Thematic Roles and Language Comprehension[1]

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1. Introduction. The general idea of thematic roles has played an important part in linguistic theory in the past twenty years or so. Since the seminal insights of Gruber (1965), Fillmore (1968), Jackendoff (1972), and others, there has been a flurry of more recent activity from a variety of different points of view (e.g. Verkuyl, l979; Stowell, 1981; Chomsky, 1981; Jackendoff, 1983, 1985; Culicover and Wilkins, 1984). Nonetheless, fundamental questions about the identification, individuation, and, especially, the theoretical status of thematic roles remain unresolved. For instance, there is not only considerable question about whether thematic roles are syntactic, semantic, or conceptual in nature, but also whether they should be regarded as grammatically significant entities at all (e.g. see Ladusaw and Dowty, this volume).

While it is not our present purpose to resolve any of these issues, we wish to discuss an alternative perspective which may shed light on some of these questions in the future. The idea we will be exploring is that thematic roles play a central role in language comprehension. We will suggest that thematic roles provide a mechanism whereby the parser can make early semantic commitments, yet quickly recover from the inevitable misassignments that occur as a consequence of these early commitments. Further, we will suggest that thematic roles provide a mechanism for interaction among the syntactic processor, the discourse model, and real-world knowledge, and that thematic roles help create coherence in local discourse structure.

Details of our representational and processing assumptions will be presented later. Here, we present an outline of the basic ideas. We assume that:

i) Lexical access makes available all the senses of an ambiguous verb in parallel, and the sets of thematic roles associated with each sense (one set of such roles we will call a "thematic grid," following Stowell (1981)).

ii) Only the one sense of the verb that is contextually most appropriate (or, in the absence of biasing context, the most frequent sense) remains active, along with its thematic grid(s).

iii) Thematic roles are provisionally assigned to arguments of the verb as soon as possible; any active thematic roles incompatible with such an assignment become increasingly inactive.

iv) Any active thematic roles not assigned to an argument remain as open thematic roles in the discourse model, appearing as free variables or unspecified "addresses" in the model.

2. Background and motivation. Our primary motivation for exploring these ideas comes from a confluence of findings from the language comprehension and word recognition literature. First, research on language processing suggests that the processor makes extremely early (and hence often incorrect) decisions, with each word being integrated as fully as possible with preceding context as it is encountered (Marslen-Wilson, 1975). Secondly, the processor appears to compute structures serially (Frazier, 1978; Ford et al, 1983; Frazier and Rayner, 1982). Evidence comes from studies demonstrating local increases in processing complexity when the parser pursues an analysis that turns out to be inconsistent with the remainder of the sentence or the biasing context. Yet, the parser is usually able to rapidly recover from these misassignments, and in the case of biasing context may avoid these local garden-paths altogether. This picture suggests that while the parser computes structures serially, it also has ready access to alternative structures.

Frazier and colleagues (Frazier, 1986; Rayner, Carlson and Frazier, 1984) have argued that thematic relations are the only vocabulary shared by the parser, discourse model, and world knowledge. They have proposed a special thematic processor which provides a channel of communication among these domains. On our view, quite similar in spirit to theirs, thematic roles themselves can do much of this work by virtue of the way they interact with other comprehension mechanisms. If all thematic roles on an active grid remain active in parallel, the parser could pursue a single analysis while much of the time having available the critical information required to revise the parse rapidly and mechanistically. In effect we would have a serial parser with latent parallelism . (See Cottrell, 1984, and McClelland and Kawamoto, 1986, for computational models in which parallel activation of case roles (roughly, thematic roles) play an important part in resolving lexical and syntactic ambiguities.)

Placing the source of parallelism in the lexicon is attractive because a large body of research on lexical processing demonstrates that multiple codes in a word's lexical entry become activated in parallel regardless of context. For instance, multiple senses of ambiguous words are initially accessed even in the presence of biasing context (Onifer and Swinney, 1981, Seidenberg et al, 1982; Swinney, 1979; Tanenhaus et al, 1979). Moreover, a number of lexical and sublexical phenomena, such as the word-superiority effect (i.e. that letters, for instance, are recognized more quickly as parts of words than as parts of non-words), effects of spelling-sound regularity and of orthographic regularity in visual word-recognition, can be explained elegantly on the assumption that there is parallel bottom-up activation, with incompatible representations competing with one another (McClelland and Rumelhart, 1981; Seidenberg, 1985). When representations are compatible, on the other hand, all remain active (Seidenberg and Tanenhaus, 1979; Tanenhaus, Flanigan, and Seidenberg, 1980).

There have also been a number of recent demonstrations that verb structure mediates or interacts with structural decisions in parsing. Ford, Bresnan, and Kaplan (1982) show that in the absence of biasing context, lexical preference determines the more salient interpretation of sentences with attachment ambiguities (see also Kurtzman, 1985), although it remains an open question whether these lexical preferences can override structural parsing biases (e.g. minimal attachment) in determining the initial parse (Frazier, 1978). Mitchell and Holmes (1985)) demonstrate that lexical preference has a greater initial impact on some parsing decisions than purely structural biases. Clifton, Frazier, and Connine (1984) demonstrate that verbs which have both transitive and intransitive readings show lexical bias in favor of one over the other, rather than there being some general structural bias applying to all. Clifton et al (1984), Tanenhaus, Stowe, and Carlson (1985), and Stowe and Tanenhaus (forthcoming) all report lexical effects in making filler-gap assignments.

Thus, we see two primary issues of interest in this work. The one issue is how language processing proceeds in real time. But an equally important matter is the structure of the lexical entries themselves. We are interested in what the nature of on-line processes can tell us about these lexical structures: what kinds of information are associated with lexical entries, and how and when does that information contribute to the developing

representation? In light of the growing evidence for multiple code activation in lexical processing, for strong lexical effects in parsing, and for on-line serial commitment and rapid local garden-path recovery, it seems reasonable to seek a mechanism whereby lexical structures can help to organize a parse, guide local garden-path recovery, and communicate with the discourse model. Thematic roles provide a promising candidate for such structures.

