

## **Verbal Integration: The Interaction of Participant Roles and Sentential Argument Structure**

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*This paper explores the interaction between sentence level syntactic information and the semantic information that is carried with the verb during sentence comprehension. A cross-modal integration task was employed to examine whether the number of participant roles (thematic roles associated with the central meaning of the verb) causes an increase in processing load during integration of the verb into on-going sentence comprehension. The effect of preceding sentential structural information (varied with respect to the number of argument and/or adjunct NPs preceding the verb) was also manipulated. Independent of the structural information preceding the verb, verbs with two participant roles were integrated into the sentence faster than verbs with three participant roles. This finding suggests that participant roles are stored with the representation of the verb and made immediately available during integration and comprehension. In addition, the syntactic distinction between arguments and adjuncts is also shown to play an immediate role in parsing and integration of language on-line.*

### **INTRODUCTION**

A detailed theory of sentence processing must identify at what point in time the language processor uses specific types of information. Verbs, in particular, encode information that is potentially critical to the processor, in the form of subcategorization frames, argument structures, or thematic roles (depending on what theory one is adopting). In English, which is typologically classified as a subject-verb-object language, the verb occurs in the middle of an on-going

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sentence. This means that the verb can, in principle, provide information about the following noun phrases or prepositional phrases before they are actually heard. A fundamental question, then, is when and how the processor actually uses such information.

Linguistic theories differ concerning claims as to what specific information the verb itself carries and what information is contributed by the sentential context. For example, within a lexicalist theory, the information that the verb provides is postulated to be the semantic relations that are involved in verb-argument structures. Linguistic theories have examined these semantic relations since Fillmore (1968), who adopted a lexicalist case-role approach. Syntactic-based linguistic approaches, such as Government and Binding Theory (Chomsky, 1981), have also attempted to deal with semantic relations and verb argument structure, which have become embodied in the linguistic concept of thematic roles. Thematic roles entail a set of characterizations of the relationships between the verb and its semantic relationship to the nouns and prepositional phrases in the sentence.

Thematic relations provide a foundation for underlying discourse and sentential meaning that must be maintained in a language even though word order and grammatical function may vary. Information about thematic roles is presumed to be stored with the verb in the lexicon, and the lexicon is postulated to be distinct from the constraints, representations, and rules that are postulated to occur in the syntactic and semantic systems (DiSciullo & Williams, 1987; Hale & Keyser, 1986, 1987, 1993; Pinker, 1989; Rappaport & Levin, 1988). This paper explores hypotheses about the nature and time-course of the information made available from the lexicon to the comprehension device when the verb is integrated into a sentence, in particular focusing on the thematic roles that the verb carries.

Within linguistic theory, lexicalist accounts propose that semantic and syntactic information is projected from the verb (Levin, 1985; Levin & Rappaport Hovav, 1995, Rappaport & Levin 1988; Rappaport, Laughren, & Levin 1987, 1993; Rappaport Hovav & Levin, 1998). Moreover, the semantic and syntactic information are connected via linking rules. Thus every time a word occurs in a different syntactic configuration it has a new lexical conceptual structure associated with it (Fig. 1).

Thus the individual lexical conceptual structures (LCSs) are postulated to be *listed* in the lexical entry of the verb and associated with predicate argument structures by linking rules. For the purposes of language processing, the processor must access the individual lexical representation in order to know the lexical conceptual structure of the word and to know which syntactic structure is associated with that semantic meaning. The Rappaport Hovav and Levin proposal is that the verb activates its semantic class and then the semantic class provides the list of lexical conceptual structures and associated argument structures. From a processing point of view, the information in the representation of the

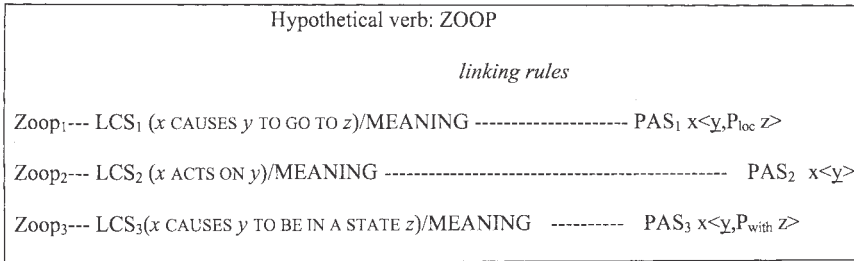


Fig. 1. A lexical entry for a hypothetical verb under a lexical account.

verb does not change, but an additional step to access that information must take place because the verb must first retrieve its semantic class.

