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Thematic Role Assignment in Context

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Two experiments are described in which participants read sentences of the form "He drank some . . ." in contexts which either did or did not introduce something drinkable. Participants were more likely to report that the sentence stopped making sense at the verb "drank" if nothing drinkable had been introduced. When participants responded, in this case, that the verb *did* make sense, their reaction times tended to be elevated relative to when the context did introduce a suitable antecedent. The experiments were modeled on a series of studies reported by Boland, Tanenhaus, Garnsey, and Carlson (1995), who used the same stop-making-sense judgment task to investigate the processing of filler-gap dependencies of the form "I wondered which food the man drank . . . ." They observed increased "no" responses on the verb when the prior filler was an implausible recipient of the patient role associated with the verb and concluded that the wh-phrase is assigned a thematic role as soon as the verb "drank" is encountered. In the studies reported here, with materials which did not contain obligatory syntactic (filler-gap) dependencies, the equivalent phenomenon was observed—thematic information conveyed by a verb's lexical entry was apparently evaluated, at the verb, with respect to its fit with whatever contextually introduced entities were available to receive the associated role. The data suggest that thematic roles may be assigned at a verb on the basis of thematic fit with context.

Key Words: thematic roles; parsing; context.

Much research into parsing has focused on attempts to understand better the relationship between our knowledge of grammar and the interpretive processes that operate on that knowledge. In this regard, Pritchett (1992) formulated an important, and influential, constraint on sentence processing: broadly speaking, the processor attempts at each point in the sentence to assign as many thematic roles onto as many arguments as are licensed by the grammar—"when a theta role is available, it will be discharged onto any available target, and when a target is available, it will assume any available role." (p.13). This paper presents evidence in support of the idea that thematic roles are assigned to targets as soon as both become available. Whereas previous studies have explored such assignments when they have been driven by obligatory syntactic dependencies between a verb and the linguistic entities to which its roles are assigned (cf. Boland et al., 1995), the present study explores thematic role assignments driven instead by optional contextual dependencies—they explore occasions when thematic role assignments are made on the basis of the thematic fit between a verb and the discourse antecedents which could plausibly receive a role from that verb, even when the anaphoric expression that refers to (one of) those antecedents is postverbal and has yet to be encountered.

Pritchett's claim that the processor attempts

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to assign roles to targets as soon as both are available is supported by experimental data on the processing of filler-gap dependencies. A large body of data has accrued which suggests that fillers are assigned roles as soon as the role-defining verb is encountered and before the syntax unambiguously signals which role to assign to which filler (e.g., Boland et al., 1995; Garnsey, Tanenhaus, & Chapman, 1989; Pickering & Barry, 1991). Boland et al., for example, explored the processing of filler-gap dependencies in the following structures (among others—see below).

(1) a. Which military base did Hank deliver the machine guns to _ last week?
b. Which preschool nursery did Hank deliver the machine guns to _ last week?

In (1a), the verb *deliver* signals three roles: Agent, Recipient, and Theme. When *deliver* is encountered, the Agent role will be assigned to *Hank*. In addition, Boland et al. claim, the wh-filler *military base* will be assigned the Recipient role also (not the Theme role because a military base is an implausible theme). When *machine guns* is encountered, they are assigned the Theme role. To test this, Boland et al. looked for an anomaly on *machine guns* in (1b), where the machine guns would be an unlikely Theme if *preschool nursery* had already been assigned the Recipient role. Boland et al. used a word by word stop-making-sense judgment task (cf. Boland, Tanenhaus, & Garnsey, 1990) and found increased "no" responses (indicating that the sentence had ceased to make sense) on *machine guns* in (1b) but not in (1a). This result suggests strongly that a thematic role has been assigned prior to the point at which the syntax unambiguously signaled which role should have been assigned.

In the filler-gap constructions studied by Boland et al. (1995) and others, the processor does not wait, then, until the syntax unambiguously signals the correct gap location. This does not mean, however, that the role assignments that it makes are not in accord with the principles of grammar; the wh-construction indicates that the wh-filler must receive a role, and the verb's argument structure, coupled with knowledge of the grammar, indicates the configurational positions in which the gap associated with that filler is likely to be found. The results obtained by Boland et al. (1995) and Pickering and Barry (1991) can therefore be explained in terms of a processor which, in effect, uses the information conveyed by a verb to *project* structure—it is this projected structure which triggers the appropriate role assignments (cf. Gibson & Hickok, 1993; Gorrell, 1993; but see Pickering, 1993).