3. Representational Assumptions. On our view, thematic roles are semantic, or conceptual phenomena, roughly in keeping with the views of Jackendoff (1983), Verkuyl (1979), Parsons (1979), Chierchia (1984), Carlson (1984), and Culicover and Wilkins (1984, 1986), rather than being fundamentally syntactic constructs (Chomsky, 1981; Stowell, 1981). We most closely follow Parsons (1979) and Carlson (1984) in assuming that a main function of thematic roles is to relate "arguments" of a verb to the meaning of the verb in semantic interpretation. This is at variance with the common view that verb meanings are n-ary functions, operating on a sequence of n arguments to yield a proposition. See Dowty (in press) for a detailed discussion contrasting the two positions. Thus, we assume thematic roles to be the elements which, when associated with a verb, are responsible for that verb's ability to "take" semantic arguments. We also assume, in keeping with some common assumptions of psychologists and formal semanticists (e.g. Johnson-Laird, 1983, Kamp 1979, 1981; Heim, 1982; Partee, 1984, Seuren, 1985), that an integral element of the interpretation of a sentence is a discourse model which represents an ongoing record of the discourse. Thematic roles appear in the discourse model as elements relating the interpretation of a verb to the various entities that play "roles" in what a verb is taken to denote. Carlson (1984, 1985) generally follows the lead of Davidson (1967) and Bach (1977) in suggesting that verbs denote eventualities, or types of events, processes, and states.

Like many other aspects of semantic interpretation, thematic roles are closely associated with the syntactic/lexical structure of a sentence. Obviously, there must be some means of associating a particular thematic role with a given argument of a verb. While we do not offer a particular mechanism for carrying out this association, we do share with Bresnan (1982) and many others the following guiding assumptions:

i. Every argument of a given verb is assigned a thematic role.

ii. No argument is assigned more than one thematic role

iii. Every argument of a verb is assigned a unique thematic role.

Though none of these can be fully accepted without qualification, we take them as reasonable generalizations which, if properly qualified, may serve as primary guiding assumptions.[2]

We also wish to advance some more specific hypotheses about the linguistics of thematic roles which may not be so widely shared. First of all, the set of syntactic arguments of a verb--those constituents whose meanings are assigned thematic roles--are the subject of the sentence, and the subcategorized phrases in the VP, which are sisters of and governed by the verb. The verb, we assume, assigns thematic roles to no constituents beyond these.[3] This places a principled (and empirically determinable) upper limit on how many thematic roles may be associated with a given verb. No adverbial modifiers or adjuncts are assigned thematic roles by the verb. This is probably most controversial in the cases of instrumentals and benefactives (e.g. sweep the floor with a broom; fix a sandwich for your mother). In such cases, we hold that the PP's are not subcategorized phrases (not being sisters of the main verb by standard tests of VP constituency--see Lakoff and Ross (1966), McCawley (1982)), and hence are not assigned thematic roles by the verbs directly. Instead, the lexical meanings of the prepositions themselves relate the prepositional objects to the meaning of the VP. If a PP is a subcategorized element, on the other hand, we take it that a thematic role is assigned to the PP itself; in some instances the preposition may have no lexical meaning (as, perhaps, in 'give the book to Mary,' or ' be complimented by your host'--see Gazdar et al (1984)),whereas in other cases it might have lexical meaning ('take candy from a baby'). Either way, a thematic role and not the preposition itself mediates the relation between the PP and the verb meaning for those PP's that are subcategorized. Additionally, we allow thematic roles to be assigned to sentential phrases, both finite and nonfinite.

In a verb's lexical entry, the first major lexical division is into senses ("core meanings") of the word. Each distinct sense may have a number of different syntactic subcategorizations associated with it. Our assumptions in this respect are quite standard. Once we bring in thematic roles as independent elements, a number of immediate questions arise concerning

the relationship between verb subcategorizations and thematic grids. We take the position that while grids and subcategorizations appear to encode very much the same sort of information, they are independent of one another. Let us illustrate some of the linguistic consequences of this claim.

Consider the very productive class of causative/'ergative' pairs of intransitive and transitive verbs, as in (3):

3. a. The butter melted/John melted the butter.
   b. The vase broke/Mary broke the vase.
   c. The meat cooked/Sam cooked the meat.

On the intransitive readings of each, there appears to be no necessary Agent participant implied, whereas an Agent serves as the subject in each of the alternative transitive versions. Our hypothesis is that such examples do not involve a sense ambiguity, but rather involve identical core meanings of verbs associated with different thematic grids. The intransitive examples have the set of thematic roles {Theme}, whereas the transitive versions have {Agent, Theme}. Thus, a verb meaning consists of (at least) two separable components: a core meaning plus a thematic grid

Or, consider the "middle" construction (Keyser and Roeper (1984)), where there is some intuitive appeal to the claim that the core verb meaning is the same (as in the pairs of examples below) while the difference in meaning resides in the sets of thematic roles associated with the verb:

4.a. John drives his car well. {Agent, Theme}
   b. This car drives well. {Theme}
5.a. Mike plays the trumpet poorly. {Agent, Theme}
   b. This trumpet plays poorly. {Theme}

If this is correct, then more than one thematic grid may be associated with a single verb sense; in these cases, the grids are associated with individual subcategorizations as well, though this is not always so, as we shall see.

That we are dealing with the same verb sense in such examples as (3)-(5) is plausible, and we leave it thus for now. We do note, though, that verb alternations where we claim there is a shared single core meaning that has alternative thematic grids are often associated with inflectional (as well as derivational) morphology, in a variety of languages. If alternative inflected forms (as opposed to derived forms) never operate on the core meaning of the word, as we suspect, we nonetheless allow for inflectional operations to manipulate thematic roles since roles are not a part of core verb meaning. In

affirming that grid manipulation can be associated with syntactic operations, this suggestion is at variance with the Theta-Criterion (Chomsky, 1981)).

Not all changes of subcategorization entail a change in the associated thematic grid. In many cases, the syntactic elimination of an argument position does not entail a corresponding revision of the roles in a grid, as might be suggested by the causative/inchoative and middle examples of (3-5). Under these circumstances, a thematic role on a grid may be assigned to no constituent. When this occurs, open thematic roles arise.

Consider the well-known example of passive sentences like those below:

6.a. The fire was extinguished by the firemen.

b. The fire was extinguished.

