



Brief article

Reading time evidence for enriched composition

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Abstract

Verbs like ‘begin’ and ‘enjoy’ appear to semantically select a complement that expresses an activity or an event (Jackendoff, R. (1997). *The architecture of the language faculty*. Cambridge, MA: MIT Press; Pustejovsky, J. *Cognition* 41 (1991) 47; Pustejovsky, J. (1995). *The generative lexicon*. Cambridge, MA: MIT Press). When these verbs occur with a complement that does not directly denote either an activity or an event (e.g. ‘...began the book’ or ‘...enjoyed the book’), the complement must be type-shifted from an object to an activity to conform to the verb’s semantic restrictions. We report an experiment in which self-paced reading times were found to be longer for complements that required type-shifting than for complements that directly matched the semantic restrictions of the matrix verb. This finding is argued to provide on-line evidence for a type of enriched lexical processing posited in recent lexical semantic research. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Verbs like ‘begin’, ‘finish’, ‘enjoy’, and ‘endure’ have been argued to be examples of classes of verbs that semantically select for an activity or an event (e.g. Jackendoff, 1997; Pustejovsky, 1991, 1995). The argument is partly motivated by

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the fact that these verbs subcategorize for syntactic forms that can explicitly mark the complement as an activity or event (Levin, 1993; Quirk, Greenbaum, Leech & Svartvik, 1985), such as a participle ('-ing' or gerundive) clause (e.g. 'The critic began reading the book') or an infinitival clause (e.g. 'The critic began to read the book'). When these verbs occur with a simple noun phrase (NP) complement, the NP often unambiguously denotes an activity or event. For example, 21% of the sentences with 'begin' in the Brown corpus involve NP complements, 73% of which can be clearly classified as such (e.g. 'negotiations', 'work', 'operations', 'its session'). The examples in (1) illustrate, however, that the complement for these verbs need not directly denote either an activity or an event.

(1) a. The critic began the book.

(1) b. The critic enjoyed the book.

Crucially, however, speakers agree (see norming data below) that the interpretations of (1) are adequately paraphrased by one of the sentences in (2).

(2) a. The critic began [reading/reviewing/to read/to review] the book.

(2) b. The critic enjoyed [reading/reviewing] the book.

In the context of verbs like 'begin' and 'enjoy' (but not in others, such as 'burn', 'purchase', 'drop') the complement appears to be interpreted as an activity or event by implicitly projecting a predicate phrase which incorporates the NP as its direct object.

Examples like (1) have motivated arguments for an enriched form of semantic composition in which lexical-semantic properties of key sentential elements conspire to modify default interpretations and introduce semantic structure that is not explicitly represented in surface form (Jackendoff, 1997; Pustejovsky, 1991, 1995). Enriched composition contrasts with the standard view of semantic composition in which an interpretation is determined simply by combining lexical representations according to their position in syntactic structure (Jackendoff, 1997). We report a reading time study that provides behavioral evidence for enriched composition.

1.1. Enriched composition

Jackendoff (1997) outlines several types of constructions that are argued to require enriched composition, many of which involve forms of type-shifting (e.g. Bach, 1986; Partee, 1992). In cases like (1), the complement must be type-shifted from an object or entity to an activity in order to conform to the verb's semantic restrictions (Jackendoff, 1997; Pustejovsky, 1991, 1995). For verbs like 'begin' and 'enjoy', this operation can be viewed as a general function: "interpret NP as ... an unspecified activity involving NP" (Jackendoff, 1997, p. 61). The specific activity ascribed to the NP is determined by semantic and pragmatic information associated with the NP, the verb's subject, and, in some cases, the discourse context. For example, (1a) is often interpreted as one of the examples in (2a), but (3) is most likely to be interpreted as (4).

(3) The author began the book.

(4) The author began [writing/to write] the book.

Properties of the subject NP appear to determine the default interpretation in an otherwise neutral context. That interpretation can be usurped by an appropriate discourse context, as in (5).

(5) The author disliked proofreading his work. Reluctantly, in the morning, the author began the book.

Pustejovsky (1995) accounts for contrasts like these, and for the general problem of how different meanings emerge in different contexts, with a set of compositional rules that operates over a semantic typing system. The lexical representation for objects such as ‘book’ is argued to include a qualia structure, which codes attributes of the object, such as its constituent parts, telic properties (purpose and function), and agentive properties (mode of creation), among others. Qualia are relational structures with variables that are bound during interpretation. For example, the telic representation for ‘book’ is a two-argument event structure headed by the verb ‘read’. The agentive representation for ‘book’ is also a two-argument event structure, but one that is headed by the verb ‘write’. The default interpretation of (1a) as (2a) and (3) as (4) results from type-shifting operations in which the qualia structure for the subject picks out either the telic or agentive structures in the complement’s representation. This information is then combined with the verb’s semantic/conceptual representation to produce a complex predicate, of which ‘book’ is the argument.