The results are also easily accommodated within the constraint-satisfaction approach to sentence processing (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994; Trueswell & Tanenhaus, 1994), which views sentence processing as the application of probabilistic constraints in parallel as a sentence unfolds, with no single constraint being more or less privileged than any other except in respect of its probabilistic strength; the stronger one kind of constraint, the weaker the potential influence of others (cf. Spivey-Knowlton & Tanenhaus, 1994). It follows that if one constraint is lacking, other constraints could in principle come to the fore. For instance, the presence of a wh-filler, and the associated syntactic dependency with the subsequent verb, is just one of a range of constraints on which specific entities should receive an upcoming thematic role. In these filler-gap cases, grammatical constraints determine coreferentiality between some antecedent (the wh-filler) and a projected (null) referring expression (the gap). However, in principle at least, *contextual* information (as embodied within the discourse model) could also constrain, with some degree of probability, the range of entities which should be considered as potentially coreferential with the projected referring expression and which should therefore receive the role that the projected expression would receive. In (2) and (3) below, for example, there is a high likelihood that thematic roles associated with the underlined verbs in the final sentences will be assigned to entities introduced in the prior sentence. This high likelihood "qualifies" the context as a constraint on the interpretation of the subsequent sentence.

(2) The small boy reached up for the biscuits.
He ate . . .
(3) Hank parked his van outside the local military base.
He delivered the machine guns . . .

It is an empirical question, and one which this paper addresses, whether any role assignments other than the Agent assignment would be made at the underlined verbs—if roles are assigned simply on the basis that a role becomes available and a potential recipient exists for that role (irrespective of the source of the constraint on the identity of that recipient), the processor should assign the Patient role associated with *ate* in (2) above to the boy and the Recipient role associated with *delivered* in (3) above to the military base.

In Experiment 1 below, context–target pairs similar to that shown in (2) above were presented to participants. The contexts introduced either a plausible antecedent for a role associated with the subsequent verb or an implausible antecedent.[1] In Experiment 2, dative constructions such as that shown in (3) were used, as well as constructions that used an equivalent to the filled-gap logic introduced by Crain and Fodor (1985) and by Stowe (1986) and used also by Boland et al. (1995). In both experiments, context–target pairs were presented to participants using Boland et al.'s stop-making-sense paradigm. This paradigm was used in part because the materials used here were based on the same range of structures as were used by Boland et al., and the intention was to establish whether the same phenomena observed by Boland et al. for grammatically forced filler-gap dependencies would be observed also for optional contextual dependencies of the kind outlined above. One criticism of this paradigm, however, is that the judgment task may tap only late integrative processes which do not reflect the initial analysis that would be pursued during normal language comprehension—the task may not even reflect normal comprehension processes, but may reflect instead reading and judgment strategies that are unique to this task. However, alternative paradigms which resemble normal reading have shown equivalent patterns of data to the stop-making-sense task. For example, Pickering & Traxler (1998) monitored participants' eye movements as they read sentences such as those in example (4) below.

(4) a. That's the child that Mark reminded several of the women to watch this evening.
b. That's the movie that Mark reminded several of the women to watch this evening.

The postverbal region ("several of the") unambiguously signals that there is no gap site immediately following the verb (cf. ". . . the child that Mark reminded _ to brush his teeth"). According to the filled-gap logic employed by Boland et al. (1995) and others, an anomaly should be observed in this region if the processor commits itself at the verb to assigning the role associated with a postverbal gap (the Benefactive role) to either the child or the movie. And because a child is a plausible recipient of this role whereas a movie is not, such a commitment could be made, and the associated anomaly observed, in (4a) but not in (4b). Boland et al. did indeed find such a filled-gap effect—increased "no" judgments in the postverbal region of sentences equivalent to (4a) but not (4b). Pickering and Traxler (1998) also observed a filled-gap effect, with longer first pass reading times at the postverbal region in (4a) compared with (4b). These data, based on a more naturalistic reading task, thus replicate Boland et al.'s (1995) filled-gap effect and hence validate their use of the stop-making-sense judgment task to explore the processing of these filler-gap constructions.

Despite Pickering and Traxler's (1998) replication of the Boland et al. (1995) effects, it could still be argued that whereas Boland et al.'s judgment task tapped initial (or at least early) processing in their cases, it may somehow tap some other level of processing if used in the contextualized cases investigated here. This possibility will be returned to in the General Discussion, after data are presented which do indeed show the same patterns of results as

[1] The term "antecedent" will be used henceforth to refer to a discourse entity which may, in the subsequent target sentence, receive a role from the main verb. In fact, it is an antecedent to the subsequent anaphoric referring expression whose existence can be projected at that verb.

reported in Boland et al., including the equivalent of the filled-gap data, despite the fact that the antecedents were introduced extrasententially, with no obligatory syntactic dependencies between the verb and the expressions that referred to those antecedents.