Assuming the "the fire" is assigned the role Theme and "the firemen" is Agent in (6a),[4] how should (6b) be analyzed on the nonstative verbal reading? Certainly, "the fire" should still be Theme, but should there also be an Agent role associated with this occurrence of the verb as well? We will assume that there is an Agent role present in (6b), even if no constituent is actually assigned that role. In part, this decision is based on the intuition that (6b) is understood as having some unstated agentive participant (this is reflected in the formerly common transformational analysis deriving (6b) by Agent Deletion from a structure like (6a)). Contrast (6b) with "the fire went out" in which there is no such understood agentive participant, though the meaning is quite similar in all other respects. But further substantiating these intuitions is the presence of an alternative subcategorization of the same verb, with intuitively the same core meaning, in which an agent is overtly expressed--as in (6a). We take this as an indication that an Agent role is to be associated with the verb in (6b), even if assigned to no constituent. Thus, we will assume that there can be unfilled or "open" thematic roles. Open thematic roles, we suppose, appear in the discourse model as free variables, or "addresses" in need of further identification or elaboration.[5]

Open thematic roles appear in many other constructions besides agentless passives. Consider lexically-governed constructions of English reminiscent of "applicative" constructions of a variety of other languages

(Baker 1986, Marantz, 1984), exemplified by the verb "load". This verb, has at least three subcategorizations, exemplified in (7):

7. a. John loaded the truck. (__NP)

b. John loaded the furniture onto the truck (__NP $PP_{[+loc]}$)

c. John loaded the truck with furniture (__NP $PP_{[+with]}$)

In (7a), "load" is a simple transitive; in (7b) it takes an object and a following locative PP; and in (7c) "load" takes an object and a PP headed by the preposition "with."[6] In the latter two versions, three associated thematic roles appear: the Agent (John), the Theme (the furniture), and Location (the truck). In the case of the simple transitive (7a), we assume that all three thematic roles are available there as well. Here, John is Agent, and the truck could be either Location or Theme, though the former is more plausible (trucks get other things put into them more often than they are put into or onto other things). Whichever role is assigned the object in (7a), there is the clear understanding that the other role remains, though unspecified (i.e. if Location, then something was put into the truck; if Theme, that the truck was put somewhere (e.g. onto a railroad car)). So we conclude that the verb in (7a) has three thematic roles associated with it as well. Some other constructions we assume to give rise to open thematic roles are examples of "object deletion" or detransitivization ("John ate the cake" vs. "John ate"), and ditransitives used transitively ("John served the meal to his guests" vs. "John served the meal"), in addition to a number of other less productive classes.

We have seen that it is possible for the same thematic grid to be associated with alternative subcategorizations of a verb. As a result, in any given case of a verb with alternative subcategorizations, there is some uncertainty about whether it retains the same thematic grid or whether the grid is adjusted. Ultimately, we would hope that psycholinguistic results of the sort to be discussed in the next section would serve as a means of resolving such uncertainties. However, in the interest of making future experimental predictions, we would like to discuss two particularly controversial cases: instrumentals and benefactives.

Benefactives typically can show up as either "for" adjuncts or as (derived) objects, and are optional:

8. a. John bought a book <u>for Sally.</u>

b. John bought <u>Sally</u> a book.

c. John bought a book.

As we noted above, the PP in (8a) is not a subcategorized element, and hence is not assigned a thematic role by the verb. In (8b), on the other hand, the Beneficiary role is assigned to Sally by the verb, as the NP Sally is in the thematic domain of the verb. This does not necessarily mean that only the verb in (8b) has a beneficiary role in its grid. It would be possible for the verbs in (8a) and (8c) to have the same grids. However, we believe that the verbs in (8a) and (8c) have no Beneficiary role, for two reasons. First, it is not clear that a Beneficiary is a necessary participant in such actions as described in (8c); it seems one can buy something and then later decide what to do with it, or that one can make a cake without making it for someone, etc. Second, since contrastive judgments are often more compelling than absolute ones, we detect no striking differences in judgment of necessary Beneficiary participation between those verbs like "buy" or "make" which display the alternation illustrated in (8), and those that do not, as those verbs in (9):

9. a. John smiled a broad smile for Mary./*John smiled Mary a broad smile.

b. Max gathered the family for his mother/*Max gathered his mother the family.

c. Antonio phoned his cousin for his father./*Antonio phoned his father his cousin.

d. John performed Hamlet for his classmates/*John performed his classmates Hamlet.

That is, we do not sense a consistent contrast between the verbs in (9) and those that may take the benefactive as an indirect object that could be characterized in terms of the necessary participation of some role (e.g. "The bomb exploded" vs. "The bomb was exploded"). Furthermore, these alternations appear to be subject to significant individual or dialectal variation. For instance, while we ourselves find "prepare Max a meal" or "confiscate the kids some more weapons" to be unacceptable, others find them acceptable. This does not, however, appear to be a question of how to interpret such verbs; it seems rather a dispute about which structural configurations certain verbs may participate in--a structural matter. Given that we find no striking differences in intuition between the two classes of verbs about necessary participants, and given that by our criteria such verbs

as those in (9) cannot have a Beneficiary role on their grids since no Beneficiary ever appears as a subcategorized element, we tentatively assume there are no open Beneficiary roles in such examples as "John bought a book."

Much the same can be said about English instrumentals, which have been occasionally regarded as within the thematic domain of the verb (we construe, for instance, Fillmore (1968) and Bresnan (1982) as making such a claim). Instrumentals, like benefactives, show an adjunct-argument alternation, illustrated in (10):

10. a.John sliced the salami with the razor-sharp knife.

b. The razor-sharp knife sliced the salami with ease.

Since "with a knife" in (10a) is not a subcategorized PP, it is only necessary for the verb to assign Agent to John and Theme to salami for an interpretation, an Instrument role being unnecessary. In (10b), though, the verb must assign an Instrument role to the subject as that argument is in the thematic domain of the verb. The question, then, is whether Instrument is a role in a sentence like (11):

11. John sliced the salami.

Here, direct intuition is less decisive than in the case of benefactives (e.g. can one slice things without an instrument? If one uses one's hand, is that an instrument? etc.). However, we are going to claim that there is no Instrument role in examples like (11). Cases can be found which allow "with" phrases but not Instrument subjects, (12), yet one does not find a striking difference regarding Instrument participation when contrasting such examples to those which do display the alternation, (10).

12. a. John ate the salami with a fork/*John's fork ate the salami.

b. Max first noticed the galaxy with a radio telescope/*A radio telescope first noticed the distant galaxy (cf: "detected")

c. Fred read the phone book with a magnifying glass/*The magnifying glass read the phone book.

d. Mary addressed the crowd with a bullhorn/*A bullhorn addressed the crowd.

Again, by our criteria, none of these verbs has Instrument on their grids as Instrument is never assigned to a subcategorized phrase. Thus, we will claim that in such cases as "John sliced the salami" there is no open Instrument role. This does not mean, however, that the core meaning of the

verb itself does not entail, or strongly imply, the presence of an instrument; entailed participation is a necessary but not a sufficient condition for the presence of a thematic role.