2. The experiment

We examined reading times for sentences that are argued to require enriched composition to determine whether these arguments are psychologically justified. If a semantic mismatch between a verb and its complement triggers type-shifting and the introduction of additional semantic structure, reading times should be longer for a sentence with mismatching constraints than one in which the complement matches the verb’s semantic restrictions.

A self-paced reading task was used to contrast constructions requiring type-shifting (6) with constructions requiring simple composition ((7) and (8)).

(6) The author was starting the book in his house on the island.

(7) The author was writing the book in his house on the island.

(8) The author was reading the book in his house on the island.

Sentences like (7) used a verb that readers report is implicitly part of the interpretation of the type-shifted form. Because ‘The author was starting the book’ does not explicitly specify what activity is taking place, the reader must somehow apply stored knowledge about authors and books to interpret the string. Constructions like (6) should engender longer reading times than (7) and (8) at or shortly after the complement if type-shifting is needed to coerce the NP into an appropriate semantic type. Constructions like (8) used a verb that reflects a plausible but non-preferred interpretation of the type-shifted constructions. As these constructions express less prototypical relationships than constructions like (7), they may engender longer reading times. However, non-preferred constructions may be less costly

than constructions that require type-shifting and the introduction of new semantic structure.

To derive preferred and non-preferred sentences, we asked participants to provide fill-in-the-blank responses to type-shifting sentences like ‘The author was starting _____ the book’ indicating how they would interpret the string. The list of materials included a mixture of sentences with simple past tense (‘...started the...’) and past progressive (‘...was starting the...’) verbs. Two hundred and twelve candidate sentences were randomly assigned to four lists, and 23 subjects completed each list. Thirty-three test sentences were selected such that the dominant response occurred more than twice as often as the next most frequent response. The verbs selected for the preferred condition (e.g. ‘to write’ in (7)) occurred on average 15.2 times (out of 23), ranging from 8 to 23 times. Those selected for the non-preferred condition (e.g. ‘reading’ in (8)) occurred on average 1.3 times, ranging from 0 to 5 times.

To ensure that potential reading time differences were not due to differences in the sensibility of the strings, a further pre-test collected plausibility ratings for the selected constructions. One of each of the constructions illustrated in (6)–(8) was assigned to one of three lists. The constructions were rotated across lists such that each list contained an equal number of sentences from each condition and only one of the versions illustrated in (6)–(8). Twenty-four new subjects participated in this rating task, each assigned to one of the three lists. The raters assigned a number from 1 (makes no sense) to 7 (makes perfect sense) to the sentences in each list. Mean plausibility ratings were 6.4 (type-shifted), 6.4 (preferred), and 6.3 (non-preferred). One-way ANOVAs treating condition as a within-items and within-subjects factor revealed no reliable differences among conditions (all $F < 1$).

To ensure that potential reading time differences were not due to differences in the predictability of the noun phrase given the crucial verb, we had 50 raters complete sentence fragments. The fragments were constructed by removing the critical complement noun and all of the following material from each version of each experimental sentence. For example, the fragment for (6) was ‘The author was starting the’. The mean close probabilities were 0.07 (type-shifted), 0.13 (preferred) and 0.09 (dispreferred). An ANOVA with condition as a within-items factor showed that the conditions did not differ in terms of their close probabilities ($F(2, 64) = 1.27$, NS, $MSe = 0.021$). Correlational analyses on the reading time data from the critical noun and the following word also found no relationship between the close probability of the critical noun and reading time on the critical noun or the following word (both $t(98) < 0.85$). Hence, the reading time differences we report cannot be explained by the predictability of the critical noun.

To ensure that potential reading time differences were not due to differences in the frequency of the matrix verb, we consulted the Francis and Kucera (1967) corpus. The mean frequency of the matrix verb by condition was 123 (type-shifted), 89 (preferred), and 78 (dispreferred). An ANOVA with condition as a within-items factor produced a marginally reliable main effect ($F(2, 64) = 2.64$, $P = 0.08$, $MSe = 6751$). This was mainly due to the greater frequency of the type-shifted verbs. This difference did not lead to a reliable reading time difference on the matrix verb (see below) and it cannot explain the longer reading times on the critical noun

Table 1
Mean reading times

	Verb	Determiner <i>the</i>	Noun <i>book</i>	+ 1 <i>in</i>	+ 2 <i>his</i>	+ 3 <i>house</i>
Type-shifted	388	364	377	385	348	355
Preferred	374	358	357	360	334	344
Non-preferred	380	367	380	361	345	349

and the following word in the type-shifted condition. Any spillover effects due to the frequency of the matrix verb would, if anything, serve to obscure differences between conditions caused by other factors (e.g. type-shifting).

