dead(m)]           [dead(m)]
LCS:
              become([dead(m)])
```
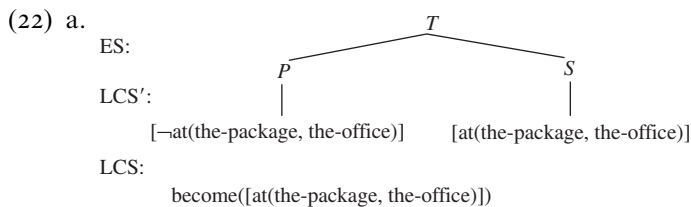
Although this analysis might be intuitive for most cases of achievement verbs, an agentive role does seem implicit in many achievement predicates. For example, the sentences in (21) seem to involve an agent:

(21) a. Mary arrived at the party.
     b. John won the race.

The question, however, is whether the agency is part of the verbal semantics of *arrive* and *win* or is contributed by other means, for example, the animacy of the subject, or pragmatic effects. The position that agency is not intrinsically part of the verb's meaning is not as implausible as it might seem. First, notice the absence of agency in the sentences in (22), with the same verbs as in (21):

(22) a. The package arrived at the office.
     b. Our anniversary has finally arrived.
     c. Mary won the lottery.

The event structure for (22a) is simply the non-agentive transition shown in (22a′).

(22) a.

ES:

```
                               T
                    P                    S
LCS':               |                    |
        [¬at(the-package, the-office)]   [at(the-package, the-office)]
LCS:
            become([at(the-package, the-office)])
```

Rather than being metaphorical uses of an agentive predicate, we argue that the sentences in (22) are typical instances of non-agentive transitions (i.e., achievements). Secondly, notice how intentional adverbials such as *deliberately* cannot felicitously modify predicates such as *win* and *die*.

(23) a. *Mary won the race deliberately. (But cf. Mary lost the race deliberately.)
     b. *Mary deliberately died of cancer.

These data suggest that Dowty's observation concerning agentivity does in fact act to complete the distinctions between the conventional aspectual classes by dividing the class of transitions into two logical subclasses. Configurationally, as event structures, however, the two classes are identical.

5   EVENT COMPOSITION

Having studied the basic event structures associated with verbs, we will now turn to how they interact with other syntactic constituents to form derived event representations, that is, the phenomenon of *event composition*. In particular, we look at two classes of event composition, PP attachment and resultative constructions. There are several types of syntactic constructions that directly affect the event type of a phrase: temporal adverbials, adjunct phrases, complement type (e.g., individuated or not), and aspectual coercion (e.g., the progressive). For reasons of space, we consider only the first two types here (for further discussion see Pustejovsky (to appear)). The basic idea is that the event type for a sentence need not be the event type of the main verb. Category changes may occur because of explicit rules setting out the ways events can compose and be modified.

Briefly, as mentioned in the Introduction, temporal adverbials are sensitive to the type of event being modified (Kenny, 1963; Vendler, 1967). For example, the process verb *run* can be modified by a *durative* adverbial, while the transition *build* cannot:

(24) a.   Mary ran *for an hour*.
     b. *Mary built a chair *for an hour*.

Conversely, *build* can be modified by a *frame* adverbial while *run* cannot:

(25) a. *Mary ran *in an hour*.
     b.   Mary built a chair *in an hour*.

Within our theory of events, there is one basic principle that accounts for these facts: only when an event contains a logical culmination (e.g., it belongs to the set of transitions) is it modifiable by a frame adverbial. Why should this be? Given our assumptions about the subeventual analysis for verbs, it is possible with our analysis that temporal predicates in the language might make reference to a subevent, or to an assembly of subevents denoted by the verb. Thus, imagine that the frame adverbial *in an hour* requires *two* events to be present for a proper modification, for example, the two subevents of *build*, e_1 and e_2. One can say, then, that this temporal modifier takes as its argument the temporal distance between e_2 and the onset of e_1. The logical form for our sentence (25b) then will be something like (25c):

(25) c. $\exists P,\ S[\text{build}((P,\ S)) \wedge \text{agent}(m,\ (P,\ S)) \wedge \text{theme}(chair,\ (P,\ S)) \wedge \text{in-an-hour}(P,\ S)]$

The last conjunct of this expression, *in an hour*, can be interpreted as being:

temporal measure of (time of) S – onset of P = 1 hour

Such an analysis would immediately explain why the other event types (states or processes) are ungrammatical with such adverbials, without the "coerce" reading (cf. (25a)).[14]
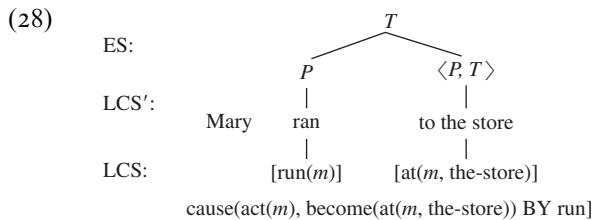
---

[14] I would like to thank an anonymous reviewer for pointing out this analysis to me.

A second kind of event composition involves the interaction of a prepositional phrase with the event structure of a verb. These include cases of PP attachment that change the event structure of the verb phrase (VP), as shown in (26) and (27):

(26) a. Mary **ran**.
     b. Mary **ran** to the store.

(27) a. John **pushed** the wagon.
     b. John **pushed** the wagon to Mary.

What the sentence pairs in (26) and (27) have in common is a recognizable shift in their event types. In particular, for each case, a sentence denoting a *process* (in the (a) examples) has been transformed into a *transition* by the presence of a prepositional phrase (PP) denoting a bounded path, a *to*-PP. As Chomsky (1957) notes, these are, in fact, examples of a general phenomenon in language, where the grammar allows a syntactic construction to mirror an already existing lexical representation; that is, in this case, a transition (see also Jackendoff (1983) and Talmy (1985) for similar points). When this structure arises from syntactic composition, we have what we will refer to as *event composition*. Informally, the rule can be stated in the following way. In certain constructions, when the verb denotes a *process* (e.g. *run*, *push*), and there is a phrase present which denotes a function from processes to transitions, then the event type of the entire verb phrase (VP) is construed as a *transition*.[15] Notice that this is the same structure carried by lexically specified transitional verbs such as *build*.

