Constructional Sources of Implicit Agents in Sentence Comprehension

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Abstract

Much of the literature studying on-line sentence comprehension focuses on the contributions of individual lexical items, with specific interest in verbs. One aspect of sentence meaning that has been claimed to be rooted in verb representation is event structure. There is a growing body of evidence supporting the claim that the verb is not the sole contributor of event structure, but the syntactic construction also contributes to event structure. One study that is construed to support a verb-based view is Mauner & Koenig (2000). One way to show this constructional influence is through the interpretation of a novel denominal verb (Kaschak & Glenberg 2000). We replicated Mauner & Koenig (2000) with novel denominal verbs suggesting a reinterpretation of their findings. We propose that verbs and constructions each contribute event structure to on-line sentence comprehension, and we discuss how constraint-based models can account for these results.

Keywords: Sentence Comprehension, Event Structure, Construction Grammar, Thematic Roles, Semantics.

Introduction

The meaning of most sentences are events, or situations (Jackendoff, 2002). The event structure is the "who does what to whom" aspect of meaning. This is the aspect of meaning that determines the sentence's structure, its syntax. The event structure of a sentence is composed of the participants (or arguments) of the event and how they relate, i.e. an agent acting on a patient. Two different accounts for the source of event structure in language have been proposed. The "lexical" account is that the sentence's event structure is built entirely from the event structures of its words, with verbs as the major contributor (e.g. Pustejovsky, 1991, Levin & Rappaport Hovav, 2005). The "constructional" account is that the syntactic frame itself contributes event structure independently of any of the particular words that make up the sentence (Goldberg, 1995). Theoretical and experimental evidence for each view will be discussed. Then we will present a study designed to provide support for the constructional account.

The Lexical Account: The theoretical evidence for the lexical account is that a verb's meaning is decomposable and the components predict its syntactic behavior (Jackendoff, 1990). Furthermore, verbs can be classified by the semantic components and syntactic behavior they share (Levin, 1993). For example, all verbs that share the semantic component *become* (which specifies a change of state for one of the participants) can appear in the "middle construction." The middle construction is composed of a simple intransitive sentence, with a patient as subject plus an adverb.

(1) *The bread sliced easily.*
(2) *The ice melted quickly.*

The event structure for these verbs and sentences can be represented as (3), and (4). The adverb modifies this whole event; the modification is not formalized here[1].

(3) bread BECOME [<*Sliced*>]
(4) ice BECOME [<*Melted*>]

The general form for this class of verbs is shown in (5)

(5) x BECOME [<*State*>]

These event structures can be read as: The patient, y, comes to be in the state specified by the verb. All of the verbs of this class share this event structure; they differ in what state they specify. These verbs can also appear in the passive, where the agent is always in the semantic representation, but it is optional in the syntax. The general form of the sentence structure is shown in (8) and the event structure in (9).

(6) *The bread was sliced easily (by the knife).*
(7) *The ice was melted quickly (by the heat).*
(8) *The X was Y-ed Z-ly (by W)*
(9) [w ACT] CAUSE [x BECOME [<*State*>]]

This event structure can be read as: The agent, w, acts causing the patient, x, to come to be in the state specified by the verb. In (6) and (7), the events to which the verbs refer have a different structure than the events in (3) and (4). If the entire event structure solely comes from the

[1] The adverb is included in the example sentences because some verbs, i.e. *slice*, cannot appear in an intransitive sentence with a patient as a subject without the adverb. Of course some verbs, i.e.*melt,* do not need the adverb to get the proper reading.

verb then one has to posit that verbs' have multiple event structures. According to at least one account (Jackendoff, 2002) these event structures are not stored separately from the rest of the semantic representation; they are an intrinsic piece of the semantic representation. So, two event structures mean two semantic representations. Two semantic representations means that the verbs are polysemous, and polysemous words have separate storage in the lexicon (Klein & Murphy, 2001); different "senses" of the same "word" are actually different lexical items. Lexical accounts often posit a different stored item for each syntactic form in which a verb appears (Pinker, 1989, Stevenson & Merlo, 1997).