Summing up, we assume that at least two sets of thematic roles are associated with verbs like "buy" and "slice," though there is no ambiguity of verb sense:

13. a. John bought Mary a present ({Agent, Beneficiary, Theme})
    b. John bought a present for Mary. ({Agent, Theme})
    c. Seymour sliced the salami with a knife. ({Agent, Theme})
    d. A sharp knife sliced Seymour's salami. ({Instrument, Theme})

Though the core verb meanings of (13a,b) and (13c,d) are the same, in (13b,c) the Beneficiary and Instrument "roles" are provided by the lexical meanings of the prepositions, and do not emanate from the verb itself.

4. Empirical Predictions. Our view of thematic roles in processing, coupled with our representational assumptions, make some potentially strong claims about language processing. In this section we present a mix of intuitive and experimental evidence which provides encouragement for the view we are developing. We will focus on three areas: differences between proposed components of verb meaning involving thematic ambiguities vs. ambiguities of core meaning ("sense ambiguities"), feedback between thematic assignments and parsing decisions, and the how thematic roles may play a part in the creation and integration of local discourse structure.

4.1. Sense and thematic role ambiguities. Our assumptions about lexical access predict processing differences between sentences with verbs displaying sense ambiguities (e.g. "set" meaning "to place" or "adjust (as a clock)", and those displaying thematic ambiguities (e.g. "load the truck" where the truck is either Theme or Location). Lexical access will make available multiple senses of such a word as "set," but only the contextually most appropriate (or, in absence of context, most frequent) sense will remain active and the others become unavailable (see Simpson, 1984, for a review of relevant literature). In contrast, in a thematic ambiguity, all the thematic roles on the active grid remain, and all remain available, even if (as we wish to hold) thematic roles are assigned to constituents on-line.

These assumptions have a number of empirical consequences. When a reader or hearer initially selects the wrong sense of an ambiguous verb, reinterpretation would require retrieving the no longer available alternative

sense. This should take time and processing resources. However, when the wrong thematic assignment is initially made, then thematic reassignment should be relatively cost-free because: (a) the core meaning of the verb remains constant, and hence the verb's lexical entry need not be reopened, (b) the alternative thematic roles on a grid are often already active and available, and (c) even if they are not, the syntactic-thematic mappings provide explicit information about how roles are to be assigned, so only a limited domain of information needs to be reexamined; this may result in ease of recovery, as well. Thus, thematic roles allow the processor to make early commitments without undue cost; thematic reassignment may not be completely cost-free, of course, but it will be easier, we assume, than reopening lexical entries. The null hypothesis is that both types of ambiguities are really just sense ambiguities, and hence are not fundamentally distinct.

A recent experiment conducted in collaboration with Curt Burgess provides initial confirmation of our predictions. We constructed sets of materials similar to those sense ambiguities in (14) and the thematic ambiguities in (15):

14. a. Bill set the alarm clock for six in the morning.
    b. Bill reset the alarm clock for six in the morning.
    c. Bill set the alarm clock onto the shelf.
    d. Bill put the alarm clock onto the shelf.
15. a. Bill loaded the truck with bricks.
    b. Bill filled the truck with bricks.
    c. Bill loaded the truck onto the ship.
    d. Bill drove the truck onto the ship.

In examples (14a) and (14c), different senses of "set" are selected by the final disambiguating phrase; disambiguation does not take place until after presentation of the direct object NP. Examples (14b) and (14d) are control sentences using unambiguous verbs that have core meanings related to the appropriate sense in the ambiguous version of the sentence. The sentences of (15) repeat that same pattern for the thematic ambiguities: (15a) and (15c) involve temporary ambiguity of thematic assignment to the direct object, to be disambiguated by the final constituent; (15b,d) serve as unambiguous controls.

The sentences were displayed on a CRT and the subjects' task was to decide as quickly as possible whether the sentence "made sense" (many of the filler trials were sentences that did not make sense). We assume that subjects will initially select the incorrect verb sense or thematic assignment on approximately half the trials where temporary ambiguity is possible. If incorrect sense selection results in a garden path once disambiguating information to the contrary arrives, this should be reflected in longer reaction times in deciding whether such sentences make sense, and should result in fewer of these judged to make sense, all relative to controls. Data from 28 subjects are presented in Table 1, which displays mean reaction time (in msec) to the sentences judged to make sense, and percentage of sentences judged to make sense.

Table 1

		Type of Verb	
		Ambiguous	Control
Type of ambiguity:	Sense	2445 (77%)	2290 (94%)
	Thematic	2239 (92%)	2168 (93%)

There is a clear difference between sense and thematic role ambiguities. Sense ambiguities take longer than their controls to comprehend, and are less often judged to make sense. In contrast, sentences with thematic ambiguities are not significantly more difficult to comprehend than the unambiguous controls, and are fully as often judged to make sense. Using our own intuitions, we divided the ambiguous sentences into those in which preferred and non-preferred initial sense or thematic assignment is correct. Table 2 presents these results.

Table 2

	Type of Verb	
	Ambiguous	Control
Sense Ambiguity:		
Preferred Sense	2277	2317
Less Preferred Sense	2613	2264
Thematic Ambiguity:		
Preferred Assignment	2198	2177
Less Preferred Assignment	2268	2158

Table 2 shows that the sense ambiguities are more difficult than their controls only when the less preferred sense turns out to be correct. This is predicted by our assumptions. In addition, there is a slight (marginally significant) reprocessing cost for selection of the incorrect thematic assignment, though not nearly as high a cost as recovering from an incorrect sense. Thus, this experiment provides support for a processing contrast between sense and thematic ambiguities, as well as some reason to think that provisional thematic assignments are made on-line.

We can also present intuitive evidence for the distinction between sense and thematic ambiguities. One of our key representational assumptions is that the same verb meaning may be associated with different thematic grids (as the transitive and intransitive uses of verbs such as "break" in (3)), the alternative hypothesis being the different uses of such verbs reflect an ambiguity in the verb's core meaning. Experimental evidence shows that in the absence of biasing context, the dominant reading of an ambiguous word is rapidly selected (Simpson and Burgess, 1985; Hudson and Tanenhaus, 1984). A standard assumption in the word-recognition literature is that frequency is a function of recency. On this account, recent choice of one meaning of an ambiguous word should bias the reader or listener to select the same meaning the next time the word is encountered, making selection of the alternative sense more difficult.

Consider the following short paragraphs, in which either of the first two sentences is taken to immediately precede the third; (16) contains a sense ambiguity, while (17,18) contain thematic ambiguities:

16. The general commanded the troops in battle.
    The general led the troops in battle.

Afterwards, he commanded their respect.