Construction Grammar, however, postulates that top-down information is provided by the construction and that bottom-up information is provided by the verb. Construction Grammar theorizes that syntactic constructions have meaning independent of the lexical items that are used in the construction (Goldberg, 1992, 1995). Under this scenario the construction contributes its argument roles (the placeholders where arguments can occur) and the verb contributes its participant roles. For example, the verb “kick” contributes the participant roles “kicker” and “kickee.” These two roles fuse with the argument roles of agent and patient, respectively, in the ditransitive construction according to the semantic coherence principle. This principle states that only roles that are semantically compatible can be fused (Goldberg, 1995). The recipient role is provided by the construction. The verb “give,” on the other hand, will contribute three roles—the “giver,” “givee,” and “(thing) given” to the agent, recipient, and patient roles, respectively. What is crucial to note is that the verb has participant roles independently of the constructions it may occur in. The hypothesis put forward by Ahrens (1995) and Ahrens and Swinney (1995) is that the verb has participant roles associated with its central sense. Participant roles are unique to each verb. For example, “give” is a three-participant-role verb involving the *giver*, *givee*, and *thing given*. The verb “throw” is a two-participant-role verb involving the *thrower* and the *throwee* (as in “The girl threw the ball”). Note that although “throwing” may involve a recipient (“to Sue”), it is not crucial to the central sense of the verb “throw.” One advantage to the constructionalist account is that novel verb senses can be parsimoniously handled because the verb’s participant roles integrate into a new construction. However, under a lexicalist account a new verb sense means that an additional argument structure must be postulated. This would then mean that the verb would no longer be able to belong to its semantic class, because it would differ in argument structures from the other verbs of that class.

In sum, the constructional account postulates that there is integration between sentential information and verbal information, while a lexicalist account postulates that the verb projects its argument structures up to the sentence. However, both linguistic accounts suggest that the verb carries information that is crucial to integrating sentential arguments into the sentence. One natural question is which type of information is actually crucial: the argument structure information that a verb carries or the number of participant roles that it carries?

Shapiro, Zurif, and Grimshaw (1987), following an earlier version of lexicalist theory in Grimshaw (1979), tested whether it was the number of argument structure possibilities or the number of subcategorization possibilities a verb has that influences the lexical access of the verb. They used a cross-modal lexical decision (interference) task (CMLD) to infer the complexity of the verb information that was available immediately upon access. In this interference task, lexical decisions were made to an unrelated word presented visually immediately after hearing the verb in an auditorally presented sentence; the amount of time needed to make the lexical decision to the visual probe was used as an indicator of the processing load caused by the access of the verb in the sentence. They found no processing load effect related to the number of subcategorization frame possibilities, but a significant effect was found related to the number of argument structure possibilities (the more argument structures possibilities that the verb had, the more interference there was on the secondary lexical decision task). Shapiro *et al.* (1987) concluded that argument structures are stored and accessed with the verb, whereas subcategorization relations are not.

Ahrens and Swinney (1995) further refined this experiment to look at the issue of whether it was in fact the number of argument structure permutations per se that was underlying the Shapiro *et al.* (1987) results, or whether it might have to do with the number of participant roles associated with the verb. Using the same methodology, Ahrens and Swinney (1995) demonstrated that it was the number of participant roles associated with the central sense of the verb, not the number of argument structures, that resulted in differences in lexical access at the verb. In particular, CMLD reaction times to unrelated words following verbs with three participant roles were longer than those with one participant role. However, no differences were found for verbs that differed in their number of argument structure permutations, holding participant roles constant. Ahrens and Swinney concluded that the number of participant roles is represented in the lexical entry and is accessed with the verb and supported a model of lexical storage and access that emphasized that what is crucially accessed with a verb is the verb's central sense. (See McRae, Ferretti, & Amyote, 1997, for additional support for this view.)

However, there is potentially a large distinction between what is accessed with the phonetic form of the verb and what is actually used in the verb's inte-

gration into the sentence. This paper focuses on the latter issue. That is, is the information that there are a certain number of participant roles associated with the central sense of a verb accessed not only when a listener hears a verb but also when the listener integrates the verb into the sentence?

Considerable evidence exists that various types of verb information are utilized during on-line sentence integration. For example, Melinger and Mauner (1999), using a cross-modal naming task, demonstrated that it took longer to name a verb carrying an implicit agent role (e.g., “spun”) at the end of an intransitive sentence than it did at the end of a sentence that expected an agent role (e.g., a passive construction). The authors concluded that agent roles, even implicit ones, must be accessed upon encountering and integrating the verb into a sentence. Boland (1991, 1993, 1997 [Experiments 3A and 3B]) presented a cross-modal integration experiment in which nouns (as visual targets) were presented as continuations to ongoing auditory sentences. She found that at the point of integration of the noun, information concerning whether or not the correct syntactic frame and correct number of thematic roles was available affected response (integration) times, suggesting that both the verb’s thematic role information (which, in her examples, could be related straightforwardly to participant roles) and subcategorization information were available for use at least as early as one word after the verb.

The present paper directly addresses a number of unanswered central issues concerning the integration of verb participant-role information and sentence-level syntactic information during on-going auditory sentence comprehension. In particular, the issues addressed include: (1) Does the number of participant roles associated with the central sense of the verb affect verb integration into an on-going sentence; (2) does the presence of arguments before the occurrence of the verb facilitate a verb’s integration into a sentence, and (3) do adjuncts that carry thematically useful information (as compared to adjuncts that only give descriptive information) facilitate integration of the verb in the sentence? The answers to these questions will help us to formulate a processing model of language that will fit in not only with what is known about on-line processing constraints on interpreting incoming information, but also will fit in with the linguistic knowledge and representations of that knowledge that speakers are postulated to have.