The Constructional Account: Construction Grammar, (CG) (Goldberg, 1995) takes a different approach that links event structure with the syntactic form itself. On this view verbs need not be polysemous because they can assume the event structure of the construction in which they appear.

(10) *John sneezed the foam off the coffee.* (*Sneeze* assumes the meaning of the *Caused-Motion* construction)
(11) *Bob baked his mother a pie.* (*Bake* assumes the change of possession aspect of the dative construction's meaning)

If (10) was the first time a reader encountered *sneeze* in this construction, and the verb is the only source of event structure, then this reader could not construct an event representation and consequently would not be able to comprehend the sentence.

More evidence for constructional event structure is that the same words in a different order specify different events.

(12) *John loaded the hay onto the cart.* (The cart may not be fully loaded.)
(13) *John loaded the cart with hay.* (The cart is fully loaded.)

If constructional event structure relieves the need to posit polysemous verbs, then maybe it completely relieves the need to posit any complex event structure to verbs. It seems possible that some other meaningful aspect of verbs inform the processing system of the constructions in which they can appear. The verb would always assume the constructional event structure while contributing none of its own. It does not seem to be the event structure of *sneeze* that allows it to appear in (10), so what does license this use of *sneeze*?[2] Maybe whatever that is allows it to appear in the syntactic forms it usually does.

[2] One of the biggest challenges facing CG researchers is how to formalize the semantics of verbs that allows them to be productively inserted into constructions. Constructional event structure's existence does not entail that any verb can be inserted into any construction and just assume its event structure.

Methods for Experimentally Studying the Accounts: There is strong experimental evidence showing that the constructional event structure cannot entirely replace verb event structure. Koenig, Mauner, & Bienvenue (2003) show that some verbs encode instruments while others do not. For example, the verb *behead* specifies that an agent uses an instrument on a patient, while *kill* only specifies the agent and patient. Because an instrument is part of *behead's* event structure, readers can more easily integrate an instrument into their semantic representation if one is mentioned later in the utterance.

While a complex verb-based event structure representation is needed to explain the results of Koenig et al (2003), constructional event structure may be the best explanation for the results of Mauner & Koenig (2000). In these experiments, Mauner & Koenig contrasted the differences between linguistically encoding the agent of an event and just having conceptual knowledge of the agent. In the first experiment, subjects judged both (13) and (14) as nonsensical.

(14) *The clocks had sold quickly, but no one sold them.*
(15) *The clocks were sold quickly, but no one sold them.*

Neither (14) nor (15) explicitly mention that there was an agent of the selling, but one's conceptual knowledge of selling events includes an agent. Mauner & Koenig hypothesize that (15) linguistically encodes an agent while (14) does not. In their framework the event structure of passive verbs encodes an implicit agent; while the middle forms of the verbs do not (see (5) and (9) respectively for the representations). They argue that (16) is grammatical while (17) is not because the infinitive clause they share needs an agent to be comprehended, and only (16) encodes the agent who is raising some money for charity.

(16) *The antique clocks were sold easily to raise some money for charity*.
(17) **The antique clocks had sold easily to raise some money for charity*.

In their study, subjects read the entire first clause and judged its sensicality. After the judgment, the rest of the sentence was presented one word at a time. After each word subjects pressed one button if the sentence continued to make sense, and another if it did not. If the sentence was judged as non-sense then the trial was over and the next sentence's main clause would appear. It was predicted that if no agent was encoded in the first clause then subjects should judge the sentence as non-sense somewhere in the first four words of the infinitive clause. In the examples above, the critical region is *to raise some money* because it is this action that needs the agent. Every sentence's critical region shared the form of *to,* a verb, a modifier, and a noun. Subjects judged significantly more sentences with middle first clauses than passive at the verb and the noun in the critical region.