EXPERIMENT 1

Boland et al. (1995) established that increased "no" judgments were observed on the verb *read* in wh-filler constructions such as (5) below.

(5) Which food did the boy read . . . ?

The purpose of Experiment 1 was to establish whether equivalent effects would be observed if the recipient of the role associated with grammatical object position was introduced extrasententially. Contexts were constructed which either introduced a potential antecedent for a subsequent Theme or Patient role, given the selectional restrictions associated with that role, or did not. Target sentences were constructed using two kinds of verbs: "selecting" verbs whose selectional restrictions would, depending on the context, either allow selection of a discourse antecedent or would not; and "nonselecting" verbs whose selectional restrictions, if any, allowed selection of any discourse antecedent. The basic design is exemplified in (6) and (7) below.

(6) *Antecedent condition*
A car was driving downhill when it suddenly veered out of control.
In its path were some pigeons and a row of bollards.
It injured/missed . . .

(7) *No-antecedent condition*
A car was driving downhill when it suddenly veered out of control.
In its path were some dustbins and a row of bollards.
It injured/missed . . .

("Bollard" is the British English for a short post used to impede the passage of cars.) In (6), a plausible antecedent ("pigeons") is introduced which could plausibly receive the Patient role associated with *injured.* In (7), no such antecedent is introduced. If the processor attempts to assign roles to available discourse antecedents, evidence of a processing anomaly should be observed on the verb *injured* when it follows the context in (7) but not when it follows the context in (6)—in (6), the Patient role can be assigned to the pigeons, whereas in (7) there are no plausible antecedents which could receive the Patient role (the basis for responding "no" in this task is discussed in more detail in the Discussion).

All target sentences referred in grammatical object position to one of the discourse entities introduced in the prior context. Thus, the selecting targets always became implausible at the postverbal noun phrase.

(8) *Selecting target*
It injured several bollards that came close to being destroyed.

(9) *Nonselecting target*
It missed several bollards that came close to being destroyed.

Whereas participants were all expected to indicate an anomaly at *bollards* in response to the selecting target, at issue in Experiment 1 was whether evidence of an anomaly would also be seen on *injured,* but not on *missed,* in the case of the contexts that did not introduce anything that could plausibly be injured.

Method

Participants. Forty-eight members of the University of York were paid £2 to participate in the experiment, which lasted approximately 30 min.

Apparatus. All stimuli were presented on an Apple Macintosh with a 17-in. monitor running PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993).[2] Participants responded on a button box on which were marked a "yes" and a "no" button.

Materials. Thirty-two context–target pairs such as the items shown in (6) to (9) above were constructed. See Appendix 1 for the full set of items. Each target sentence consisted of 10 words, except for one target consisting of 11 words. They each had the following structure:

[2] The PsyScope script for running word-by-word moving window displays with sentences of variable lengths is available from the author.

pronoun (it)–verb (injured)–adjective (several)–noun (bollards)–continuation. The selecting verbs averaged 6.2 characters in length, and the nonselecting verbs 6.3 characters in length. Seventy-five percent of items continued with a relative clause. The 32 experimental items were embedded among 68 filler items. Overall, the fillers were designed to rule out any strategic anticipation regarding either a "no" or a "yes" response; overall, 50% of the target sentences were plausible and did not violate the selectional restrictions of the verb.

The fillers were constructed as follows: 32 of the fillers used selecting verbs. Twenty-four of these had "antecedent" contexts (containing an entity to which the selecting verb could apply), and 8 had "no-antecedent" contexts. These eight filler items with "no-antecedent" contexts (and selecting verbs) were rendered plausible in the target sentence by introducing a new entity (cf. "it injured several people that were standing on the sidewalk"). Of the 24 filler items with "antecedent" contexts (and selecting verbs), 8 mentioned in postverbal position the appropriate antecedent, 8 introduced a new entity that could plausibly appear in that position, and 8 introduced a new entity that nonetheless violated the selectional restrictions of the verb. Sixteen fillers used nonselecting verbs. All of these were rendered implausible at the postverbal noun by introducing a novel entity that violated the selectional restrictions of that verb. There were 20 other fillers with contexts and targets that did not resemble the experimental items at all; half violated selectional restrictions in the target, and half did not.