The following experiment examines these questions by varying the number of arguments and/or adjuncts that preceded the verb for two different verb types—two-participant-role verbs and three-participant-role verbs, in a passivized cleft sentence. The types of argument/adjunct contextual manipulations that are made are (1) an adjunct plus one argument, (2) two arguments, (3) two arguments plus a modifier adjunct, and (4) two arguments plus a source adjunct. An example of each of these manipulations is demonstrated below for the three-participant-role verb “GIVE.”

- (1) **Adjunct plus argument:** “It was with love that the rabbit was GIVEN to Jen for her birthday.”
- (2) **Two-argument:** “It was to Jen that the rabbit was GIVEN for her birthday yesterday.”
- (3) **Two-arguments plus adjunct (modifier):** “It was to Jen that the rabbit with spots was GIVEN for her birthday yesterday.”
- (4) **Two-arguments plus adjunct (source):** “It was to Jen that the rabbit from Mike was GIVEN for her birthday yesterday.”

In sentence (1), “with love” is an adjunct, and “the rabbit” is an argument.<sup>2</sup> Adjuncts are modifier phrases that do not contribute necessary information to the construction, whereas arguments do.<sup>3</sup> In this case, *how* the rabbit is given is not necessary information for the ditransitive construction, but it is necessary to know *what* was given. In sentence (2) “to Jen” and “the rabbit” are both argument roles of the construction that precede the verb. The prediction is that both verb types will integrate into the *two-argument sentence type* faster than they will into the *Adjunct plus one argument sentence type*, because the structural information projected by the sentence will facilitate their integration. In (3), the adjunct “with spots” is a pure modifier of the argument “the rabbit.” It describes the appearance of the argument. A second kind of adjunct describes the origin of the argument, as shown in (4). In this example, the adjunct describes where the argument “the rabbit” comes from. It does not describe the appearance of the rabbit. Neither adjunct type [(3) and (4)] adds information that is crucial to verbal integration; they should not differ significantly from the basic *two-argument sentence type* in (2), because although information is being added in the adjunct type, this information is not the kind that the verb needs to use. In addition, in the case of examples (3) and (4), what is being compared is whether adjuncts that attach at a lower structural position in the sentence (i.e., to the noun phrase) will increase the complexity level of the sentence on the basis of the additional length and descriptive information. In the previous comparison [examples (1) and (2)], what is being compared is whether a sentential-level adjunct would carry information that would facilitate the verb’s rate of integration into the sentence when compared with argument role information.

<sup>2</sup>Under either the lexicalist approach or the constructionalist approach the definition of argument and adjunct remains the same. The theories differ as to whether the verb is the one providing all the argument roles or if the verb provides the participant roles, whereas the construction provides the other argument roles.

<sup>3</sup>Common syntactic tests for adjuncts have to do with whether they are optional, whether they can move to the front of the sentence without special pragmatics, whether they modify the entire event, whether more than one of the same type can occur, whether they can be left out of *do so*, and whether they can occur after an obvious adjunct.

In sum, what is critical for the integration of the verb is postulated to be the following: (1) the number of participant roles the verb carries and (2) the number of argument roles that the sentence provides before the verb. The verb attempts to match up the number of participant roles it carries with the number of argument roles the sentence carries. The faster it can do so, the faster it will be integrated into the sentence. It is postulated that the appearance of adjuncts preceding a verb will not influence the integration process. An additional question examined here has to do with the interaction between the number of roles that the verb carries and the number of arguments that the sentence provides.

## **EXPERIMENT 1: EXPERIMENTAL DETERMINATION OF ROLE PREFERENCE FOR VERBS**

### **Method**

The premise that the availability of a greater number of participant roles influences the integration of certain verbs into sentences was examined based on the use of two types of verbs. The first type was verbs that prefer information about the agent, goal, and theme to be explicit in the sentence. The second type was verbs that require information about the agent and the theme, while the goal may not be inherently obvious. An initial experiment was run to empirically determine the verbs that categorized as these “types.”

### *Materials and Procedures*

Participant role preference possibilities for 32 verbs (16 two-participant-role and 16 three-participant-role) were initially identified using two standard linguistic measures, followed by empirical verification. The first measure was based on the linguistic intuition of the experimenter. The syntactic frame “No \_\_\_\_ing occurred” was used to determine the number of roles associated with each verb (Goldberg, 1992, 1995). The idea was that “The number and type of participant roles implicitly understood to be involved in the interpretation of this expression correspond to the number and type of participant roles in the frame semantics associated with the verb (Goldberg, 1995, p. 43).” For example, in the case of “No handing occurred” there must be at least three entities involved: the hander, the thing handed, and the person it is handed to. In the case of “No pulling occurred” there are only two entities involved: the puller and the thing being pulled.

