

Title of Dissertation: **Event Structure in Language Comprehension**

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Abstract

This dissertation makes a significant contribution to the fields of cognitive psychology and linguistics. It presents findings that bear on arguably the most central question in the field of human language comprehension: is the **meaning** of linguistic material computed as early as its **structure**? The results of the dissertation research support a “yes” answer: the meaning of the words and word parts affect the way that the brain perceives their structure at the earliest stage of language understanding. The research also raises a new question: is there a sharp distinction between the way that the brain handles the basic meaning of words and word parts and the way it handles other kinds of meaning, such as real world knowledge about objects?

This dissertation focuses on a particular kind of meaning information: predicate event structure. Event structure refers to the type of event denoted by a predicate and the relationship between the subparts of the event and the syntactic components of the predicate, such as the verb and its arguments (Rosen, 1999). For example, if Morpheus is building a ship and then he quits in the middle of doing it, it is not true that he has built a ship. In contrast, if Trinity is running and then she quits in the middle of running, it is still true that she has run. These two events, *building a ship* and *running*, differ in their event structure. A crucial difference in their event structure is the existence or non-existence of an endpoint. The reason that Morpheus has not built a ship if he quits in the middle is that the meaning of *build a ship* includes an endpoint. The reason Trinity has run even if she quits early is because the meaning of *run* does not include the notion of an endpoint (Vendler, 1957; 1967). There are other aspects of a verb's event structure such as a causer and a process portion (Folli, 2001), though there is much controversy over the representation of both of these event subparts. This dissertation focuses on one particular component of verb event structure, the endpoint or **terminus**. An event that includes an

endpoint in its meaning is known in the event structure literature is known as a **telic** event. An event that does not include an endpoint in its meaning is considered **atelic** (Dowty, 1979).

The major experimental finding presented in this dissertation is that event structure information, specifically verb phrase telicity, immediately affects sentence comprehension at the earliest stage. In order to understand what is meant by the earliest stage, consider what must happen in order for you to understand a sentence. Imagine that you heard or read the words in (1).

(1) *The actress noticed...*

Previous research (Bever, 1970; others) shows that you begin making decisions about who did what to whom immediately, certainly before the sentence is finished. Research also shows that upon hearing the words in (1), you will most likely assume that the actress is the semantic **agent** (do-er) of the noticing event, the one who did the noticing, as opposed to the semantic **patient** or **theme** (undergoer), the one who got noticed by someone else.

Now imagine that the sentence in (1) is continued as shown in (2).

(2) *The actress noticed by the writer...*

This continuation makes it clear that the initial assumption that the actress noticed someone was wrong. At this point, your language comprehension system must reanalyze the sentence in order to figure out that the writer is the semantic agent of the noticing event and the actress is the semantic patient/theme of the noticing event. Previous research (Trueswell, Tanenhaus, & Garnsey, 1994) has shown that this reanalysis process is associated with a significant increase in reading times on *by the writer* in (2). This slowdown is known as the **reduced relative effect (RRE)**; it is measured as the difference in reading times between a reduced relative clause sentence, such as the one that begins in (2) and the corresponding unambiguous unreduced relative clause version, such as the sentence that begins in (3).

(3) *The actress that was noticed by the writer...*

Now, you may be thinking about whether or not you in fact make these assumptions. The mental computations that sentence comprehension research is often concerned with take place on a millisecond time-scale. Consider how quickly you understand sentences when you are listening to a news report on the radio, for example. Normal speech occurs at a rate of about four words per second; in other words, each word takes an average of about 250 milliseconds to utter (Duffy & Pisoni, 1992). The rate of normal language comprehension is so fast that it is not possible to be consciously aware of many of the mental events that occur as you understand language. For this reason, reaction time data are used as evidence that a mental event occurs. This is done by comparing the amount of time it takes to understand different sentences, such as the ambiguous reduced relative clause structure in (2) and the unambiguous unreduced relative clause structure in (3). You may not be aware that you initially assumed that the actress noticed someone in (1), but the experimental evidence for an increase in reading times on *by the writer* in (2) but not in (3) suggests that you did.

The idea that the earliest stage of sentence comprehension involves syntactic structure building without the influence of semantics has been promoted by Frazier and colleagues (beginning with Frazier, 1979). Rayner, Carlson, and Frazier (1983) found there was no difference in the amount of processing difficulty (in terms of reading times measured by an eye tracker) between (4)a and (4)b.