Mauner & Koenig (2000) suggested that the differences between the two sentence types are rooted in the differences in the representations of the verb. A constructional account is not ruled out however. There is evidence that the verb contributes the same event structure each time it is processed (McKoon & Ratcliff, 2003), which is predicted only if constructional event structure is the source of the difference.[3]

How could someone show that Mauner & Koenig's results were actually rooted in constructional event structure? One way would be to follow the method used in Kaschak & Glenberg (2000) to provide experimental evidence for constructional event structure.[4] In their study subjects interpreted sentences with novel denominal verbs in different constructions. A denominal verb is a verb derived from a noun, i.e. *to hammer*. The logic of the experiment was that any difference in interpretation of the novel denominal verbs was completely due to the constructional event structure because if the verb was novel, it could not have a pre-existing event structure.

(18) John *crutched Bill the apple.*
(19)*John crutched the apple.*

Subjects interpreted (18) in line with the meaning of the dative construction, which specifies a transfer of possession, that is *John transferred the apple to Bill using the crutch*. There was no such interpretation for (18). This technique is relevant for the interpretation of Mauner's & Koenig's (2000) results. If their results can be replicated with novel denominal verbs, then that supports constructional accounts.

Experiment

Kaschak & Glenberg (2000) showed that the interpretation of novel denominal verbs depends on the construction, because being novel, they have no event structure of their own. The goal of the current research is to replicate the results of Mauner & Koenig (2000) with novel denominal verbs showing that constructions can provide event structure independently of the verb.

The middle construction encodes no agent, and for a verb to appear in it, it must have the notion of a change of state in its meaning (Levin, 1993). To help produce this interpretation, the nouns picked from which to derive the verbs had a change of state as part of their meaning, i.e. *jelly* is fruit in another state; *vodka* is made from potatoes. Before the main task subjects read short passages that made explicit what was meant by use of these nouns as verbs. The passages made explicit that *The potatoes had vodkaed easily* means that vodka was made easily from those potatoes. We included the original stimuli from Mauner & Koenig (2000), with only minor adjustments to the post-critical region. If constructions can provide event structure independently from the verb then sentences with novel denominal verbs (i.e. (20) and (21)) will show the same pattern of sensicality judgments as Mauner & Koenig's original stimuli.

(20) *The Russian potatoes were vodkaed easily to spike the punch at the frat party.*
(21)**The Russian potatoes had vodkaed easily to spike the punch at the frat party.*

One limitation of the present study is that it does not completely isolate when the constructional event structure makes its contribution. There are at least two potential loci of this effect. One is during the main phase when one is reading the main clause and using the construction to interpret the novel verb. A second possibility is that participants use event structure information when reading the passages explaining the intended meaning of the novel verbs. On this view, they instantiated an event structure for the novel verbs, and that event structure affected comprehension during the main phase of the experiment. This explanation does not rule out the contribution of constructional event structure because that structure determined how the novel verbs were interpreted during the passages. Therefore even if event structures were instantiated for these verbs after a single reading, that event structure was taken completely from the constructional event structure. These possibilities will be discussed below.

Methods

Materials for the experiment included a packet of short passages that made the intended meaning of the novel denominal verbs apparent. During the main task, 14 sets of sentence pairs (similar to the pair shown in (20) and (21)) were included. Separate lists were made with one of each pair in each list, counterbalanced across participants. Also, the 14 pairs from Mauner & Koenig (2000) Experiment 2 were used. These 28 experimental items were intermixed with 42 filler sentences, 12 of which were intended to not make sense. The filler sentences shared features with the critical trials to ensure that strategies were not being employed, adopting Mauner & Koenig's method. To prevent participants from making judgments based on auxiliary verb alone, passive sentences that contain the auxiliary *have* were used, as well as sentences that contained *was/were* that did not introduce an implicit agent. Also, sentences with infinitive clauses in various sentence positions were used to prevent special notice of their role.