Second, the categorization of all 32 verbs was determined from the Oxford’s Advanced Learner’s Dictionary (1974). Verbs with two-roles hypothesized were classified 85% of the time as transitive verbs with possible prepositional phrase attachment, and verbs with three-roles hypothesized were classified 90% of the time as ditransitive verbs.

Finally, an empirical verification of these classifications was conducted.

### *Participants*

One hundred monolingual native speakers of English from U. C. San Diego received course credit for participation. They were asked to continue sentence fragments that ended at each of the 32 critical verbs, as seen in the following examples:

Three-participant-role verb: *It was Mary that was given \_\_\_\_\_*

Two-Participant-role verb: *It was Mary that was kicked \_\_\_\_\_*

The task was written and untimed, and the categories of responses made by participants (NP, PP, etc.) were analyzed to determine the extent to which participant preferences fit with the linguistically based criteria used to initially select the verbs, as described above.

## **Results**

Verbs in the three-participant-role category were predominantly followed by a noun phrase (i.e., “the ball”) in this sentence completion task (mean NP completion = 90%). Verbs in the two-participant-role group were predominantly followed by a prepositional phrase (i.e., “in the shin”) (mean PP completion = 80%). These tests served to confirm that native speakers encoded the difference in the number of participant roles between the two verb types. The two-role and three-role verbs employed (based on the above three measures) are listed in the Appendix.<sup>4</sup>

## **EXPERIMENT 2: ON-LINE EXAMINATION OF VERB INTEGRATION**

### **Method**

#### *Participants*

Sixty-six undergraduates from U. C. San Diego (44 females and 22 males; age range 17–22) participated in this on-line verb integration experiment for course credit. All subjects were neurologically intact, native English speakers by self-report, had normal or corrected vision, and normal hearing. Based on

<sup>4</sup>It may be argued from a Construction Grammar point of view that the verbs *donate*, *return*, *supply*, and *entrust* are not good exemplars of two-role verbs. However, the fact that these verbs are classified as such in these three pretests actually works against the hypothesis examined here.

*a priori* criteria, six subjects were excluded from data analysis for the following reasons: one female participant had a greater than 10% error rate on lexical decisions during the experiment; two male participants had a greater than 40% error rate on the comprehension questions during the experiment; computer difficulties resulted in the loss of data from three female participants. This left a total of 60 participants (40 female and 20 male) whose data were subjected to analyses.

### *Stimuli and Design*

Sixteen two-participant-role verbs and 16 three-participant-role verbs were placed in the four different sentence contexts (adjunct plus argument, two-arguments, two-arguments plus modifying adjunct, and two arguments plus source adjunct) as discussed above. The conditions of verb type and sentence context (type) were completely counterbalanced in a full factorial design across the experiment so that participants contributed data equally to every condition, but never saw or heard more than a single version of any one stimulus sentence/verb. This counterbalancing resulted in four auditory tapes in which each sentence context was paired (across tapes) with the same verb. This constituted a mixed factorial design, with the four tapes as a between-subjects factor, and the four levels of sentence type (context) and two levels of verb type constituting within-subjects factors.

The task was a sentence-continuation lexical decision paradigm, wherein full sentence recordings (to keep natural intonation) were made by a native English female speaker, and then the end portion of the sentence beginning with the verb was digitally removed (Boland, 1991; Marslen-Wilson & Tyler, 1980; Melinger & Mauener, 1999). In addition to the 32 experimental sentence fragment-verb target pairings, each list contained an additional 18 "filler" sentence fragments with real word (nonverb) visual targets and 40 "filler" sentence fragments with orthographically possible nonword targets (similar in length to the experimental verb targets). Ten of these filler items (half with word targets, half with nonword targets) served as practice materials. Thus each participant heard a total of 90 sentence fragments paired with word or nonword targets. The length of the adjunct phrases in the experimental sentences was equated with the length of the argument phrases, so that the number of syllables before the verb was equal. Participants heard the sentence fragments over headphones, immediately followed by visual presentation of the visual target word, to which they made lexical decisions

### *Apparatus*

The experiment, run on PC computers, was controlled by RTLab 11 experimental software and conducted in isolated, sound-attenuated testing chambers. Auditory information was delivered to participants by a reel-to-reel tape recorder.

A 1/4-second square wave tone (recorded on a channel inaudible to participants) was placed simultaneous with the offset of the sentence fragment. This tone triggered a diapirot, which sent a signal to the computer to present a target probe. Each probe was presented in lowercase letters to the subject for a total of 300 milliseconds, with a 2000-millisecond inter-stimulus interval (ISI). Subjects' lexical decision responses to the probe were recorded.

### *Procedure*

Subjects were seated in a response cubical with a button-press response box and a computer monitor in front of them. They were told that they would be required to perform two tasks: listen to and understand the sentences they would be hearing over the headphones, while simultaneously making lexical (word/nonword) decisions to a string of letters that appeared on the screen in front of them. Subjects were instructed to keep their fingers on the buttons at all times, and to respond as fast as they could, while still being accurate. They were also told that the sentences that they would hear over the headphones might be incomplete sentences, but that they were to try to understand them as best as possible. They were told that at various points during the experiment, questions would be asked about the sentence they had just heard, to ensure that they were paying attention. Five multiple-choice questions were asked of each subject throughout the experiment; all questions were asked of filler sentences.