17. John packed the books in the morning.
John crated the books in the morning.
Then he packed the truck.

18. John hurried the kids off to school.
John rushed the kids off to school.
Then he hurried off to work.

When different senses of an ambiguous verb are used in adjacent sentences, as in (16), the second occurrence seems awkward ("The general commanded the troops in battle. ? Afterwards, he commanded their respect."). The awkwardness seems to go away, though, when the priming occurrence is replaced by a close synonym (e.g. "The general led the troops in battle. Afterwards, he commanded their respect."). But thematic ambiguities behave differently. Using the same verb with different thematic assignments, as in examples (17, 18), does not result in the same sense of awkwardness found in (16) ("John hurried the kids off to school. then he hurried off to work.") Thus, the ambiguity of a verb like "hurry" is not like a sense ambiguity. This is just what we would predict since we would not attribute the different meanings of "hurry" in (18) or "pack" in (17) to an ambiguity of core meaning.

4.2 Thematic feedback to the parser. The assumption that arguments are assigned thematic roles immediately (at least once the verb is encountered) suggests that provisional thematic role assignment may provide a mechanism whereby pragmatic knowledge and processing context influence subsequent syntactic decisions. It seems plausible that the meaning of an argument, the core meaning of the verb, as well as general world knowledge are taken into account in making provisional thematic assignments (e.g. "pack the suitcases" prefers suitcases as Location, while "pack the clothes" prefers clothes as Theme, because of the nature of suitcases and clothes, but not because of any grammatical properties NP's denoting these things may have). Since thematic assignments often have direct syntactic consequences, the nonsyntactic information used in assigning thematic roles might well have parsing consequences. Some evidence in support of the hypothesis that initial thematic assignments can provide feedback to the parser comes from some studies by Stowe and Holmes (reported in Stowe, in press).

In one experiment they used causative/'ergative' verbs such as "stopped." Used transitively ("Frank stopped the car"), the subject is Agent and the object is Theme; used intransitively ("The car stopped") the subject is Theme. These verbs were placed in subordinate clauses preceding the main clause, as in "Even before the police stopped the driver was getting nervous." Frazier (1978) and Frazier and Rayner (1982) have shown that in the absence of punctuation, readers initially assume that the NP following the verb is its object, rather than closing off the subordinate clause and taking the NP to be the subject of the main clause. This results in a garden-path effect in this example. If, however, the subject of the subordinate clause is inanimate, and thus more likely to be a Theme than an Agent, then the reader may "close off" the subordinate clause after the verb, there being no unassigned roles remaining on the grid. To test this prediction, Stowe and Holmes manipulated the animacy of the subject of the subordinate clause, using materials like (19).

19. a. Even before the police stopped the driver was getting nervous.
    b. Even before the truck stopped the driver was getting nervous.
    c. Even before the police stopped at the light the driver was getting nervous.
    d. Even before the truck stopped at the light the driver was getting nervous.

Subjects read sentences such as these one word at a time, with a secondary task of pressing a button if and when the sentence became ungrammatical. Reading times were recorded, as were judgments of ungrammaticality.

The main finding was that when the subject of the subordinate clause was animate (19a), the reading times for the main clause were longer by more than half a second compared to controls (19c,d). On the other hand, there was no corresponding effect when the subject was inanimate (19b). This provides evidence that at least animacy was playing a role in determining parsing decisions. In the presence of an animate subject, the verb was taken as a transitive, leading to a garden-path in the main clause. Our account is that animacy, in this case, affects thematic assignment, which in turn has direct consequences for the syntax of the sentence being processed. Whether or not properties other than animacy (a salient and often grammatically important property) can have similar effects has yet to be shown. Under the hypotheses advanced here, though, similar effects

should be found for other semantic distinctions that may affect thematic assignment.

We caution that this issue remains controversial. It will be important to replicate the Stowe and Holmes results with a task that does not involve an explicit decision on each word. This is particularly important because Ferreira and Clifton (1986) report results that appear to be inconsistent with the Stowe-Holmes results. Ferreira and Clifton examined eye fixation durations in sentences such as "The baby (skin) (that was) felt by the blind man was very soft and delicate." The subject NP was either animate or inanimate. They reasoned that if thematic assignment could provide feedback to the parser, then reading times for the postverbal "by" phrase, which unambiguously shows the verb to be a past participle (in a reduced relative) rather than a simple past tense, should be shorter when the subject is inanimate ("the skin felt...") than when it is animate ("The baby felt..."). Reading times on the verb were longer when the subject was inanimate, which would be consistent with a thematically-based revision. However, there was no significant animacy effect at the "by" phrase, suggesting that the parser was not able to use thematic feedback. But this lack of an effect may have been due to the nature of Ferreira and Clifton's materials. As Susan Garnsey and Tom Bever pointed out to us, more than half the sentences had plausible continuations in which the inanimate subject could be continued with a simple past (e.g. "The skin felt smooth"). Clearly, further work is necessary to resolve the issue of thematic feedback.

4.3 Open thematic roles and the discourse model. We have proposed that open thematic roles are represented as unspecified entities in a discourse model or other conceptual representation of a discourse, and that they, like anaphors and presuppositions, can help create local discourse coherence (Grosz, Joshi, and Weinstein, 1983). We now consider several predictions that follow from this view.

First, definite NP's will be more rapidly integrated into a discourse interpretation if a previous sentence introduces an open role which can plausibly be "filled" by the NP. An open role, it appears, represents a point in the discourse which invites further specification, or is otherwise salient; in "filling" such a role, one does not have to rely wholly upon general inferential processing of the type typically required to integrate information into a single scheme.

Consider by way of example a sentence like "John loaded the truck." In understanding this sentence, not only are John and a truck introduced into the discourse, but so is an unspecified entity playing the role of the Theme (i.e. whatever got loaded onto the truck). In contrast, a sentence like "John wrote a letter" introduces just John and the letter, and no entity playing the role of an instrument (such as a pen), even if an instrument is conceptually judged to be a necessary participant in such actions; such entities would have to be introduced inferentially.

In a preliminary experiment conducted in collaboration with Susan Hudson, we demonstrate that sentences beginning with a definite NP are comprehended more rapidly where preceded by a context sentence introducing an open thematic role the NP can plausibly fill. In (20) are sample materials:

20. a. Bill hurried to catch his plane.
    a'. Bill hurried to unload his car.
    b. <u>The suitcases</u> were very heavy.

A sentence such as (20b) was preceded by either a sentence like (20a'), which leaves an open thematic role of the sort a suitcase could plausibly "fill" (here, the Theme), or a sentence like (20a) which introduces no open role but which invites at least as plausible an inference that a suitcase would be a part of the scene (e.g. that John while rushing to his plane was lugging suitcases is at least as likely as that while he was unloading his car he was unloading suitcases).[7] The subjects read the context sentence (e.g. 20a, 20a'), and then judged whether the target sentence (e.g. 20b) made sense given the context. We found that when the context introduced an open thematic role, mean reading time to the target sentence was 1628 msec, with 97% judged to make sense. When no open role was introduced by the context sentence, reading times rose to 1847 msec, and judged sensibility fell to 84%. In such cases, the open roles did appear to aid discourse integration.