Such a process of composition can be made clearer if we consider a specific example. In (26b) above, the event type of the VP containing the lexical process verb *run* shifts to a transition in composition with the PP. In this example, the notation $\langle P, T \rangle$ is taken to represent a function from processes to transitions:

(28)

ES:
$$T$$
$$P \qquad \langle P, T \rangle$$

LCS′:
Mary   ran   to the store

LCS:
$$[\text{run}(m)] \qquad [\text{at}(m, \text{the-store})]$$
$$\text{cause}(\text{act}(m), \text{become}(\text{at}(m, \text{the-store})) \text{ BY run}]$$

In this example, the prepositional phrase is able to project its own event structure, the *state* of Mary being at the store. It is easy to verify that the above event structure is a transition, since modification by a frame adverbial is well formed, as illustrated in (29):

(29)   Mary ran to the store *in an hour*.

To explain the behavior of this type of event composition, we suggest that the preposition *to* is to be analyzed as denoting a relation between states and processes, such

---

[15] This is a slight simplification for illustration purposes. In Pustejovsky (to appear), prepositions such as "to" are treated as relational event functors, applying first to a state, and then to a process, to give a transition: i.e. $\langle S, \langle P, T \rangle\rangle$. The treatment above, however, is useful as a general description of this case of event type-shifting. It should be pointed out that the event type $\langle P, T \rangle$ has consequences for the mapping to LCS as well. Because the event type of the matrix predicate is actually treated as an argument to $\langle P, T \rangle$, it effectively is subordinated in Levin and Rapoport's (1988) sense, hence creating a "BY manner" expression. For discussion, see Pustejovsky (to appear).

that the resulting event type is a transition. That is, the PP acts like a function from processes to transitions.[16] Importantly, however, as with lexical transitions, this construction sets up a predicate opposition involving the culminating state introduced by the PP. Thus, the LCS derived from this construction looks like that of a lexically specified causative verb.[17]

Similar principles of event composition seem to be operating in the *resultative* construction as well. Resultative constructions are verb phrases, such as those in (30), consisting of a verb with an object, together with an adjunct phrase predicated of the direct object, that specifies the state the object obtains as a result of an action:[18]

(30) a. Mary hammered the metal flat.
     b. Mary wiped the table clean.
     c. The men drank the pot dry.

Rappaport and Levin (1989) argue that the resultative phrase (e.g. *flat* and *clean*) can only be predicated of the direct object, a restriction they call the *direct object restriction* (*DOR*). We will return to this restriction in Section 7, but for now, let us first examine how this construction is relevant to event composition.
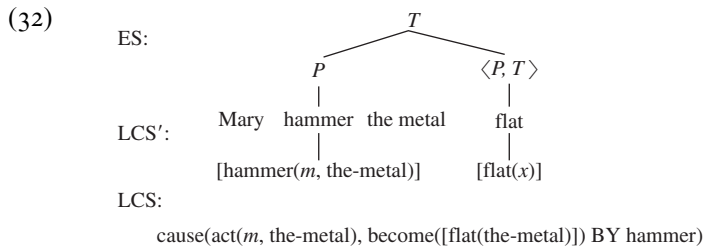
The examples are relevant because the resultative construction involves what appears to be a systematic event-type shifting from processes to transitions. This systematic ambiguity, we argue, is the result of principles of semantic composition, rather than an underlying lexical ambiguity in the verb involved. This follows the general methodology outlined in Pustejovsky (1989a, 1991), where, whenever possible, the logical ambiguity of a word should be generated by general principles operating in the grammar rather than by positing multiple lexical entries. Rappaport and Levin's (1989) analysis assumes a similar position with respect to lexical operations. Although we cannot touch on the richness of the problem (see, for example, the discussion in Rapoport (1990, to appear)), consider the resultative interpretations for the verb *hammer* in (30a) and the verb *wipe* in (30b); they arise from a similar event composition rule to that proposed for PP attachment above. That is, both verbs are underlyingly specified as *processes*, while the adjectival phrases *flat* and *clean* have event interpretations as *states*. Notice, then, how the resultative construction requires no additional word sense for the verb, nor any special semantic machinery in order for the resultative interpretation to be available, beyond the rules of event composition. Briefly, the solution involves analyzing the notion of stage-level predicate (Carlson, 1977) within event semantics as a subset of the states; namely, *those which can be changed by being acted upon*, functions that take processes to transitions, i.e. $\langle P, T \rangle$. Thus, the resultative construction formally reduces to the type of event composition encountered earlier with PP attachment; see (32) below (Ingria and Pustejovsky, 1990) for a discussion of the syntactic consequences of this solution):

(31) a. Mary **hammered** the metal. (*hammer* $\in$ process)
     b. Mary **hammered** the metal flat. (*hammer* $\in$ transition)

---

[16] This is similar to the proposals in Hinrichs (1985) and Dowty (1979), where such phrases behave like functions from properties to properties.

[17] For a different approach to such constructions, see Levin and Rapoport (1988), where rules of "lexical subordination" derive such new word senses.

[18] Simpson (1983) and Rappaport and Levin (1989) discuss the connection between resultatives, such as those in (30), and the property of unaccusativity (cf. Perlmutter, 1978). Unaccusatives are intransitive verbs whose subjects behave like direct objects of transitive verbs in many respects (see Levin (1986) and Burzio (1986) for details).

(32)

ES:

$$T$$

$$P \qquad \langle P, T \rangle$$

LCS′:

Mary   hammer   the metal   flat

[hammer(m, the-metal)]   [flat(x)]

LCS:

cause(act(m, the-metal), become([flat(the-metal)]) BY hammer)

A favorable consequence of this analysis is that it explains why just process verbs participate in this construction, and why the resultative phrase (the adjectival phrase) must be a state. Thus, by proposing that this construction participates in a semantic change at the level of event structure, we can explain the behavior as logically related to that of other subordinating constructions (in Levin and Rapoport's (1988) terms), but where the new sense of the verb arises out of syntactic and semantic composition in the grammar.