## RESULTS

Data from all 60 subjects were tallied, with incorrect response or non-responses removed before analysis (criteria was fewer than 10% such errors per subject). Means and standard deviations were calculated for all subjects for all conditions, the two- and three-role verbs in the four different sentence types.<sup>5</sup> The resultant means are provided in Table I for the two- and three-role verbs for each of the sentence (context) types.

As can be seen in Table I, two-role verbs are significantly faster to integrate into the sentence than three-role verbs in each of the sentence context conditions: the *adjunct plus argument* condition (63 ms), the *two-argument* condition (45 ms),

<sup>5</sup>To equate length and frequency for the two- and three-participant-role verbs, it was decided that one exemplar from each condition would be removed, post hoc. Thus, responses for the three role verb: "administer" and the two-role verb "kick" were discarded for all subjects. The results presented for the remainder of the items above (15 verbs each) does not differ from the pattern of results found for all 16 verbs in each group, either in terms of direction of effects or statistical significance of effects. However, the analysis present here reflects the "equated" verb conditions.

**Table I.** Mean Lexical Decision Reaction Times (ms) to Two- Versus Three-Participant-Role Verbs as a Function of Sentence (Context) Type

Sentence type				
Verb type	Adjunct plus argument	Two-argument	Two-arguments plus modifier	Two-arguments plus source
2-Role verbs	587	563	569	560
3-Role verbs	650	608	619	615
2-3 Role (difference)	63*	45*	50*	55*

\* $p < .05$

the *two-arguments plus modifier* condition (50 ms) and the *two-arguments plus source* condition (55 ms). In addition, as can be seen in Table II, both verb types are at least marginally faster to integrate into the *two-argument* condition than the *adjunct plus argument* condition, such that two-role verbs integrate 24 milliseconds faster, and three-role verbs 42 milliseconds faster. Finally, the verbs integrate faster into the *two-arguments plus source* condition than in the *two-arguments plus modifier* condition.

The reliability of these integration differences was determined by submitting the data for each experimental condition for all 60 subjects to an analysis of variance [for both subjects ( $F_1$ ) and items ( $F_2$ )] and to *a priori* planned comparisons. In an overall ANOVA incorporating the between subjects variable of tapes (4) and the within subjects variables of verb (two roles or three roles); and structure (*adjunct plus argument*, *two-arguments*, *two-arguments plus modifier*, *two-arguments plus source*) a significant main effect of verb type [ $F_1(1,56) = 37.212$ ,  $p < .0001$ ] and of structure [ $F_1(3,168) = 4,352$ ,  $p < .006$ ] were found. No other effects were significant in this overall analysis. Similar overall analyses examining items as the random variable demonstrated a significant main effect of structure

**Table II.** Difference (in ms) for Integration of Two-Role and Three-Role Verbs into Adjunct plus Argument and Two-Arguments Sentence Types

	Adjunct + argument (theme)	Two-Arguments (goal, theme)	(Difference)
2-Role verbs (agent, theme)	587	563	+24*
3-Role verbs (agent, theme, goal)	650	608	+42**

\* $p < .06$

\*\* $p < .05$

[ $F_2(3,84) = 3.204, p < .028$ ], but not of verb type [ $F_2(1,28) = 1.737, p < .2$ ]. *A priori* planned comparisons were performed for each structure type (*adjunct plus argument*, *two-argument*, *two-arguments plus modifier*, *two-arguments plus source*) comparing the two- and three-role verbs, and each was found to reach significance individually: [ $F_1(1,59) = 6.595, p < .013$ ;  $F_1(1,59) = 8.573, p < .005$ ;  $F_1(1,59) = 9.144, p < .004$ ;  $F_1(1,59) = 10.332, p < .002$ ], respectively.

Of major importance to the hypothesis under investigation, *a priori* paired comparisons (one-tailed t tests) were performed on the *adjunct plus argument* sentence type versus *two-arguments* sentence type independently for each verb type. For the three-role verbs, there was significant facilitation for the two-argument condition compared with the *adjunct plus argument* condition [ $t(59) = 1.813, p < .04$ ]. There was also marginal facilitation in the case of the two-role verbs when comparing the *two-argument* condition with the *adjunct plus argument* condition [ $t(59) = 1.586, p < .06$ ]. Importantly, there was no indication of a significant difference between *two-arguments plus modifier* and the *two-arguments plus source* condition for either two-role [ $t(59) = .689, p = .49$ ] or three-role verbs [ $t(59) = .207, p = .83$ ]. In addition, the *two-argument plus modifier* and the *two-arguments plus source* conditions when compared as a group do not differ from the plain *two-argument* condition [ $t(59) = .468, p = .64$ ]. Critically, these three two-argument context conditions do differ from the *adjunct plus argument* condition [ $t(59) = 2.424, p < .02$ ].