One consequence of the assumption that thematic roles create discourse addresses is that introducing a definite NP should result in more of a perceived topic shift when it can fill no open role, and is hence not elaborating on something "already introduced." Intuitions suggest that this is the case. Consider the examples of (21).

21. a. Mary put dinner on the table.

a'. Mary served dinner.

b. The guests were complimentary.

c. Dinner was delicious.

c'. It was delicious.

(21a) does not introduce an open Goal role, whereas (21a') does (to serve is to serve to someone). In (21b), a definite NP is introduced which can plausibly fill the open Goal role of (21a'), or easily be integrated inferentially with the event described in (21a) (e.g. that guests were seated at the table). Subsequently, a third sentence follows these sequences, one beginning with a full NP, and the other with a pronoun, referring back to an entity already presented in the discourse (the dinner). If the second sentence introduces a topic shift, the noun version (21c) should be more easily understood than the pronoun version (21c'). This appears to be the case. We find that the sequence beginning with the introduction of an open role and ending with the pronoun (22) is more natural than a very similar sequence which introduces no open role (23):

22. Mary served dinner at the table. The guests were complimentary. It was delicious.

23. Mary put dinner on the table. The guests were complimentary. It was delicious.

(22) is, in our opinion, more natural than (23), because there is no introduction of a topic shift in (22). We find similar intuitions when the open role is presented subsequently to the NP that "fills" it. Consider cases of sentences giving rationale for an action, keeping in mind that rationale is particularly keyed to the role of Goal (Jones, 1985). If the second sentence contains an open Goal role plausibly filled by an entity already introduced, it is much more easily integrated with the first sentence than when no open role occurs. Consider the contrast found in (24), between the (b) continuation with an open Goal role, and the (b') continuation lacking such a role.

24. a. Her nephew's birthday was coming up, so...

b. Mary sent a book. (open Goal)

b'. Mary bought a book. (no open Goal)

From a general conceptual point of view, if one knows that someone's birthday is coming up, buying a gift is certainly at least as common as

sending a gift; so situational plausibility offers no straightforward account of this contrast. Similar results may be obtained by filling the role in the second sentence, so no open goal occurs, but there is still the inference of some entity involved. For instance, "give away" and "donate" mean roughly the same thing, but we would analyze "give away" as having the Goal role "filled" (by "away", it appears):

25. a. The Salvation Army was having a Christmas drive, so...

b. John donated some toys. (open Goal)

b'. John gave away some toys. (no open Goal)

We perceive a marked contrast between the (b, b') continuations in these examples, with (25b') being more difficult to integrate with (25a) than (25b).

We are not suggesting that thematic roles are the only mechanism for discourse integration effects with definite NP's, by any means. It is well known that definite NP's can be used felicitously in part-whole situations, such as, "Bill climbed out of his car. Then he shut the door." Verb core meanings as well may lead to ease of integration, even in the absence of thematic roles. Melissa Bowerman pointed out to us the verb "perform," which on our analysis does not provide a thematic role for an audience. Still the core meaning of the verb would involve saying something about a performance being intended for an audience (even if one doesn't show up). Thus, the ease of integrating a discourse like "The schoolboys performed the play. The audience was wildly enthusiastic." We see open roles as but one road to discourse integration.

Finally, we find some support for the idea that open roles may play a part in parsing decisions. In particular, they may provide an integral part of an account of ease of recovery from garden paths. Consider the well-studied types of garden paths introduced by reduced relative clauses beginning with past participles, as in Bever's well-known example, (26).

26. The horse raced past the barn fell.

Though sentences of similar structure may always result in some degree of garden path, various other factors, including length, semantic plausibility, and existing presuppositions, affect the magnitude of the garden-path effect, presumably by influencing speed and ease of recovery (Frazier and Fodor, 1978; Crain and Steedman, 1985; Kurtzman, 1984). The thematic proposal we are pursuing suggests that lexical properties of the verb may also play a role in ease of recovery. Consider momentarily the thematic structure of the

verb "raced" in (26), which is ambiguous between a transitive and an intransitive form (we set aside consideration of the directional PP), where the transitive version (the past participle) has two roles associated with it--an Agent and a Theme--while the intransitive version has but a Theme for subject. Two things are of importance here. First, in the confusion between the transitive passive participle and a simple past tense, the role assigned to the horse is Theme in both cases. Secondly, on the (mistaken) intransitive analysis, there is no remaining role available. Contrast this situation with a case where there is an open role available on the main verb reading, as in (27).

27. a. The girl sent the flowers.
    b. The man served the rare steak.

In cases such as these an open Goal role remains--the note was sent to someone, the steak was served to someone. Our intuition suggests that garden path recovery is easier when these structures are placed into sentences that invite mistaken main verb analyses, such as (28), in contrast to the more difficult (29), with examples structurally similar to (26):

28. a. The girl sent the flowers didn't appreciate them very much.
    b. The man served the burned steak complained to the head waiter.
    c. Professors taught German are better than those who know Latin.
29. a. The child hurried out the front door slipped on the icy steps.
    b. The butter melted on the stove dripped onto the kitchen floor.
    c. Dogs walked quickly live a lot longer.

The more difficult examples of (29) represent verbs falling into the causative/ 'ergative' pattern, with the same role assigned to subject of the intransitive and (underlying) object of the transitive. In contrast, the open roles in (28) appear to us to facilitate recovery.

An alternative pattern exists for transitive/intransitive pairs which is traditionally thought of as detransitivization (e.g. John ate the soup/John ate). Here, the subject retains the same role in both versions. In "John ate the soup," for instance, John is Agent and the soup Theme, while in the intransitive "John ate," John remains Agent and the Theme is either eliminated, or quite possibly remains as an open role (whether all such detransitives leave open roles is uncertain). The verbs "sue," "watch," and "study" pattern likewise. Now consider the reduced relatives of (30).

30. a. The doctor sued for a million dollars became very upset.

b. The opponents studied very carefully were easily defeated.

c. The spy watched through the mirror saw Sally and ran.

Our intuitions are that such examples are again substantially easier to comprehend than examples such as those in (26) and (29). The difference appears to correlate with the presence of an open role in the mistaken main verb analysis of the reduced relative, and the fact that the initial NP is assigned different roles on the main verb analysis and the reduced relative analysis.