2.1. Method

2.1.1. Participants

Fifty-one native English speakers from The Florida State University participated in the self-paced reading study to fulfill an undergraduate course requirement. All had normal or corrected vision, and none had participated in either pre-test.

2.1.2. Materials

The 33 sets of three sentences were randomly distributed among three lists such that all conditions were equally represented in each list and only one version of each set occurred in each list. The participants were divided into groups, each of which was assigned a separate list.

2.1.3. Apparatus and procedure

Participants were instructed to read at a normal, comfortable pace in a manner that would enable them to answer comprehension questions. Sentences were presented with a self-paced moving window procedure using PC running purpose-built software. Each trial began with a series of dashes on the computer screen in place of the letters in the words. The first press of the space bar replaced the first set of dashes with the first word in the sentence. With subsequent space bar presses, the next set of dashes were replaced by the next word, and the preceding word was replaced by dashes. A yes-or-no question followed each sentence. The computer recorded the time to the nearest millisecond from when a word was first displayed until the next press of the space bar.

2.2. Results

Responses longer or shorter than 2.5 SD of the condition means for each region were treated as missing data. In total, 2.2% of the data were excluded from the condition means and analysis. Table 1 presents the mean reading times for the six words starting at the matrix verb (either ‘starting’, ‘writing’, or ‘reading’ in examples (6)–(8)).

There were no significant differences at the verb or the determiner (DET) of the

NP complement. Differences emerged at the noun and noun + 1 position. Three-way ANOVAs treating either subjects as a random factor ($F1$) or items as a random factor ($F2$) yielded significant effects at the noun ($F1(2, 100) = 5.10, P < 0.01, MSe = 1587; F2(2, 64) = 3.16, P < 0.05, MSe = 1954$) and at the noun + 1 positions ($F1(2, 100) = 7.22, P < 0.001, MSe = 1459; F2(2, 64) = 6.67, P < 0.002, MSe = 1289$). There were no significant effects beyond position noun + 1. The crucial statistics concerned planned comparisons among the three constructions. Reading times at the noun did not differ for the type-shifted and the non-preferred constructions ($F1(1, 50) < 1; F2(1, 35) < 1$), but both constructions engendered longer times (20 and 23 ms, respectively) than the preferred construction (type-shifted versus preferred: $F1(1, 50) = 6.46, P < 0.01$ and $F2(1, 32) = 4.53, P < 0.04$; preferred versus non-preferred: $F1(1, 50) = 8.67, P < 0.004$ and $F2(1, 32) = 4.94, P < 0.03$). At the noun + 1 position, reading times were nearly identical for the preferred and non-preferred constructions ($F1(1, 50) < 1; F2(1, 35) < 1$). Reading times for the type-shifted constructions were, however, 24–25 ms longer than the times for both the preferred and non-preferred constructions (type-shifted versus preferred: $F1(1, 50) = 11.36, P < 0.001$ and $F2(1, 32) = 8.51, P < 0.005$; type-shifted versus non-preferred: $F1(1, 50) = 10.26, P < 0.001$ and $F2(1, 32) = 11.30, P < 0.001$). There were small residual differences beyond the noun + 1 position, but none approached significance.

3. Discussion

Our normative data indicated that the type-shifted constructions were interpreted in a manner similar to the corresponding preferred constructions. Reading times were, however, longer for type-shifted constructions at and shortly after the complement – the point at which type-shifting operations are predicted to coerce the complement into a semantic form that is compatible with the verb. Similar interpretations are presumably computed for both strings but additional operations are needed for cases in which the interpretation is underdetermined and must be inferred from conflicting semantic properties.

The data also indicate that interpreting type-shifting constructions is more computationally intensive than interpreting non-preferred constructions. At the noun, both constructions engendered longer reading times than did the preferred constructions. One word later, however, there was no difference between preferred and non-preferred constructions, but type-shifted constructions continued to display longer reading times. Longer times for the non-preferred constructions at the noun were likely due to the fact that a non-prototypical relationship was expressed: that, for example, ‘writing’ is a more prototypical activity for ‘authors’ than ‘reading’ in an otherwise neutral discourse context. Given an explicit description of the activity and enough time, readers can construct the appropriate semantic representation, and conclude that it is sensible. However, this process takes less time when the prototypical (or preferred) relationship is expressed (Carroll & Slowiaczek, 1986; Rayner

& Well, 1996). The semantic constraints associated with the subject NP clearly affect processing time, but readers appear to quickly recover from these types of mismatching constraints. Type-shifting constructions engender a more protracted slowing period, suggesting that processing demands are greater than those associated with a non-prototypical structure.