## DISCUSSION

The answers to the questions raised in the beginning of this paper can now be summarized briefly as follows. First, the number of participant roles associated with a verb influences the verb's rate of integration into the sentence. That is, verbs that prefer three participant roles are slower in every case to integrate than those that prefer two participant roles (Table I). This is in line with the finding that verbs with three participant roles are accessed slower than verbs with two participant roles (Ahrens & Swinney, 1995). These findings suggest that the number of roles associated with the central sense of the verb is crucial information that is accessed and used in real-time sentence processing.

Second, as also can be seen from Table I, the more arguments that precede the verb, the faster the verb will integrate into the sentence. Similarly, both verb types integrate faster into the *two-argument* condition than into the *adjunct + argument* condition. Since both verb types integrate into sentences with two preceding arguments faster than into sentences with one preceding adjunct and one preceding argument, the hypothesis is that sentential level arguments, but not sentential level adjuncts, play a role in facilitating the integration of a verb into a sentence.

There are two implications that can be drawn from this finding, one theoretical and the other methodological. First, and most importantly, sentential information that is structurally crucial to a verb (i.e., the argument roles in a sentence context) facilitates integration of the verb into the sentence (as opposed to, for example, access of the verb). Such argument information is fused with the information that the verb provides (i.e., the participant roles) during the integration process of comprehension. This finding fits with evidence from Taraban and McClelland, (1988), and Carlson and Tanenhaus (1988) (among others), who demonstrated savings in reading times when thematic roles were saturated during comprehension. What is important here is that the savings can now be clearly identified as belonging to sentential integration processes rather than lexical access processes. Second, the technique of examining the integration of verbs into sentences using a cross-modal integration paradigm may provide a viable empirical method for determining what is likely to be an adjunct and what is more probably an argument, when linguistic tests fail to draw a robust conclusion.

The third finding is that attaching *different* types of adjuncts to the theme does not influence the verb's rate of integration into the sentence. Thus, even though the "source" adjunct carries more thematic-role-like information than the modifier adjunct, the fact that these prepositional phrases are adjuncts is still the overriding determiner in how the processor treats them. Moreover, even though the sentences get longer and more complex with the addition of the adjuncts as compared with the "plain" *two-argument* condition, the verb's rate of integration into the sentence does not differ. However, verbs in sentences that have only one preceding argument role take significantly longer to integrate than in all the other two-argument role conditions. Thus, when dealing with verb integration, the processor is concerned with the nature of the information that the sentence provides, not simply the length of information that precedes the verb.

An additional finding concerns the relationship between the number of participant roles that a verb carries and the number of arguments that precedes the verb. The three-role verbs show a relatively faster facilitation into the two-argument condition, which would make sense given the fact that the sentence is providing the appropriate number of argument roles, as well as the appropriate semantic type of argument. That is, three-role verbs need what the sentence is providing: namely the goal and theme, and the rate of facilitation for three-role verbs in the two-argument case versus the argument plus adjunct case is even faster than for the same comparison with two-role verbs (e.g., compare the 42-ms facilitation for three-role verbs versus the 24-ms facilitation for two-role verbs shown in Table II).

This finding is even more interesting in light of the following fact: the argument roles that the sentence provides in the two-argument case are theme and goal, whereas the argument roles that two-role verbs need are agent and theme. Thus, even though there is a mismatch in the *types* of argument roles

that the sentence is providing, there is still marginal facilitation overall (24 ms), compared to when only one argument role (the theme) is provided as in the adjunct plus argument case.

There are at least two models of the language processor that are not in accord with this data, namely a basic “stack” model and a basic theta-role model. First, a stack model that pops off only the *number* of arguments the sentence provides, without attaching additional semantic information, does not adequately explain why three-role verbs are greatly facilitated in the two-argument condition, compared to two-role verbs in the same condition. If just the number of arguments is crucial, then one would expect equally faster integration for both two and three-role verbs in the two-argument condition simply because there are more arguments available. Similarly a theta-role match-up model cannot explain why two-role verbs are faster in the two-argument condition than in the argument plus adjunct condition, because there is no change in the thematic information provided by the two-argument condition, compared with the argument plus adjunct condition for two-role verbs (i.e., two-role verbs do not *need* the thematic role information of goal that the two-argument condition provides).

There are, however, two models that can potentially explain the findings presented here: an Expectation Model and an Argument Saturation Model.

An Expectation Model minimally involves the following two principles. (1) The presence of certain types of thematic arguments increases the expectation for certain semantic classes of verbs, and (2) the presence of pragmatic knowledge from the actual lexical items in the sentence allows the expectation for particular verb classes to increase. The expectation account must deal with the following questions. First, it is not readily apparent what types of semantic and pragmatic information are used by the processor, nor is apparent how a level of expectation is determined and assigned.<sup>6</sup> Second, the idea of a processor that builds expectations for particular *words* has not received support from on-line processing work.