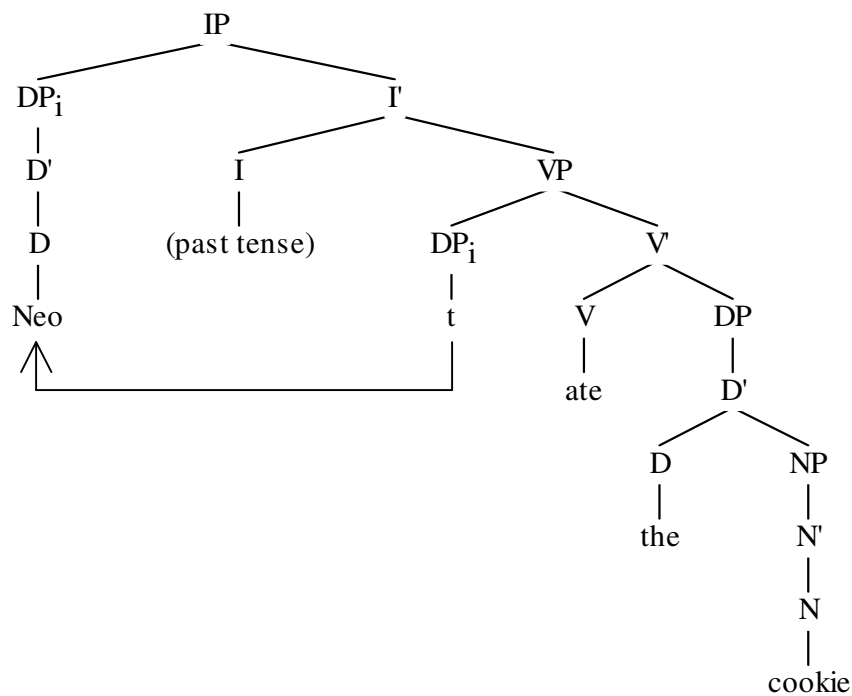
(4)

- a. *The performer sent the flowers was very pleased.*
- b. *The florist sent the flowers was very pleased.*

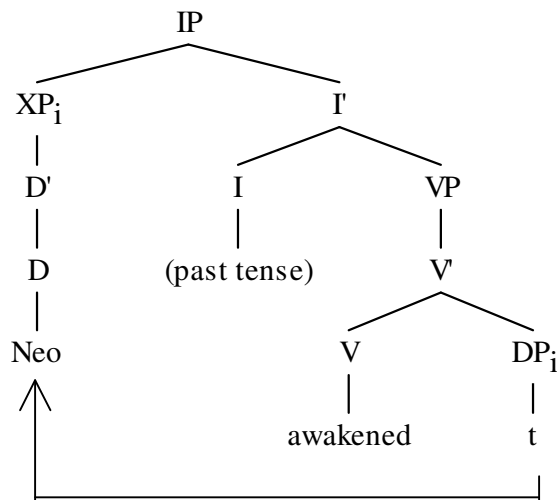
This finding was taken to support the garden path model, a two stage model in which the earliest stage of comprehension involved only syntactic structure building and the second stage involved the integration of meaning information (such as information about whether performers and florists are more likely to send or receive flowers).

In order to argue that meaning information does not influence syntactic parsing, Rayner et al. showed that one kind of meaning information, real world knowledge, does not affect structure building decisions during the earliest stage of comprehension. Predicate event structure is another kind of meaning information that differs from real world knowledge in a way that is critical with regard to the controversy: event structure distinctions such as telic versus atelic are tightly correlated with differences in syntactic structure. In other words, if a verb's lexical entry specifies that it is inherently telic, the following two things will be true of it: 1) its meaning requires the notion of an endpoint, and 2) it has a particular syntactic structure—one that necessarily includes an internal argument (underlying direct object) (Tenny, 1987). All telic predicates either have an overt direct object, e.g. *the cookie*, as shown in (5) or an unaccusative structure which has an underlying direct object, e.g. *Neo*, as shown in (6).

(5) Example of an overt direct object: *Neo ate the cookie*.



(6) Example of an underlying direct object (in an unaccusative structure): *Neo awakened*.



Because telicity has both semantic and syntactic implications, it is a critical area of investigation in the controversy over whether syntactic structure building decisions are influenced by meaning.

The major empirical question that has been investigated in this dissertation is whether inherent verb telicity information reduces the RRE (the same parsing effect investigated in the aforementioned studies by Bever 1970, Trueswell et al. 1994, and Rayner et al. 1983). This question was investigated in three experimental paradigms: 1) word maze, 2) speaker change monitoring (a spoken language comprehension task), and 3) self-paced reading. Results from all three paradigms support the conclusion that the RRE is smaller when the embedded verb is telic than when it is atelic. The most compelling results are from the word maze experiment. In the word maze paradigm, participants are presented with a series of word pairs, and their task is to choose which of the two words is a grammatical continuation of the sentence at each step. In order to complete a trial successfully, the participant must process the sentence incrementally, parsing the previously presented words in order to make each choice. The participant's reaction time for integrating each word into the sentence is measured. The word maze experiment showed that reduced relative effects (RREs) measured as reaction times for choosing the word *by* were significantly smaller when the embedded verb was telic as in (7)a than when it was atelic as in (7)b.

(7)

- a. *The actress tripped by the writer left in a hurry.* (*tripped* is telic)
- b. *The actress sketched by the writer left in a hurry.* (*sketched* is atelic)

A significant effect of telicity on the RRE was also found in the speaker change monitoring paradigm. In this paradigm, participants listen to spoken sentences and indicate whether they hear a word or part of a word spoken by a different speaker than the rest of the sentence (Townsend & Bever, 1991). The results showed that RREs measured as speaker change detection errors were significantly smaller when the embedded verb was telic than when it was atelic. The sentences were almost identical to the ones used in the word maze paradigm (such as the sentences in (7)a and (7)b). The speaker change always occurred on the first syllable of the noun in the *by*-phrase, e.g. *writer* in (7)a and (7)b.