The reading time profiles provide behavioral evidence for enriched composition. These data are consistent with approaches such as that by Pustejovsky (1995) in which lexical structures interact to form an interpretation for an otherwise under-determined structure. Reading time differences do not, of course, motivate an approach such as that by Pustejovsky (1995) to the exclusion of other approaches. However, alternative approaches will need to draw an analogous distinction between structures such as (6) and what the data indicate are simpler structures like (7) and (8). Fodor and Lepore (1998) take issue with the generative mechanisms that Pustejovsky (1995) localizes in the lexicon (but see Pustejovsky, 1998), and argue for an approach in which lexical representations are atomistic and lexical meaning is identified with denotation. Contra Pustejovsky (1995), the semantic content that a lexical item contributes to a phrasal interpretation is argued to be context invariant.¹ If the complexity of structures like (6) is not attributed to generative lexical operations, then the locus of the difference must be ascribed to other aspects of interpretative processing. Our view is, however, that that explanation will have to ultimately appeal to differences in processing lexical information for verbs like ‘begin’ and ‘write’ or ‘read’, as the differences reported here are found in constructions that are otherwise identical.

Claims for enriched composition have primarily rested on judgments of semantic equivalence (i.e. that examples in (1) can be adequately paraphrased by the examples in (2)). Reading time measures appear to provide a convergent and potentially more compelling means of identifying complex forms of interpretation. Other on-line measures may also serve this purpose. Recently, Pinango, Zurif, and Jackendoff (1999) found differences in processing load in a cross-modal priming task for constructions that were argued to require a simple versus enriched form of aspectual processing. Our results, like those of Pinango et al. (1999), provide the initial steps in identifying simple and complex interpretative operations. Further work with additional contrasts and measures will be needed to specify the exact nature of the mental operations that mediate simple and enriched composition.

¹ Fodor and Lepore (1998) do not give a detailed treatment of examples involving verbs like ‘begin’ and ‘enjoy’. However, they illustrate their approach with the verb ‘want’. The string ‘John wants a beer/steak’ is argued to be interpreted as ‘John wants to have a beer/steak’ rather than ‘John wants to drink/eat a beer/steak’. The latter is the specific interpretation that follows from an approach like Pustejovsky’s in which ‘want’ induces type-shifting of the complement based on the agentive quale structure. Note, however, that Fodor and Lepore (1998) assume that constructions involving ‘want’ require interpretative operations that also introduce additional structure, in particular the light verb ‘to have’ into the logical form representation for the surface form of ‘...want a beer/steak’. This account differs from Pustejovsky’s only in assuming that the additional information is context invariant. However, we suspect that one can not give an adequate treatment of the interpretation of verbs like ‘begin’ and ‘enjoy’ without appeal to the content that the subject and the complement contribute to the interpretation.

Appendix A. Sentences presented to readers

Each member of a triplet varied in the matrix verb only (separated by slashes). The first verb is the type-shifted version, the second is the preferred version, and the third is the dispreferred version.

The surfer endured/wore/rented the tuxedo but felt very uncomfortable.

The secretary began/typed/read the memo before the annual sales conference.

The pilot mastered/flew/landed the airplane and moved on to the helicopter.

The author was starting/writing/reading the book in his house on the island.

The soldier attempted/climbed/scaled the mountain as part of his training.

The artist began/painted/analyzed the portrait in his studio in the city.

The doctor expected/received/composed the report before the patient returned for further tests.

The chef started/prepared/ate the dinner long before any guests arrived.

The pilot preferred/flew/landed the biplane with the bright red tail.

The composer started/wrote/directed the symphony at the concert in the park.

The receiver tried/opened/closed the door to the basement.

The customer started/ate/ordered the dinner at the new French restaurant.

The nurse preferred/wrote/felt the velvet and the jet black silk.

The builder started/built/demolished the house after the last of the snow melted.

The waitress started/poured/drank the coffee before she went home for the night.

The writer finished/wrote/reviewed the novel before going on vacation in Mexico.

The composer was attempting/composing/singing the solo before the spring concert.

The teenager started/read/wrote the novel about things that happened in the high school.

The dieter resisted/ate/bought the ice cream at her niece's birthday party.

The cook savored/tasted/bought the spice at the restaurant on the corner.

The architect started/designed/planned the house in his studio downtown.

The teacher was enjoying/eating/serving the sandwich in the lunch room.

The professor survived/visited/advised the dentist the other day.

The diner was starting/eating/making the meal at the counter in the back.

The girl preferred/wore/bought the sandals with the thick leather sole.

The worker began/read/wrote the memo to the district managers.

The engineer started/wrote/read the memo late at night in his home office.

The cook started/prepared/served the meal at the restaurant near the river.

The student began/read/wrote the book late in the semester.

The lawyer preferred/drove/parked the convertible with the yellow racing stripe.

The pupil started/took/wrote the test in the chemistry lab.

The pianist began/played/composed the symphony in a nearly empty concert hall.

The banker started/drank/brewed the coffee late in the afternoon.

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