The Argument Saturation model involves minimally the following two principles: (1) *Argument Saturation Principle*: A verb’s participant roles prefer to be saturated by the arguments of a sentence, and (2) *Thematic Agreement Principle*: The thematic information of a verb prefers to agree with the thematic information of the arguments in the sentence. The argument saturation principle presented above differs from the maximal arguments principle proposed by Ferreira and McClure (1997), which holds that the parser prefers to construct analyses that allow as many constituents as possible to be analyzed as arguments of the verb or other argument assigner (cf. Pritchett’s [1988] principle of theta-attachment). However, what was found in this experiment is contrary to the maximal arguments principle because both the two-role and three-role verbs

<sup>6</sup> But see Jurafsky (1992) for a computational model of human sentence interpretation that is expectation based.

integrated more quickly into the sentences with two arguments than into the sentences with one argument and one adjunct. This demonstrates that the parser has already made the decision that the “with” phrase, as well as the “from” phrase, are not arguments before reaching the verb. Even though the parser does not attempt to make every complement an argument, this experiment does show that arguments occupy a privileged position in the syntax because they provide information that is crucial to the integration of the verb. Thus it can be said that the parser prefers arguments over adjuncts in the narrower sense that the parser distinguishes between arguments and adjuncts and then uses only the argument information to facilitate integration of a verb.

## CONCLUSION

This paper argues on the basis of an on-line verb integration experiment that the number of roles associated with the verb is crucial to the processor in integrating the verb into the sentence. This finding, in combination with McRae *et al.* (1997), demonstrates that thematic roles have verb-specific information and lends support to the concept of participant roles in Construction Grammar—particular roles that are associated with the central sense of a verb. Moreover, the finding that two preceding arguments facilitates integration of two- and three-role verbs when compared with one preceding argument favors a constructional account over a lexical account, because the former assumes the integration of constructions (top-down information) and lexemes (bottom-up information), whereas the latter only postulates lexical (bottom-up) information. Additional evidence for a constructional account comes from the data that argue that participant roles are accessed immediately upon encountering the verb (Ahrens & Swinney, 1995), as well as the data in this paper that show that the number of participant roles influences the rate of integration of the verb. Lexicalist accounts do not include this information in the verbal representation; thus they have no way to account for these data.

In addition to the bottom-up information that the verb provides, the sentence also provides top-down information in the form of argument roles. Two models are proposed to account for the findings presented here. In the Expectation Model, the argument structure information is postulated to help in narrowing the semantic classes of verbs that could appear. In the Argument Saturation Model, the number of syntactic arguments that the sentence projects is postulated to match up with the number of roles that the verb projects, and then thematic role information from the arguments attempts to agree with the participant role information of the verb.

These two models differ fundamentally on the notion of whether pragmatic information can influence the integration of a verb into a sentence during normal

language processing. Conclusive evidence is not available in the current experiment to decide between the two models. What is important to note, however, is that the information preceding a verb has an effect on the integration of the verb in the sentence. The precise nature and time course of the information—that is, whether it is semantic as an Expectation Model predicts, or first syntactic and then semantic as the Argument Saturation Model predicts—is a question to address in future research.

## APPENDIX

The stimuli below are presented in condensed format. See examples (1–4) for an explanation of each of the four sentence types. The words in the parentheses were said when the sentences were recorded to tape, in order that the sentence had a natural sounding intonation pattern. However, the subjects actually heard the sentence only up to the second “was” in each instance.

### Three Participant Role Verbs

- (1a) It was with love that the rabbit was GIVEN (to Jen for her birthday).
- (1b–d) It was to Jen that the rabbit [(c) with spots]/[(d) from Mike] was GIVEN (for her birthday yesterday).
- (2a) It was with care that the duck was SERVED (to John for dinner last night).
- (2b–d) It was to John that the duck [(c) with orange sauce]/[(d) from Prince Charles] was SERVED (for dinner last night).
- (3a) It was with disdain that the raise was PROMISED (to Matthew last Christmas).
- (3b–d) It was to Matthew that the raise [(c) of a hundred dollars]/[(d) from the vice-president] was PROMISED (last Christmas).
- (4a) It was with certainty that the delivery was GUARANTEED (by the company).
- (4b–d) It was to Mary-Beth that the delivery [(c) of flowers]/[(d) from Thomas] was GUARANTEED (by the company).
- (5a) It with pride that the grant was ALLOCATED (to Kay last semester).
- (5b–d) It was to Kay that the grant [(c) of a thousand dollars]/[(d) from the vice-chancellor] was ALLOCATED last semester (before they ran out of funds).
- (6a) It was with trepidation that the case was ASSIGNED (at the meeting).
- (6b–d) It was to Elizabeth that the case [(c) about the killing]/[(d) from the district judge] was ASSIGNED (at the meeting).
- (7a) It was with nervousness that the visa was ISSUED (to Susannah).