To close this section, we will briefly examine the class of psychological predicates such as *fear* and *frighten*, and how event structure contributes to the binding violations associated with the latter set of these verbs. The considerations reviewed briefly here motivate Grimshaw (1990) to analyze such violations in terms of event structure rather than in terms of structural configuration effects.[19]

The normal conditions on anaphoric binding, according to syntactic-based theories of grammar, involve the notions of *precedence*, *c-command*, and a *binding domain*. One class of examples that violates this definition of anaphoric licensing is that involving the *experiencer* verbs (we will not review the literature on this subject here, but will refer the reader to Belletti and Rizzi (1985), Pesetsky (1987), and Grimshaw (1986) for details). The problem can be stated as follows: there are two types of psych predicates—both with an argument structure of (experiencer, theme)—the first where the argument bearing the experiencer role is expressed as the subject (e.g. *fear*) and the second where the argument bearing the theme is expressed as the subject (e.g. *frighten*).[20]

Although these classes seem to have identical argument structures the syntactic behaviour of their members is very difficult. For example, the *fear* class behaves as expected by the binding theory, while the *frighten* class allows violations of the c-command requirement on anaphoric binding. Normally, an anaphoric pronoun must be structurally c-commanded by its antecedent, as in (34) or (36). Thus, an anaphor in matrix subject position is ill-formed, because there is no possible antecedent to c-command it as in the *fear* sentences (33a). An exception to this rule comes from the *frighten* class of experiencer verbs, however, as illustrated in (33b, c):

(33) a.   *Each other's students fear the teachers.
     b.   The pictures of each other frighten the teachers.
     c. ?? Each other's students frighten the teachers.

(34) a.   The women fear each other.
     b.   The women frightened each other.

---

[19] For discussion of how this phenomenon extends beyond this verb class, see Pustejovsky (1989b) and (to appear).

[20] There are of course two readings for "frighten" type verbs: one which is purely causative (x occasions fear in y), and the other which is being considered here. As Pesetsky (1987) notes, the backwards binding effects introduced below obtains only in the second interpretation.

(35) a. *Himself fears John.
    b. *Himself annoys John.

(36) a. John fears pictures of himself.
    b. The women frightened each other's students.

Although both classes disallow backward binding when the anaphor is the subject itself (see (35a) and (35b)), when the anaphor occurs embedded within the subject NP, as in (33b, c), binding is permitted with *frighten* verbs. What is it about *frighten* that allows the violation of the normal binding conditions? Following Grimshaw (1986) and Williams (1987),[21] we claim that the argument structure of the verb contributes information that accounts for the binding ability of its arguments. Grimshaw assumes that the argument structures for the members of the two verbs classes is as given in (37), distinguished only by a case-marking diacritic on one argument, Exp_{acc}, indicating it must appear as a direct object:

(37) a. fear ($Exp(Th)$)
    b. frighten ($Exp_{acc}(Th)$)

Grimshaw argues that the notion of *argument command* is as important for licensing anaphoric binding as is c-command. Briefly, this can be defined as in (38):

(38)   *Argument command*: ($\theta_1(\theta_2 \ldots \theta_n)$): members of outermost lists (recursively)
        a-command all other arguments.

Equipped with two separate dimensions of evaluation (both c-command and argument command), Grimshaw's theory can predict the subtle grammaticality differences that arise. What is left unexplained, however, is this: if such a minimal structural difference between the two verb classes (see (37)) has such a profound effect on binding possibilities, then there should be strong evidence for this distinction.

We will now demonstrate that the theory of event structure outlined above provides a well-motivated semantic explanation for the structural distinctions between the two experiencer verb types, thereby providing evidence for this distinction. Furthermore, the binding violations that the *frighten* class exhibits are part of a much wider phenomenon. We suggest that the event structure for the *frighten* verbs is that of a transition, while the event structure for *fear* verbs is that of a state. The difference between the two classes of experiencer verbs can be given as follows:

(39) a. Type(*fear*) $\in$ state; object is intensional.
    b. Type(*frighten*) $\in$ transition; subject is extensional.

Although it has long been noted that verbs such as *fear* are stative and those such as *frighten* are not, there has been little formal use made of this distinction. Furthermore, it is interesting that the *fear* class introduces an intensional object, compared to an extensional subject introduced by *frighten* verbs. This distinction is shown in (40):

(40) a. Mary fears ghosts/big dogs.
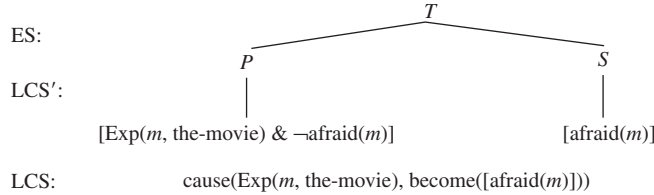   b. Big dogs/*ghosts frighten Mary.

That is, Mary can fear something without there necessarily existing the object of her fears. Something which frightens Mary, however, must exist and be more than an intensional object.

---

[21] Williams' (1987) proposal is somewhat different from Grimshaw's, but we will not review the differences here.

Grimshaw's argument structure distinction between the two classes is supported if one assigns the *fear* class to states and the *frighten* class to transitions, as shown in (41):

(41) a. The movie frightened Mary.
     b. Event structure:

ES:

$$T$$

$$P \qquad\qquad\qquad\qquad S$$

LCS′:

[Exp(*m*, the-movie) & ¬afraid(*m*)]   [afraid(*m*)]

LCS: cause(Exp(*m*, the-movie), become([afraid(*m*)]))

The structure above suggests that the appropriate command relation which exists for verbs such as *frighten* derives from the underlying LCS′ relation of *experiencing*, within the initial event. For this example, the experiencer variable *Exp* might be filled by the binary predicate *see*(*x*, *y*). As Grimshaw argues, one possible effect of such "semantic dominance" within a predicate is the licensing of variable binding, for example, anaphora. Thus, the representation provides an explanation for certain syntactic effects which were problematic when analyzed in purely syntactic terms.

6 ADVERBIAL MODIFICATION

In this section we suggest that an event structure provides a natural representation for adverbs as event predicates. We will claim that there are two types of adverbs: *wide-scope* and *narrow-scope*. The ambiguity exhibited by an adverbial, in terms of behaving as a manner- versus speaker-oriented adverb, can be explained in terms of different scope assignments of the same adverb. Such a solution is possible only if we examine the finer structure of the event being modified.

Consider first the examples discussed in Cresswell (1985) and Higginbotham (1989) involving adverbs such as *fatally:*

(42)   Mary fatally slipped

Within a Davidsonian analysis, where adverbs are taken as event predicates, the intended interpretation for this use of the adverb is represented as (43):

(43) $\exists e[slipped(e, m) \land fatal(e, m)]$

where one can read this as, "there was a slipping event such that it was fatal to Mary". But there are more complicated examples where the adverb can also be interpreted as a manner adverbial. As McConnell-Ginet (1982) points out, the sentence in (44) has two readings: (a) it was rude of Lisa to depart, and (b) she departed in a rude manner:

(44)   Lisa rudely departed.