Experiments using the self-paced reading paradigm also showed a significant effect of telicity on the RRE. On each trial in the self-paced reading paradigm, participants are presented with a sentence, one region at a time, and they successively press a key to make each region of the sentence appear on the screen. After many of the trials, the participant is asked a question about the meaning of the sentence in order to encourage reading for comprehension. A post-hoc analysis of two prior self-paced reading experiments (McRae, Spivey-Knowlton, & Tanenhaus, 1998; Tabossi, Spivey-Knowlton, McRae, & Tanenhaus, 1994) showed that RREs (measured as self paced reading times for the region including the embedded verb and the preposition *by*) were significantly smaller when the embedded verb was telic than when it was atelic. The sentences in the two self-paced reading experiments that showed the significant telicity effect were similar to the sentences in (7)a and (7)b. In summary, results from all three experimental tasks show that telicity has a statistically significant immediate effect on sentence comprehension.

One of the questions raised by the research is how to reliably determine whether a predicate is telic or atelic. Chapter 2 of the dissertation focused on this question, and chapter 3 presented a

questionnaire study aimed at developing an objective means of assessing verb phrase telicity. This questionnaire tested all of the verb phrases used in the word maze experiment in three classic telicity tests from the event structure literature. The tests require a native speaker (of English, for example) to make judgments about the acceptability and meaning of the verb phrases in particular sentence frames. For example, in one of the tests, participants were asked to choose which of two sentences is more natural. The two sentences were identical except for whether they ended with a *for* adverbial phrase or an *in* adverbial phrase, as in (8)a and (8)b.

(8) Example of *for/in* adverbial forced choice task: Choose the more natural of the two sentences.

a. *Trinity ran for an hour.*

b. *Trinity ran in an hour.*

Atelic predicates such as *ran* were predicted to be more natural with *for* adverbials, and telic predicates such as *built the ship* were predicted to be more natural with *in* adverbials. These predictions were borne out in the results of the questionnaire, which was completed by 24 native speakers of English.

In summary, the dissertation shows that telicity has a statistically significant immediate effect on language comprehension, and it also shows that a verb phrase's telicity can be determined objectively using a questionnaire. This research has implications for linguistic theory, for the study of child language acquisition, for developing more effective language processing software, for developing more effective treatments for language deficits, and for research on how the brain processes language.

The implication of this research for linguistics is that the results provide evidence that information about a verb's event structure and whether it is telic or atelic is stored in a verb's lexical entry. The results support theories of syntax in which parts of an event, such as an endpoint, are associated with particular bits of syntactic structures, such as the presence of an internal argument.

The finding that verb telicity information is used during on-line language comprehension raises the question of how children learn whether a verb is telic or atelic. Wagner (2001, 2002) has shown that

children acquire at least some verb telicity information at a fairly young age. This raises two important questions for future research. The first question is whether children learn the telic versus atelic distinction from the constructions in which adults use them. The second question is whether children have an innate mechanism that predisposes them to be sensitive to the telic versus atelic distinction.

The linguistic and psycholinguistic data in this dissertation suggest that telicity may have useful applications in computational linguistics. The linguistic data show that a verb's inherent telicity is related to the noun phrase arguments that are required and to the semantic roles that these noun phrases bear. This suggests that tagging verbs as telic or atelic in corpora, including inherent telicity in the lexical specifications of verbs, and including telicity in phrase structure rules or processing constraints could improve the performance of natural language processing software.

The finding that telicity and event structure affect on-line comprehension raises the question of how and whether it is used by speakers with language deficits such as aphasia resulting from stroke damage. The study of event structure may be particularly interesting in research on aphasia, because event structure lies at the crossroads of syntax and semantics. It has been claimed that lesions in the left inferior frontal gyrus (Broca's area) are typically associated with deficits in processing syntactic structure (among other things) and that lesions in the left temporal parietal region (Wernicke's area) are typically associated with deficits in accessing words and word meaning. The study of event structure in aphasia could provide interesting new data on how and whether language areas in the brain are specialized.

The implications of this research are particularly strong for the area of cognitive psychology. That is, the research resolves a controversy that has been the focus on the sentence processing field for decades. As mentioned above, the controversy surrounds the question of whether meaning influences syntactic structure building. It may be true that encyclopedic knowledge about words does not influence syntactic parsing at the earliest stages as Frazier and colleagues have argued. However, there are syntactically relevant aspects of meaning that are stored in the lexicon—these are accessed early, and they influence syntactic structure building during the earliest stages of comprehension. In addition to resolving this long-debated controversy, the research raises a new question: does syntactically relevant

meaning information such as event structure play a privileged role in language comprehension over other kinds of meaning information?

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