- (7b–d) It was to Susannah that the visa [(c) of entry]/[(d) from her homeland] was ISSUED (yesterday).
- (8a) It was with caution that a package was HANDED (to Jesse by the courier).
- (8b–d) It was to Jesse that a package [(c) with tape]/[(d) from Bev] was HANDED [(b) by the courier] into the mailroom [(c)/(d) at noon].
- (9a) It was with confidence that the letter was MAILED (by Tom).
- (9b–d) It was to Erica that the letter [(c) of love]/[(d) from Tom] was MAILED [(b)/(c)by Tom]/[(d)yesterday].
- (10a) It was with haste that the documents were FAXED (to Jill before the meeting at one o'clock).
- (10b–d) It was to Jill that the documents [(c) about the deal]/[(d) from the client] were FAXED (before the meeting at one o'clock).
- (11a) It was with excitement that the announcement was E-MAILED (to the conference participants).
- (11b) It was to Theresa that the announcement [(c) of the party]/[(d) from Theodore] was E-MAILED (to the conference participants).
- (12a) It was with speed that the message was RELAYED (to Bob).
- (12b–d) It was to Bob that the message [(c) of the deal]/[(d) from the boss] was RELAYED (yesterday).
- (13a) It was with pleasure that the picture was SHOWN (after the dinner).
- (13b) It was to Maxine that the picture [(c) of the cat]/[(d) from David] was SHOWN (after the dinner).
- (14a) It was with patience that the story was READ to Chelsea about the princess.
- (14b–d) It was to Chelsea that a story [(c) about the prince]/[(d) from her daddy] was READ [(b) about the princess]/[(c)/(d) before bedtime].
- (15a) It was with apprehension that the test was ADMINISTERED (to the students by the proctor).
- (15b–d) It was to Christiana that the test [(c) on anatomy]/[(d) from the professor] was ADMINISTERED (by the proctor).
- (16a) It was with affection that the roses were DELIVERED (yesterday).
- (16b–d) It was to Miss Harris that the roses [(c) with long stems]/[(d) from Steven] were DELIVERED (yesterday).

### Two Participant Role Verbs

- (1a) It was with anger that the ball was BOUNCED (to Thomas after the game).
- (1b–d) It was to Thomas that the ball [(c) with stripes]/[(d) from Sam] was BOUNCED (after the game).

- (2a) It was with care that the hula hoop was ROLLED (to Jeff during the competition).
- (2b–d) It was to Jeff that the hula hoop [(c) with polka dots]/[(d) from Natalie] was ROLLED (during the competition).
- (3a) It was with concern that a chair was CARRIED (to Michelle because of her bad leg).
- (3b–d) It was to Michelle that a chair [(c) of oak]/[(d) from Max] was CARRIED [(b)/(d) because of her bad leg]/[(c) she did not like pine].
- (4a) It was with delight that a crate was PUSHED (to Anna so that she could stand on it).
- (4b–d) It was to Anna that a crate [(c) with no nails]/[(d) from William] was PUSHED (so that she could stand on it).
- (5a) It was with great energy that the wagon was PULLED (to Maximillan before everyone took a break for dinner).
- (5b–d) It was to Maximillan that a wagon [(c) of hay]/[(d) from Ned] was PULLED (before everyone took a break for dinner).
- (6a) It was with great force that the football was KICKED (to Robert after the game).
- (6b) It was to Robert that the football [(c) with a logo]/[(d) from the coach] was KICKED (after the game).
- (7a) It was with energy that the baseball was THROWN (to Helen after the game).
- (7b–d) It was to Helen that the baseball [(c) with the autograph]/[(d) from the first baseman] was THROWN (after the game).
- (8a) It was with frustration that the hat was TOSSED (to Christopher).
- (8b–d) It was to Christopher that the hat [(c) with a wide brim]/[(d) from the porter] was TOSSED (yesterday).
- (9a) It was with adoration that the card was TAKEN (to Isabella).
- (9b–d) It was to Isabella that the card [(c) with pansies]/[(d) from Adam] was TAKEN (after her accident).
- (10a) It was with carelessness that the shoe was DROPPED (out the window).
- (10b–d) It was to Elizabeth that the shoe [(c) with laces]/[(d) from Dennis] was DROPPED (out the window).
- (11a) It was with great concentration that the box was LIFTED (off the ground).
- (11b–d) It was to Jonathon Jr. that the box [(c) of nails]/[(d) from Jake] was LIFTED (off the ground).
- (12a) It was with playfulness that the trunk was LOWERED (to the ground).
- (12b–d) It was to Helen-ann that the trunk [(c) of clothes]/[(d) from Carl] was LOWERED (to the ground).
- (13a) It was with joy that the toys were DONATED (to the relief effort).

- (13b–d) It was to Ted that toys [(c) for the homeless children]/[(d) from the community] were DONATED [(b)/(d) for]/[(c) as part of] (the relief effort).
- (14a) It was with anxiety that the book was RETURNED (to Daniella after the mix-up at work).
- (14b–d) It was to Daniella that the book [(c) about trees]/[(d) from Mark] was RETURNED (after the mix-up at work).
- (15a) It was with annoyance that the cabinets were SUPPLIED (by the manufacturer).
- (15b–d) It was to Susanna that the cabinets [(c) of pine]/[(d) from Bob] were SUPPLIED (by the manufacturer).
- (16a) It was with careful thought that the estate was ENTRUSTED (to Virginia).
- (16b–d) It was to Stephanie that the estate [(c) of 100 acres]/[(d) from her great-grandfather] was ENTRUSTED (after the death of her grandfather).

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