The ambiguity arises from there being both a manner and a stative interpretation. McConnell-Ginet's solution involves adding an additional argument to the verb in order to derive the manner reading (45a), while adopting a more traditional Montagovian analysis for the stative interpretation, (45b):
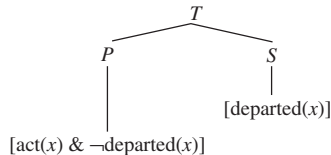
(45) a. *depart*(*rude*, *lisa*)
     b. *rude*(*depart*(*lisa*))

We will not review the details of McConnell-Ginet's proposal here but, as Higginbotham (1989) points out, she has no natural way of accounting for the factivity of the construction under both interpretations.
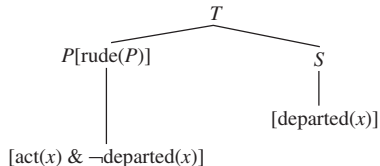
Higginbotham (1989) proposes an analysis for such constructions in terms of an event semantics which overcomes some of the problems of McConnell-Ginet's solution. In the manner of Davidson (1980) and his own previous work (Higginbotham, 1985), he suggests that quantification over an event variable allows for a first-order treatment of such adverbs. Consider the representations he proposes for (44), illustrated below in (46):

(46) a. $\exists e[depart(e,\ Lisa) \wedge rude(e, \hat{e}'[depart_0(e')])]$
     b. $\exists e[rude(e,\ Lisa,\ \hat{e}'[depart(e',\ Lisa)]) \wedge depart(e,\ Lisa)]$

The first expression says that, compared to the set of departing events, Lisa's instance was a rude one. The reading in (46b), on the other hand, says that Lisa was being rude in that she departed (e.g. when she did). For Higginbotham, such modification is another example of *θ-identification*, which results in the conjunction of two attributes predicated of a single individual (or individual variable), and *θ-marking*, which applies the adverb as a function to its argument, the verb. The problem with this analysis is that it assumes a variable adicity for the adverb. That is, *rude* takes two arguments in one case and three in another. Assuming that there is some relationship between the two adverbs, Higginbotham (as well as McConnell-Ginet) must state it independently of the semantics of each lexical item. Following the general methodology outlined above, we show that the ambiguity results from a structural distinction and not from lexical polysemy. In fact, the adverbs in both interpretations are identical, and there is a scope distinction which gives rise to the ambiguity just discussed. To begin with, consider the event structure for a verb such as *depart*, given below:

(47) a. ES:

where we minimally distinguish between the action of departing and the resulting state of being departed. This is a transition, annotated by an *act* relation, making it behave like an accomplishment. We will suggest that adverbs such as *rudely*, traditionally termed *manner* adverbials, modify a semantic expression associated with an event structure or an action subevent. Since both the process of leaving and the entire transition are actions, there will be two interpretations possible, resulting from two distinct scopes: over the process (as in (48)); and over the transition (as in (49)). Thus, if one modifies the initial event by characterizing it as *rude*, we arrive at an event predication over the process, that is, a manner interpretation; namely, that the action was performed rudely for those types of actions. The representation for this is given below. In this representation the predicate modifies only the process of *leaving*, and not the state of *having left*:

(48) ES:

In this structure the adverbial *rudely* applies to the initial event, and behaves like a *narrow-scope* adverb, relative to the entire event structure. When *rudely* takes scope over the entire event as in (49), it is necessarily interpreted relative to the speaker and situation:

(49)

ES:

T [rude(T)]

P S

LCS′:   [departed(x)]

[act(x) & ¬departed(x)]
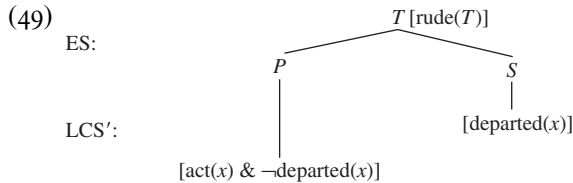
Thus, we can represent the ambiguity associated with the adverbial as one of a scope difference of the same lexical item; thus, this provides for a single one-place predicate treatment of the adverbial.

It is interesting to note that adverbs are idiosyncratic in their behavior as event predicates. For example, the adverbial *slowly* in both sentences in (50) refers to the action of walking, while *quickly* in (51) can refer either to the manner of action or to the duration of the entire event:

(50) a. Mary walked to the store slowly.
b. Mary slowly walked to the store.

(51) a. Mary walked to the store quickly.
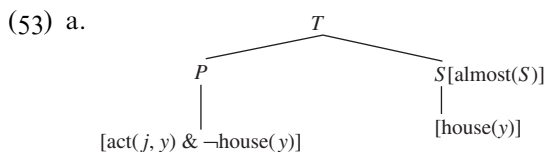b. Mary quickly walked to the store.

Such information must be associated with the individual adverb, where *quickly* may select for either reading. Notice that if *quickly* selects for a temporal interpretation, it must take wide-scope, since it requires a telic event to measure duration.
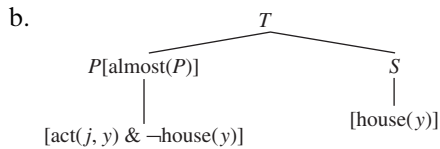
One of the diagnostics for aspectual classification discussed in the Introduction was the effect of modification by *almost*. We discovered that accomplishments allow two readings when modified by *almost* while non-accomplishments allow only one. For example, consider the sentences in (52):

(52) a. John almost built a house.
b. John almost ran.

Both sentences have an interpretation where the act is intended but never carried out, while (52a) carries the additional reading that the action is started but not fully completed. Why is it that *build* allows two interpretations while *run* allows only one?

Following the strategy introduced above, where an event structure allows for richer structural possibilities for adverbs as event predicates, we would expect a sentence to have as many interpretations for an adverbial as there are distinct predicates in the event structure. Since there are two distinct predicates involved in *build*, one within the initial event, and the other in the culminating event, there are two readings for the example in (52a), as illustrated in (53):

(53) a.

T

P S[almost(S)]

[house(y)]

[act(j, y) & ¬house(y)]

b.