Procedure. Subjects were tested individually, seated in front of a computer. Before using the computer they read 14 short passages, one for each novel denominal verb. They were asked a multiple choice question about the meaning of the novel denominal verb; there was only one plausible answer to ensure they understood the intended

[3] Of course, it is still possible that constructions can provide event structure independently of the verb and verbs can have multiple event structure representations (see discussion below).

[4] For a review of experimental evidence for Construction Grammar see Goldberg (2004).

meaning so that they could make rapid semantic judgments in the main phase of the experiment.

The main phase used the program *SuperLab* on a Dell PC. The sentences were presented as in Mauner & Koenig (2000) Experiment 2, and as described in the introduction. Partipants read the entire first clause and judged its sensicality. The rest of the sentence had dashes in place of words. After the judgment, the rest of the sentence was presented one word replacing the dashes at a time. After each word participants pressed the "1" button if the sentence continued to make sense, and the "2" button if it did not. The filler sentences were displayed in the same way. The entire first clause was presented at once because some verbs need the adverb to have the proper reading in the middle construction. Many sentences could have been prematurely called non-sensical at the main verb if the entire sentence was presented one word at a time.

Participants were instructed to read the sentences quickly, but at a natural rate, and to make their sensicality judgments as quickly as possible without sacrificing their accuracy. They were given examples of sentences that did not make sense. They then had 8 practice trials before the main phase. This procedure differed from Mauner & Koenig's only in that subjects continued to judge sentences until their completion even if they judged them non-sensical because *SuperLab* cannot conditionally present trials. During scoring, the important measure was when they first judged a sentence as non-sense, later judgments were ignored to keep analysis consistent with Mauner & Koenig (2000).

Participants. Forty English-speaking undergraduates from the University of Texas participated in this experiment for partial course credit.

Results

Scoring procedure: We adopted the scoring procedure from Mauner & Koening (2000) Experiment 2. To evaluate changes in judgments across the main clause and the critical region of the infinitive clause, we transformed data into adjusted percentages that reflected the number of remaining possibilities of responding "non-sense" at the main clause, and at each word position in the critical region. We adopted this procedure to minimize the problem of using either the raw number or cumulative percentages for which the value at any given word position would be correlated with the value at proceeding word positions. For each participant, percentages of remaining "non-sense" responses were calculated at each word position by dividing the number of "non-sense" responses obtained at a given position by the remaining number of opportunities to respond "non-sense" at that position. The remaining number of opportunities to respond "non-sense" at each position was determined by subtracting the total number of "non-sense" responses

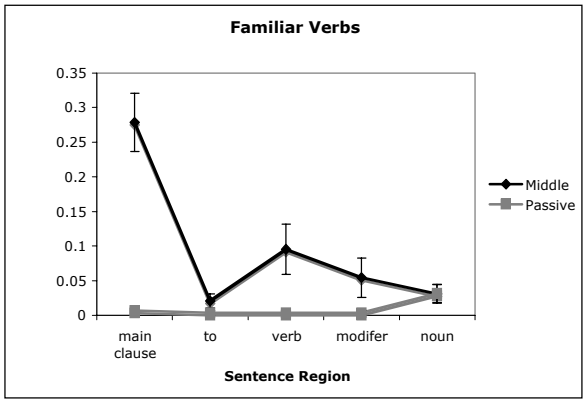

Figure 1: Means and standard errors[5] of adjusted percentages of familiar verbs by participants.

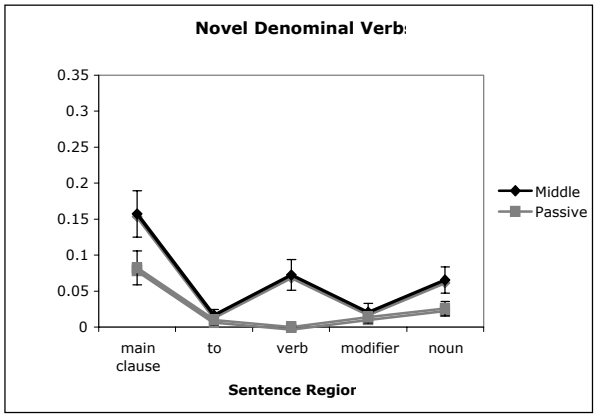

Figure 2: Means and standard errors of adjusted percentages of novel denominal verbs by participants.

from all previous word positions by 7, which was the total number of opportunities to respond "non-sense" in each sentence condition.[6] A similar procedure was followed to adjust percentages for the analysis by items across participants.