Presently lacking a fully explicit account, we can nonetheless present a sketch of an explanation, along the following lines. Consider the thematic grids associated with the verbs in "The child hurried" and "The girl sent the note." In the first, the thematic grid consists of {$Theme_i$} (the subscript indicating it has been assigned to NP_i, in this case, the girl). In the second example, the thematic grid would be {$Agent_i$, $Theme_j$, Goal} (the Goal without a subscript indicates an open role). These are the available roles present when the garden path is encountered. Presumably, recovery is governed by global strategy rather than by strict rule, but let us assume that one available strategy is to reassociate NP's with alternatively available thematic roles, open roles being the most available. In the case of "The child hurried fell," this strategy will yield no results as the comprehension mechanism is already considering the child to be Theme: in other words, it is not a new hypothesis to consider, and gets you nowhere. On the other hand, if one tentatively assigns the subject NP to the open Goal upon encountering the garden path in "The girl sent the note didn't respond," it is a new hypothesis. Its consequences for the grammatical analysis can begin to be worked out, e.g. if the girl is the Goal, "sent" cannot be an active main verb since it would not take a Goal as subject; there is, however, a homophonous Passive version which assigns Goal to its subject, being an underlying object available for passivization; it cannot be a main verb, though, lacking the copula, and structurally it can only then be a modifying phrase, etc. We are not suggesting that such consequences are worked out consciously. We are suggesting, however, that tentative reassociation of an NP with an open role forces one to give up hypotheses presently entertained about the structure of the sentence, and this represents a "foot in the door" to getting at the correct analysis. In the absence of the possibility of

reassociation, one major strategy for recovery is eliminated, and recovery is correspondingly more difficult.

5. Concluding remarks. One of our major hypotheses has been that thematic role assignment is made on-line, and that associating and reassociating thematic roles with arguments of the verb bearing those roles is relatively cost-free. We have presented intuitive as well as experimental evidence in support of this claim. In general, it does not appear to be at all difficult to change assignment of thematic roles. This appears to even hold for cases of uncertain thematic assignment to subject NP's, as well as postverbal constituents. Consider as an example a sentence that begins like (31):

31. Charlie Evans rented a very large house...

At this point, two types of continuations are possible:

32. a. ...from his neighbor's friend.

b. ...to his neighbor's friend.

If the continuation is (32a), the subject of the sentence must be assigned the role Goal, while continuation (32b) requires the subject be assigned the role Source. However, in neither case does the continuation appear to make the sentence difficult to comprehend. Our hypothesis is that, in fact, thematic commitments have already been made at the point in the sentence indicated in (31), but that reassociation is so cost-free that if the less expected continuation is encountered, the garden-path effect is slight. So, suppose at the point in (31) the thematic grid under consideration is {Source, Theme_j, Goal_i}, with Charlie Evans being NP_i and the house being NP_j (this represents our intuitions about the favored reading). Now, suppose the unequivocal Goal is encountered in continuation (32b), conflicting with the present thematic commitments. If reassociation is quite easy, then the shift to {Source_i, Theme_j, Goal} from the previous assignment clears the way for the final {Source_i, Theme_j, Goal_k} (his neighbor's friend being NP_k). A subsequent checking of this hypothesis shows that it is consistent with a possible pattern of assignments for the verb "rent."

The informal notation presented here treats thematic assignment as a sort of indexing procedure. If we take this just a bit more seriously, a possible account of the ease of thematic reassignment begins to take shape. One common observation about discourse models, in our view a grounding motivation, is that recovery from misconstrual of the reference of a series of

phrases can take place *in toto* without unduly taxing computational resources. Consider, for example, a case of a conversation in which two people think they are discussing the same person, but the listener is mistaken about the identity of the person under discussion. Upon finding the error, the listener transforms all the information formerly believed to be about the mistaken individual into information about the actually intended individual ("oh, so that's who said all those nasty things," etc.) It does not appear one must go back and recompute the meanings individually of all propositions understood incorrectly, since this transformation is achieved so rapidly and easily. Or, more locally, if one hears a sentence like (33), and initially takes "he" as coreferential with Bob, a later readjustment necessitated by further context (e.g. (34)) is relatively simple to make, rarely leading to serious garden paths:

33. Bob talked to Charlie after he...

34. ...threatened to sue Bob for slander.

Thus, if we view thematic assignment as an indexing and reindexing operation of the same general sort, we can at least reduce the question of why thematic assignment is fairly cost-free to the larger question of why indexing or reference-assignment operations in general are relatively cost-free. It is true that thematic assignments and reassignments have very strictly laid-out syntactic consequences that pronoun reassignments do not generally exhibit; evaluating these consequences may add some cost, but reassociation itself appears quite easy.

This may shed some light on some initially puzzling experimental results that we found in experiments with "filler-gap" constructions conducted in collaboration with Laurie Stowe (see Tanenhaus, Stowe, and Carlson (1985) for a preliminary report; for details see Stowe and Tanenhaus (forthcoming)). In these experiments we investigated the comprehension of embedded wh-questions which contained an optionally transitive verb (e.g. "asked"). We were primarily interested in testing Janet Fodor's (1978) hypothesis that the preferred subcategorization of the verb, or lexical preference, determines whether or not a gap is posited at the verb.

We contrasted two gap locations, one immediately following the main verb (as in (35a), and the other occurring later in the sentence after a preposition (as in (35b)); these are the "early" and "late" gaps, respectively.

35. a. The district attorney found out which witness the reporter asked __ about the meeting. (early)

b. The district attorney found out which witness the reporter asked anxiously about ___. (late)

There were two groups of verbs. Half favored the expectation of a transitive reading over the corresponding possible intransitive reading, while the other half led to the expectation of the intransitive over the transitive. An example of an early and a late gap sentence with the intransitive expectation verb "raced" is illustrated in (36).

36. a. The sheriff wasn't sure which horse the cowboy raced__down the hill.

b. The sheriff wasn't sure which horse the cowboy raced desperately past__.

Finally, we had plausible and implausible fillers. Plausibility was defined solely with respect to the direct object position of the verb. The plausible and implausible fillers were equally plausible as objects of the preposition. This contrast is illustrated in (37):

37. a. The district attorney found out **which witness** the reporter asked __ about the meeting. (plausible)

b. The district attorney found out **which church** the reporter asked ___ about the meeting (implausible)

Altogether then, there were eight conditions, depending on whether the gap was early or late, whether the verb had a transitive or intransitive expectation, and whether filler was a plausible or implausible filler with respect to the object position of the verb.