$$T$$

$P[\text{almost}(P)]$ S

$[\text{act}(j, y) \,\&\, \neg\text{house}(y)]$ $[\text{house}(y)]$

In (53a), by modifying the culmination event, *almost* prevents the assertability of the expression associated with the logical culmination of the event; namely that there exists a house. The other reading, that of intent, is represented as (53b). This is the same reading as that available to (52b), where the *almost* modifies the expression associated with the first event constituent (or the only one as in the case of (52b)):

(54) $P[\text{almost}(P)]$

$e_1 \ldots e_n$

$\text{run}(x)$
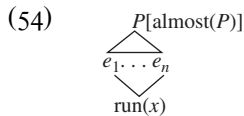
Assuming the proposal above to be correct, then we would assume that the other class of transitions, that is, achievements, should be unambiguous with respect to *almost*, since they involve only one distinct predicate in their event structure. As mentioned in the Introduction, this is in fact the case:

(55) a. John almost died.
      b. Bill almost arrived.
      c. Mary almost won the race.

The only reading available for these sentences is one where something has occurred without the terminus event being achieved (see (56)):[22]

(56) T

P $S[\text{almost}(S)]$

$[\neg\text{dead}(j)]$ $[\text{dead}(j)]$
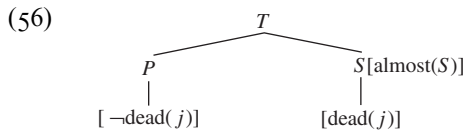
This is the only interpretation available since non-agentive transitions refer to a single predicate and its opposition. Importantly, the privative term is considered a dependent predicate, and does not allow modification by the adverbial.

To close this section, let us return to the topic of temporal adverbials. It is interesting to see what further predictions are made by a subeventual analysis concerning the scope of temporal adverbial modification. With this analysis we would expect that a complex event structure would allow modification by a durative adverbial of one of its *subevents*. This prediction turns out to be correct, in fact, as we see from sentences such as (57):

(57) a. John gave Mary the record for the afternoon.
      b. The company sent John the book for 10 days.
      c. Mary ran into the house for 20 minutes. (See Fillmore, 1988.)

These examples illustrate how the adverbial can modify a subevent of the entire event. In (57a), for example, involving a transition, the interval *the afternoon* modifies only the state referring to Mary having the record, and not the actual act of giving.

---

[22] Higginbotham (1989) proposes a scope analysis for the ambiguities involving "almost". His theory assumes a single event quantification, as proposed in Davidson (1980), and as a result is unable to capture the behavior of achievement verbs and adverbial scope.

This distinction is made explicit using our representation of the lexical semantics for *give*:

(58)

$$T$$

P   S [for(S, afternoon)]

[have(m, book)]

[act(j, book) & ¬have(m, book)]
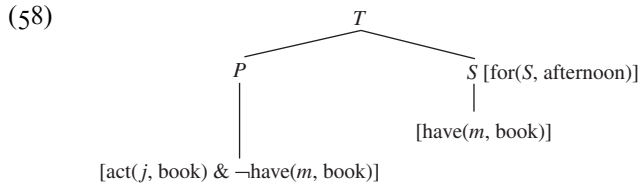
This structure states that the adverbial takes scope over the final event of the giving and not the act itself. In (57b), a similar modification occurs, where the expression *for 10 days* refers to the state of John having the book. Likewise, in (57c), the interval of 20 minutes denotes the time Mary spent inside the house rather than the duration of the act of running itself.

 Other examples where the durative adverbial seems to modify the resulting state are given below:

(59) a. John left for a week.
   b. John arrived for the day.
   c. They entered the atmosphere for an hour.

What these examples seem to indicate is that duratives tend to take a narrow scope over any event type that predicates a single property (i.e., state) of an individual. If this is true, then what do we make of the obviously ungrammatical sentence in (60):

(60) *Mary died for two years.

Why is it not possible to apply the interval to Mary's state of being dead? In fact, it does seem that such cases are marginally permitted, as (61) shows:

(61) ?My terminal died for 2 days last week.

Apparently, the state that is delimited by an interval must be something that is potentially variable relative to the interpretation for the utterance. Thus, sentence (60) predicates *death* of an individual, which to our general mode of interpretation will not vary once predicated. A computer terminal, on the other hand, will allow for this predicate to be applied over and over again. This relates to the *persistence* of a property over an object, and is outside the scope of this discussion. It seems that a stage-level interpretation may be at play here as well (see Carlson, 1977).[23]

7 INTERACTIONS OF EVENT STRUCTURE AND ARGUMENT STRUCTURE

In this section we explore how a level of event structure can contribute to our understanding of the interactions between LCSs and their mappings to argument structure. We suggest that the distinctions provided by event structure are useful in determining how semantic participants in an LCS are realized syntactically. In fact, we argue that an event structure analysis gives further support to Rappaport and Levin's (1989)

[23] A reviewer has pointed out that what might be at play here is the "reversibility" of the final event. Thus, sentence (61) is more acceptable because the final event there, that is, the terminal being dead, is reversible, whereas in (60) it is not. The notion of reversibility does seem important here and is worth exploring. This issue is taken up in Pustejovsky (to appear).

argument for deep unaccusativity. Much of our discussion, however, will be merely suggestive and must await further empirical investigations for support. For independent arguments in support of a level of event structure, see Grimshaw (1990) and Grimshaw and Vikner (1990).

We begin by discussing how the different event types translate to different verb classes as defined by their grammatical behavior. It is interesting to note that there is no direct or predictable behavior for the arguments of a verb as determined by its event type alone. For example, the verbs which are specified as transitions appear to form no equivalence class with respect to grammatical behavior. That is, all the verbs in (62) below are lexically transitions, but fall into distinct argument structure verb classes (see Levin, 1989):

(62) a. The bottle broke. (Unaccusative)
    b. Mary broke the bottle. (Causative)
    c. Mary built a table. (Creation)
    d. The movie frightened Mary. (Psychological)

Similarly, those verbs which denote processes are associated with different verb classes, for example, those in (63):
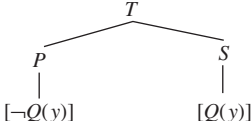
(63) a. Mary slept. (Unergative)
    b. John ran. (Manner of motion)

Using a level of event structure, we will argue that verb classes such as unaccusatives and unergatives correlate with independent principles of mapping from semantics to argument structure.

If we assume that for unaccusative verbs the subject is an underlying object (the "deep unaccusativity" analysis), then the first general behavior we see emerging from the sentences in (62) above is the following:

(A) The semantic participant involved in a predicate opposition is mapped onto the internal argument position of the lexical structure (roughly the d-structure object position).