Analysis: Adjusted percentages of "non-sense" responses for each of Mauner & Koenig's stimuli with familiar verbs and for the novel verbs were submitted to a 2 (List) x 2 (Construction) x 5 (Region/Word position) ANOVA. The analysis of the familiar verbs yielded significant main effects of construction, f (1, 38) = 48.1, $p < .001$ by participants, f (1, 13) = 54.234, $p < .001$ by items, and of region/word position, f (4, 35) = 7.01, $p < .001$ by participants, f (4, 10) = 11.711, $p = .001$ by items. There was also a significant interaction of construction X region/word position, f (4, 35) = 8.95, $p < .01$, by participants, f (4, 10) = 7.741, $p = .004$ by items. What are most important are the planned comparisons of the specific sentence region in the two constructions. Mauner & Koenig found significant differences at the main

[5] Some standard error bars are too small to see.

[6] There were 14 sentences taken from Mauner & Koening (2000) and 14 that included the novel denominal verbs, so that is 7 of each in each construction.

clause, at the verb in the critical region, and at the noun in the critical region. As can be seen in Figure 1, we replicated their differences at the main clause, t (39) = 6.54 p < .001, by participants, t (13) = 6.47 p < .001 by items, and at the verb, t (39) = 2.50 p < .02, by participants, t (13) = 2.82 p < .015 by items.[7] It should not be surprising that we did not replicate all the differences within the critical region because Mauner & Koenig did not predict which specific word position within that clause where the difference would emerge, just that it would emerge somewhere in the region. The analysis of the novel verbs revealed a similar pattern. There were significant main effects of construction, f (1, 38) = 23.07, p < .001 by participants, f (1, 13) = 6.52, p < .025 by items, and of region/word position, f (4, 35) = 5.70, p =.001 by participants, f (4, 10) = 11.916, p = .001 by items. Once again, the individual comparisons of word positions are what is most important, and can be seen in Figure 2. With the novel verbs, Mauner & Koenig's pattern was replicated, with significant differences found at the main clause, t (39) = 2.82, p < .01 by participants, but not items t (13) = 1.89, p = .08, at the verb in the critical region, t (39) = 3.40, p = .002 , t (13) = 2.52, p = .025 and at the noun in the critical region, t(39) = 2.05, p < .05, by participants, but not by items t (13) = 1.36.

Discussion

We replicated Mauner & Koenig (2000)'s key results that there were more judgments of non-sense made in infinitive clauses following middle constructions which do not contribute an implicit agent than following passive constructions that do contribute an implicit agent. This pattern was produced with Mauner & Koenig's stimuli using familiar verbs and with novel denominal verbs. The noticeable difference between the two stimuli sets' pattern is that more main clauses were rejected using the novel verbs than the familiar verbs. This finding is not surprising, because the main clauses' verbs were novel. Of importance, the majority of main clauses were accepted suggesting that the passages read in the first phase made the intended meaning clear. The present experiment indicates that constructions can provide event structure independently of the verb, and suggests a different cause for the Mauner & Koenig (2000) findings.

As mentioned above, there are two possible loci for the effect of constructional event structure. One is during the first phase of the study, when participants first encounter the novel verbs. The second was during the main phase. We do not think that the event structure was created solely in the first phase of the study however. If so the construction the verbs appeared in during that phase would elicit fewer judgments of non-sense. This was not the case however, as all verbs introduced in the first phase appeared in the middle construction, not in the passive. So this prediction is not supported. Still we cannot rule out that the construction contributes an event structure to a verb in a single reading, allowing a permanent instantiation of that verb's event structure. This possibility will be the subject of future research.