The logic behind this experiment was the following. When subjects posited and filled a gap with an implausible filler, sentences would become implausible at that point. Thus, plausibility effects could serve as a diagnostic for when gaps are posited and filled. In our first experiment, the sentences were presented one at a time to the subject on a CRT. The subject's task was to decide whether or not the sentence presented was comprehensible. It turned out that sentences with intransitive preference verbs are judged comprehensible significantly more often with late gaps (as in (36b)) than with early gaps (as in (36a)). Moreover, the plausibility of the filler at the possible early position did not affect judgment to late gap sentences. These results suggest that readers were not initially positing a

postverbal gap for the intransitive preference verbs. In contrast, the transitive preference verbs show a preference for the positing of an early gap, suggesting that readers were initially treating the filler as the direct object of the verb. Somewhat surprisingly, the penalty for missing an early gap was larger than the penalty for having to reassigning a previously assigned filler. That is, the effect of gap location is greater for the intransitive preference verbs, where our data suggest early gaps are often missed, than for the transitive preference verbs, where late gaps would require the reassignment of an already-assigned filler.

In a second set of experiments, we had the subjects read the sentences one word at a time at their own pace. It turns out that reading times in sentences with transitive preference verbs were slower beginning at the verb for the implausible fillers, demonstrating that subjects were immediately taking the filler to be the object of the verb. For sentences containing intransitive preference verbs, however, there was no effect of plausibility at the verb, demonstrating that readers were not assuming there to be a postverbal gap that the filler could be assigned to.

To summarize, then, gaps are posited and filled at the verb for transitive preference verbs; readers do not wait to identify further structure after the verb before doing this. Reassigning an erroneously-assigned filler to a later gap seems to be easier than recovering from a postverbal gap which has been missed and is in need of recovery.

This pattern appears puzzling if one thinks in terms of constructing and repairing syntactic structures. However, if one thinks in terms of thematic assignments, the pattern may make more sense. First, if thematic roles become available upon opening a verb's lexical entry, and if thematic assignments are made on-line as soon as possible to potential fillers as well as to other arguments, then we would expect effects of assignment at the verb, instead of after. On this view, then, a preliminary semantic interpretation is defined on an incomplete syntactic representation, and is maintained unless inconsistent information arrives; thus the syntax acts more like a filter for proposed interpretations than the input. A filler is temporarily assigned to a remaining available role, once the subject NP has received its role and before subsequent structure has been identified. But once temporarily assigned, reassignment is quite simple; this is what occurs in examples like (35b). Here, at the end of the sentence when the true

gap is identified as the object of the preposition, the reassignment of the filler from the thematic role of the verb to the preposition (in (35b), from the Goal of "ask" to the object of the preposition "about") is, on our account, a fairly simple matter of reindexing. On the other hand, in early-gap intransitive expectation sentences like (36b), an intransitive misanalysis of the verb leaves no available role (the subject NP takes up the only one available). Thus, when it becomes apparent at the end of the sentence that a gap should have been posited elsewhere, there is no ready thematic reassignment that could guide recovery. One must instead recover an increasingly inactive alternative thematic grid; this ought to be more difficult than working with active and hence readily available information. So not only does the perspective entertained here make sense of why filler-gap assignment takes place at the verb instead of after, but it also promises an account of the asymmetry we found in ease of constructing revised analyses. More work is plainly called for, but this approach seems promising.

One final speculation. We have been assuming that in processing, thematic roles come into play as the result of recovering a verb's lexical entry, and only at that point can thematic assignment begin. So, for instance, in English the subject role would not be assigned until the verb has been encountered. While this seems a fairly palatable state of affairs, matters become more interesting in those many SOV languages which place the verb at the end of the sentence. If indeed thematic roles are the means by which arguments are integrated into a proposition, and if thematic reassignment is a fairly cost-free computational venture, it is reasonable to speculate that preverbal arguments can be assigned tentative thematic roles, creating a set of mild expectations about which thematic roles the verb, when encountered, will actually assign. This was, for instance, the compelling intuition behind Bever's (1970) proposal that there is an N-V-N, Actor-Action-Object perceptual strategy responsible for patterns found in sentence processing and language acquisition. There is most certainly a persistent "default" pattern of thematic assignment throughout natural language--animate subjects are Agents and objects Themes, inanimate subjects Themes (encoded in various proposals for thematic assignment, such as Anderson, 1977). This pattern appears to be reflected in any number of ways, such as case-marking patterns, patterns of

preferred animacy, markedness of passives vs. actives, the relative predominance of transitives and intransitives vs. other subcategories of verbs, etc. (see Chomsky, 1986, for some discussion). The notion that thematic roles constitute the primary locus of this general pattern is certainly worth exploring.

In any case, detailed and sophisticated investigation of the on-line representations that are created in the course of language comprehension, as well as very explicit comprehension models, are required to even begin to seriously evaluate many of the hypotheses and speculations advanced here. At present, though, it appears that taking thematic roles seriously as processing entities can lead to a deeper understanding of what it is to know a language.

Footnotes

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2. It appears some NP's might not be assigned roles, as in "John pushed *his way* through the crowd"(cf: "John pushed his mother through the crowd"). In some cases the same NP may receive two roles, as in reflexively understood constructions like "John dressed," where John may be both Agent and Theme, or two NP's may receive the same role, as in reciprocally-understood constructions (e.g. "John and Mary fought"). Further, there might be different types or "tiers" of thematic roles which can be assigned the same argument; Culicover and Wilkins (1984, 1986) suggest one such distinction.

3. We speak of verbs assigning roles as a matter of convenience. We certainly wish to allow for general rules of thematic assignment (as in e.g. Anderson, 1977, or Fillmore, 1968), not associated with lexical entries themselves, to be one possible mechanism.

4. While we believe our role attributions are plausible, we wish to set aside for the time being questions about their accuracy. For our immediate purposes, it matters little if what are called Themes should instead be called Patients, or our Agents should be Causers.

5. Our notion of open thematic roles may simply be the verbal counterpart of the "implicit arguments" studied in nominalizations by Tom Roeper and others. While this work has doubtless influenced our thinking,

we have not undertaken a systematic comparison of implicit arguments and what we are here calling open thematic roles.

6. This with phrase is not an instrumental. It may, for instance, cooccur with a true instrument phrase ("Bill loaded the truck with hay with his new pitchfork") even though in general two instrumentals may not cooccur (??"John ate the meal with a fork with a spoon").

7. If one replaces the article "the" with a possessive in these examples (e.g. "His suitcases were very heavy") the contrast is much less clear. Since the pronoun makes explicit reference to something already introduced into the discourse model, it may bring into play potentially quite different mechanisms of reference assignment for the whole NP.

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