That is, an event structure like that in (64a) is associated with an argument structure like (64b):

(64) a. ES:

$$
\begin{array}{ccc}
 & T & \\
P & & S \\
\end{array}
$$

LCS': $[\neg Q(y)]$ $[Q(y)]$

    b. $V(y)$

As argued in previous sections, all transitions involve a predicate opposition of some sort. Yet, by itself, this property fails to distinguish adequately the verb classes in (62).

Independent of this principle, we argue, following Grimshaw (1990) and Pustejovsky (1989a), that the notions of causer and agent are somehow associated with the initial subevent of an event structure. More explicity, let us propose the following principle:

(B) The agentive participant in the initial subevent of event structure is mapped onto the external argument position of the lexical structure (roughly the d-structure subject).

The result of both principles A and B applying in the structure in (65a) below is the argument structure in (65b) (where an external argument is marked with an asterisk):

(65) a.

ES:

$$T$$
$$P \qquad\qquad\qquad S$$

LCS′:

$$[Q(y)]$$

$$[\text{act}(x, y) \;\&\; \neg Q(y)]$$

b. $V(x^*, y)$
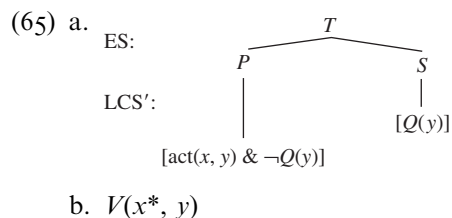
An analysis in terms of event structure allows us to speculate on just what an unaccusative is, in terms of lexical semantic structure. Namely, *an unaccusative is a transition involving a unary predicate opposition, and nothing else.*

Above it was argued that resultative constructions are formed from processes in composition with a phrase denoting a state. Here we show that the apparent counter-examples to this generalization involving unaccusatives, discussed by Rappaport and Levin (1989), are not actually cases of the resultative construction at all, but involve the addition of emphatic (or manner) adjunct phrases. These cases are the following:

(66) a. The river froze solid.
     b. The bottle broke open.

These are not true resultatives, for notice that the predication of the adjunct phrase is merely an attribute to the state introduced by the transition/unaccusative verb itself. This becomes clearer when we consider the following data:

(67) a. The river froze in 20 minutes.
     b. The river froze solid in 20 minutes.

(68) a. The bottle broke suddenly.
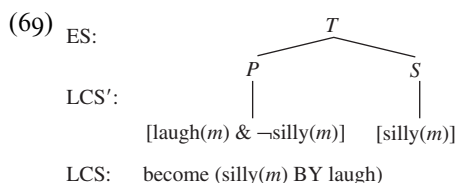   b. The bottle broke open suddenly.

The events in both (67a) and (67b) and (68a) and (68b) are coextensive. That is, it is not the case that the event denoted in (a) is a subpart of that denoted in (b); rather they are the same event, with different information being expressed about it. That is, these are unlike the previous cases where a process shifted to a transition. Thus, in our terms, the examples mentioned in Rappaport and Levin (1989) as resultative constructions are not logically the same as the classic resultative construction. If this is the case, then the generalization that an unaccusative verb is a transition involving a unary predicate opposition strengthens Rappaport and Levin's argument for deep unaccusativity, assuming that only processes enter into resultative constructions.

To conclude this section, we simply state without motivation three final principles involved in mapping from event structure to argument structure. For more detailed discussion, the reader is referred to Pustejovsky (to appear).

(C) If the predicate opposition involves a relation, then both the participants are mapped onto internal argument positions of the argument structure. Otherwise, relational arguments are mapped directly as expressed at event structure; for example, *give* and *put* are examples where the culminating state is a relation, and both arguments are realized as internal arguments.

(D) Any participant in the initial event not expressed by principles (A) or (B) is mapped onto the external argument position.

(E) Each subevent must be associated with at least one argument position at lexical structure.

It is clear from the resultative data and the false reflexive data (e.g. *laugh herself silly*), that certain predicates require the expression of a separate, unsubcategorized argument while others do not, for example, *hammer the metal flat* (see Simpson, 1983). Principle (E) requires that every subevent (in this case, *silly* and *flat*) be associated with at least one argument position. In conjunction with principles (B) and (A), the false reflexive NP serves the function of representing the predicate opposition in the transition, while the external argument represents the causer in the initial event. Therefore, there must be both an internal argument (*herself*) and a unique external argument (*Mary*) to satisfy both conditions. Thus, the reflexive NP acts as a kind of argument epenthesis in the lexical structure:

(69) ES:

$$T$$
$$\overset{\diagup\quad\diagdown}{P\qquad\qquad S}$$

LCS′:

$$\underset{[\text{laugh}(m)\ \&\ \neg\text{silly}(m)]}{|}\qquad\underset{[\text{silly}(m)]}{|}$$

LCS: become (silly(*m*) BY laugh)

Notice that in the regular resultative cases the principles (A) and (B) are satisfied by the existing argument structure, obviating the need for argument epenthesis.

In this section, we have tried to give some indication of how event structure contributes to the understanding of the mapping between the lexical semantics and syntax, as represented at argument structure. We have glossed over many details and problems which might remain, but the general theme is quite clear: the theory of grammar can be greatly enriched by representations such as those considered here for events. It remains to examine the limitations and further interactions of this system.

8   CONCLUSION

In this paper, we have tried to outline a partial theory of word meaning making use of a rich structural system for the subeventual properties of verbs. We have argued that words lexically specify a specific sequence of subevents organized by a well-defined geometry. Such configurations provide a very restrictive framework for partially defining the lexical semantics of words in the grammar. Metalogical notions such as *cause* and *become* are computed from the aspectual configuration associated with a lexical item and then a sentence.

By looking at the event structure of words in composition, we explained how the lexical specification of a verb's event-type can be overriden as a result of syntactic and semantic compositionality of the verb with other elements in the sentence.

Another advantage of proposing a richer subeventual structure for propositions is that we now have an analysis for the behavior of temporal adverbials, as well as adverbials such as *almost* and *rudely*. It was suggested that the reason accomplishments such as *build* allow two interpretations with such adverbs is due to the number of semantically specified event constituents for its event structure. Achievements, while having a very similar event constituency, have no unique semantic expression associated with the process preceding the culminating state. Finally, we examined briefly how the semantic participants in an event structure are associated with arguments in an

argument structure representation. Following Grimshaw (1990), the notion of causer and "external" argument can be linked to a participant in the initial subevent within an event structure.