How can the independent contribution of constructional event structure be incorporated into current models of sentence comprehension? Here we will only focus on constraint-based models (i.e. MacDonald, Pearlmutter, & Seidenberg, 1994, McRae, Spivey-Knowlton & Tanenhaus, 1998), though other models could potentially account for these results as well (i.e., McKoon & Ratcliff, 2003). Constraint based models already have a lot of the necessary machinery to implement a Construction Grammar framework. In Construction Grammar, constructions are conceived of as a pairing of syntax and semantics, each with equal stature, in direct opposition to "syntactocentric" models (see Jackendoff, 2002). Constraint based models process syntax and semantics in parallel in direct opposition to two stage models that consider syntax to be informationally encapsulated (e.g. Ferreira & Clifton 1986).

The constraints incorporated into constraint-based models are typically thematic fit, and the frequencies of words in syntactic structures. There is nothing to prevent these models from implementing a constraint of construction meaning. Adding this constraint may not actually change the model's behavior most of the time. Let's say that one goal of the model is to determine the event structure of a sentence. As the model makes it's syntactic parse, corresponding event structures are activated. Just as verbs activate their syntactic preferences, they will activate their event structure preferences. Often, the verb's syntactic preferences and the final parse of the sentence are in congruence, which is why the verb has the syntactic preferences it has. The same can be said for event structure. Most frequently the verb's event structure is congruent with the construction's, but when it is not (e.g. (3)) the construction's event structure should win the competition. The effects of constructional event structure will also be shown in learning novel verbs, for children (Gleitman, 1990) and adults.

A second aspect of Construction Grammar is less obviously integrated with constraint-based models. One of the main motivations behind Construction Grammar is to eliminate the need for multiple verb event structures. Event structure is the part of meaning that determines syntactic behavior. One event structure could be construed as only leading to the activation of one preferred syntactic from. A central tenet of constraint-based models is the activation of multiple syntactic forms to varying degrees. There is a way to reconcile this. In theoretical linguistics, event structure is sometimes thought of as the syntax-semantics interface, sometimes as a purely semantic representation. To reconcile the discrepancy, one should only posit a single event structure when event structure is conceived of as purely semantic, although multiple semantic event structures are needed when a verb is truly polysemous, i.e. in (22) and (23).

[7] All t-tests are two-tailed.

(22) *John accepted the gift*.
(23) *John accepted that he was defeated.*

Hare, McRae, & Elman (2003) showed that context can influence which sense of a verb is activated, and correspondingly which syntactic form that a verb can appear in is activated. But this does not reconcile the single event structure multiple syntax problem. Compare (23) with (24).

(24) *John accepted defeat*.

(24) uses the sense from (23), but the syntax from (22). So the problem is how one has the semantics of the sense from (23) and (24), with a single event structure and multiple activated syntactic forms. A simplification of *mental accept's* event structure is: X *accepts* <state of affairs>. This event structure can activate multiple syntactic forms because a state of affairs can be referred to by a noun, or by a sentential complement, as in (24) and (23) respectively.

While the support for the claim that verbs activate multiple syntactic forms comes from the activation of forms differing in the *type* of syntactic arguments (i.e from Hare et al, 2003 and Trueswell & Kim, 1998), the sentences used in this experiment, and in Mauner & Koenig (2000) differed in *number* of syntactic arguments, not type. To help resolve the issue of number, it becomes useful to posit a level of event structure that is no longer solely an intrinsic part of verb meaning, but is an interface of syntax and semantics that represents the syntactically realized event structure. If Mauner & Koenig's proposal that a verb's event structure differs as a function of the construction in which it appears means that different (verb based) event structures are syntactically realized, then the difference between their account and ours is rather small. The remaining difference disappears if the verb takes on a particular event structure by adopting the construction's event structure. The time course of this process, and the proper linguistic analysis remain open issues, but this study joins a growing body of evidence that supports the existence and importance of constructional event structures independent of particular verbs.

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