The purpose of this paper has been to show how verbs decompose into distinct event types with internal structure. Rather than examining the formal semantics of such structures, we have studied the effect that a level of event structure has on the grammar, and how it interacts with other levels of representation. In many ways, the proposal here is preliminary and merely suggestive, but we feel that an appreciation of the internal structure of events for word meaning is an important representational device for lexical semantics.

REFERENCES

Bach, E. (1986). 'The algebra of events', *Linguistics and Philosophy 9*: 5–16.

Belletti, A. and Rizzi, L. (1985). 'Psych verbs and θ-theory'. Manuscript. MIT.

Bennett, M. and Partee, B. (1972). 'Toward the logic of tense and aspect in English'. Distributed by Indiana University Linguistics Club.

Brachman, R. (1979). 'On the epistemological status of semantic networks', in N. Findler (ed.), *Associative Networks: Representation and Use of Knowledge by Computers*. New York: Academic Press.

Bresnan, J. (ed.). (1982). *The Mental Representation of Grammatical Relations*. Cambridge, MA: MIT Press.

Burzio, L. (1986). *Italian Syntax: A Government-binding Approach*. Dordrecht: Reidel.

Carlson, G. (1977). 'Reference to kinds in English'. Ph.D. dissertation, University of Massachusetts.

Carlson, L. (1981). 'Aspect and quantification', in P. Tedeschi and A. Zaenen (eds.), *Syntax and Semantics: Vol. 14, Tense and Aspect*. New York: Academic Press.

Carnap, R. (1956). *Meaning and Necessity*. Chicago: University of Chicago Press.

Chomsky, N. (1957). *Syntactic Structures*. The Hague: Mouton.

Collins, A. and Quillian, M. (1969). 'Retrieval time from semantic memory', *Journal of Verbal Learning and Verbal Behavior 9*: 240–47.

Comrie, B. (1976). *Aspect*. Cambridge: Cambridge University Press.

——(1985). *Tense*. Cambridge: Cambridge University Press.

Cresswell, M. (1985). *Adverbial Modification*. Dordrecht: Kluwer.

Croft, W. (1990). *Categories and Relations in Syntax: The Clause-level Organization of Information*. Chicago: University of Chicago Press.

Davidson, D. (1980). *Essays on Actions and Events*. Oxford: Clarendon Press.

Dowty, D. R. (1979). *Word Meaning and Montague Grammar*. Dordrecht: Reidel.

Fillmore, C. (1968). 'The case for case', in E. Bach and R. Harms (eds.), *Universals in Linguistic Theory*. New York: Holt, Rinehart, and Winston.

——(1988). 'The mechanisms of construction grammar'. Manuscript. University of California, Berkeley.

Foley, W. A. and Valin, R. D. van, Jr. (1984). *Functional Syntax and Universal Grammar*. Cambridge: Cambridge University Press.

Fodor, J. (1975). *The Language of Thought*. Cambridge, MA: Harvard University Press.

Graham, R. (1987). *Aristotle's Two Systems*. Oxford: Clarendon Press.

Green, G. (1974). *Semantics and Syntactic Regularity*. Bloomington: Indiana University Press.

Grimshaw, J. (1979). 'Complement selection and the lexicon', *Linguistic Inquiry 10*: 279–326.

——(1986). 'Nouns, arguments, and adjuncts'. Manuscript, Brandeis University.

——(1990). *Argument Structure*. Cambridge, MA: MIT Press.

Grimshaw, J. and Vikner, S. (1990). 'Obligatory adjuncts and the structure of events'. Manuscript, Brandeis University.

Gruber, J. (1965). 'Studies in lexical relations'. Ph.D. dissertation, MIT, Cambridge, MA.

Hale, K. and Keyser, J. (1986). 'Some transitivity alternations in English'. Lexicon Project Working Papers 7. Center for Cognitive Science, MIT.

Hale, K. and Laughren, M. (1983). 'The structure of verbal entries'. Walpiri Lexicon Project, MIT, Cambridge.

Higginbotham, J. (1985). 'On semantics', *Linguistic Inquiry 16*: 547–93.

—— (1989). 'Elucidations of Meaning', *Linguistics and Philosophy 12*: 465–518.

Hinrichs, E. W. (1985). 'A compositional semantics for Aktionarten and NP reference in English'. Ph.D. dissertation, Ohio State University.

Horn, L. (1989). *A Natural History of Negation*. Chicago: University of Chicago Press.

Ingria, R. and Pustejovsky, J. (1990). 'An active objects approach to syntax, semantics, and parsing', in C. Tenny (ed.), *MIT Working Papers in Parsing*. Cambridge, MA: MIT Press.

Jackendoff, R. (1972). *Semantic Interpretation in Generative Grammar*. Cambridge. MA: MIT Press.

—— (1983). *Semantics and Cognition*. Cambridge, MA: MIT Press.

—— (1987). 'The status of thematic relations in linguistic theory', *Linguistic Inquiry 18*: 369–412.

—— (1990). *Semantic Structures*. Cambridge, MA: MIT Press.

Katz, J. J. (1972). *Semantic Theory*. New York: Harper and Row.

Katz, J. J. and Fodor, J. (1963). 'The structure of a semantic theory', *Language 39*: 170–210.

Kenny, A. (1963). *Actions, Emotions, and Will*. New York: Humanities Press.

Keyser, S. J. and Roeper. T. (1984). 'On the middle and ergative constructions in English', *Linguistic Inquiry 15*: 381–416.

Klein, E. and Sag, I. (1985). 'Type-driven translation', *Linguistics and Philosophy 8*: 163–202.

Krifka, M. (1987). 'Nominal reference and temporal constitution'. Manuscript. Tübingen.

Kunze, J. (1986). 'Phasen, Zeitrelationen und zeitbezogene Inferenzen', in *Probleme der Selektion und Semantik*. Berlin: Akademie-Verlag.

Lakoff, G. (1970). *Irregularity in Syntax*. New York: Holt, Rinehart, and Winston.

—— (1971). 'On generative semantics', in D. Steinberg and L. Jakobovits (eds.), *Semantics: An Interdisciplinary Reader*. Cambridge: Cambridge University Press.

Levin, B. (1989). 'Towards a lexical organization of English verbs'. Manuscript, Northwestern University.

—— and Rapoport, T. R. (1988). 'Lexical subordination', in *Papers from the 24th Regional Meeting of the Chicago Linguistic Society*, 275–89.

—— and Rappaport, M. (1986). 'The formation of adjectival passives', *Linguistic Inquiry 17*: 623–62.

—— (1988). 'On the nature of unaccusativity', in J. Carter and R.-M. Dechaine (eds.), *Proceedings of the North East Linguistic Society (NELS 19)*, Cornell University 1988. GLSA Publications.

Levin, L. (1986). 'Operations on lexical forms: Unaccusative rules in Germanic Languages', Ph.D. dissertation, MIT, Cambridge, MA.

Lloyd, G. E. R. (1968). *Aristotle: The Growth and Structure of his Thought*. Cambridge: Cambridge University Press.

McConnell-Ginet, S. (1982). 'Adverbs and logical form: A linguistically realistic theory', *Language 58*: 144–84.

McKeon, R. (1941). *The Basic Works of Aristotle*. New York: Random House.

Modrak, D. (1987). *Aristotle: The Power of Perception*. Cambridge: Cambridge University Press.

Moravcsik, J. M. (1975). 'Aita as generative factor in Aristotle's philosophy', *Dialogue 14*: 622–38.

Mourelatos, A. (1978). 'Events, states, and processes', *Linguistics and Philosophy 2*: 415–34.

Parsons, T. (1985). 'Underlying events in English', in E. LePore and B. McLaughlin (eds.), *Actions and Events*. Oxford: Blackwell.

——(1990). *Events in the Semantics of English*. Cambridge, MA: MIT Press.

Pelletier, J. and Schubert, L. (1989). 'Mass expressions', in D. Gabbay and F. Guenther (eds.), *Handbook of Philosophical Logic, Vol. 4*. Dordrecht: Reidel, 387–453.

Perlmutter, D. (1978). 'Impersonal passive and the unaccusative hypothesis', *Proceedings of the Annual Meeting of the Berkeley Linguistic Society 4*: 157–87.

Pesetsky, D. (1987). 'Binding problems with experiencer verbs', *Linguistic Inquiry 18*: 126–40.

Pustejovsky, J. (1989a). 'Issues in computational lexical semantics', in *Proceedings of the European Association for Computational Linguistics* (pp. xvii–xxv). Manchester, UK, April 1989.

——(1989b). 'The geometry of events', in C. Tenny (ed.), *Generative Approaches to Aspect*. Cambridge, MA: MIT Lexicon Project.

——(1991). 'The generative lexicon'. *Computational Linguistics. 17(4): 409–41*.

——(to appear). *The Generative Lexicon: A Computational Theory of Lexical Semantics*. Cambridge, MA: Bradford Books/MIT Press.

Pustejovsky, J. and Boguraev, B. (1991). 'Lexical knowledge representation and natural language processing'. *IBM Journal of Research and Development 35(4)*.

Quillian, M. R. (1968). 'Semantic memory', in M. Minsky (ed.), *Semantic Information Processing*, Cambridge, MA: MIT Press, 227–70.

Rapoport, T. R. (1990). 'Secondary predication and the lexical representation of verbs', *Machine Translation 5*: 31–55.

——(to appear). 'Verbs in depictives and resultatives', in J. Pustejovsky (ed.), *Semantics and the Lexicon*. Dordrecht: Kluwer.

Rappaport, M., Laughren, M. and Levin, B. (to appear). 'Levels of lexical representation', in J. Pustejovsky (ed.), *Semantics and the Lexicon*. Dordrecht: Kluwer.

——and Levin, B. (1988). 'What to do with theta-roles', in W. Wilkens (ed.), *Thematic Relations*. New York: Academic Press, 7–36.

——(1989). 'Is there evidence for deep unaccusativity? An analysis of resultative constructions'. Manuscript, Bar Ilan University and Northwestern University.

Reinhart, T. (1976). *The Syntactic Domain of Anaphora*. Ph.D. dissertation, MIT, Cambridge, MA.

Rohrer, C. (1977). 'Die Beschreibung einiger Spanischer Verbalperiphrasen im Rahmen eines Zeitlogischen Systems', in C. Rohrer (ed.), *On the Logical Analysis of Tense and Aspect*. Tübingen: TBL Verlag Gunter Narr.

Rohrer, C. (ed.). (1977). *On the Logical Analysis of Tense and Aspect*. Tübingen: TBL Verlag Gunter Narr.

Ryle, G. (1949). *The Concept of Mind.* London: Barnes and Noble.

Scha, R., and Bruin, J. de (1988). 'The interpretation of relational nouns', in *Proceedings of the 26th Annual Meeting of the Association for Computational Linguistics*, Buffalo, NY, 25–32.

Schank, R. (1975). *Conceptual Information Processing*. Amsterdam: North-Holland.

Simpson, J. (1983). 'Resultatives', in L. Levin and A. Zaenen (eds.), *Papers in Lexical–Functional Grammar*. Bloomington, IN: Indiana University Linguistics Club.

Talmy, L. (1985). 'Lexicalization patterns', in T. Shopen (ed.), *Language Typology and Syntactic Description*. Cambridge: Cambridge University Press.

Tenny, C. (1987). 'Grammaticalizing aspect and affectedness'. Ph.D. dissertation, MIT, Cambridge, MA.

——(1989). 'The aspectual interface hypothesis'. Lexion Project Working Papers 31, MIT, Cambridge, MA.

Vendler, Z. (1967). *Linguistics and Philosophy*. Ithaca: Cornell University Press.

Verkuyl, H. (1972). *On the Compositional Nature of the Aspects*. Dordrecht: Reidel.

——(1989). 'Aspectual classes and aspectual distinctions', *Linguistics and Philosophy 12*: 39–94.

Vlach, F. (1981). 'The semantics of the progressive', in P. Tedeschi and A. Zaenen (eds.), *Syntax and Semantics, Vol. 14, Tense and Aspect*. New York: Academic Press.

Weinreich, U. (1972). *Explorations in Semantic Theory*. The Hague: Mouton.

Wilks, Y. (1975). 'A preferential pattern seeking semantics for natural language inference', *Artificial Intelligence 6*: 53–74.

Williams, E. (1981). 'Argument structure and morphology'. *Linguistic Review 1*: 81–114.

—— (1987). 'Binding and linking'. Manuscript, UMASS. Amherst.

Wright, G. H. von (1963). *Norm and Action*. London: Routledge and Kegan Paul.