Design. There were two versions of each target sentence (selecting and nonselecting) and two versions of each context (antecedent and no-antecedent). The design was a fully factorial repeated measures design incorporating a Latin Square. Four stimuli sets were constructed with each item represented in each set in just one of its versions. Each subject was thus exposed to all items and to all experimental conditions, but never saw more than one version of any individual item.

Procedure. The entire procedure—instructions, practice, and main session—was controlled by PsyScope. Participants were told that each story they would read would consist of three sentences and that the last sentence may or may not make sense. Their task was to press the "yes" button to see each of the first two sentences, which were presented in their entirety, and to then press the "yes" button to reveal each word of the final sentence. To begin with, that sentence would appear as a series of hyphens across the screen, and each button press would reveal the next word and "hide" the preceding one. They were told to press the "yes" button to each word only if the sentence continued to make sense and to press the "no" button if, at any point in the sentence, they felt that it ceased to make sense. If a participant did respond "no" at any point, the trial would be terminated. They were given two examples in the instructions that did not make sense ("he ate the books on golf" and "he read the fish on golf"). After the instruction phase, participants were given a practice session consisting of four trials, two of which contained implausible target sentences ("he drank one of the books noisily" and "he repaired the storeroom quite effortlessly"). After the practice sessions, participants were shown the practice materials again, and the reasons for the implausibility were explained to them ("you cannot drink a book" and "you cannot repair a storeroom"). During the main experimental session, participants were free to pause after any individual trial.

Results

Figure 1 shows the cumulative percentage of "no" judgments for each of the first four word positions. Following Boland et al. (1995), and in order to eliminate the dependence between the cumulative figure at one word and the cumulative figure for the preceding word, statistical analyses were carried out on the number of "no" responses calculated as a percentage of the responses still available at that point (if a participant had responded "no" at a previous point, the trial would be terminated, and no responses from that subject would be available at any subsequent point in that sentence). The corrected percentages (as a function of available

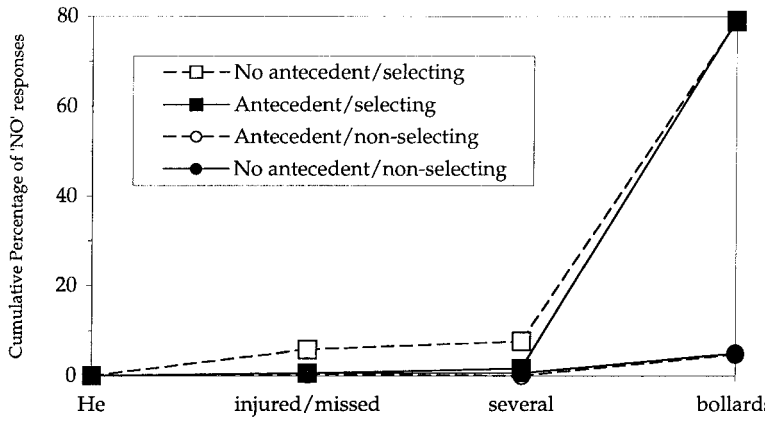

FIG. 1. The cumulative percentage of "no" responses for Experiment 1.

responses) are given in Table 1. Only the first four positions were analyzed due to the paucity of "yes" responses beyond the noun in fourth position in the selecting targets conditions.

Overall, 97% of experimental items' targets containing selecting verbs were judged, by the end of the sentence, not to make sense, and 12% of targets with nonselecting verbs ($F1(1,47) = 2266$, $P = .0001$; $F2(1,31) = 2196$, $P = .0001$). There was no effect of context on the overall figures nor any interaction with context (all $F < 1$). These figures are comparable to the figures for the fillers, with 97% of the implausible fillers being judged implausible, and 14% of the plausible fillers being judged implausible. In the case of the experimental items with nonselecting verbs, 50% of the "no" responses were made on the final word of the sentence (and only 4.7% of available responses at nouns following nonselecting verbs were "no" responses), suggesting that some other aspect of the context–target pairing (other than the relationship between the verb and its object) was judged implausible in these cases. The statistical analyses reported below include trials on which subjects "misjudged" the (intended) plausibility of the target sentences—in effect, these data were treated as "noise," and exactly the same statistical patterns were observed with these trials excluded.

Separate two-way analyses of variance (2 contexts $\times$ 2 verbs) were carried out on the judgment data at each word position separately. There were no "no" judgments in position one—the pronoun. At the following verb, there were main effects of context ($F1(1,47) = 4.3$, $P < .05$; $F2(1,31) = 6.1$, $P < .02$) and verb ($F1(1,47) = 5.2$, $P < .03$; $F2(1,31) = 17.55$,

TABLE 1

Percentage of Remaining "No" Responses, for Each of the First Four Word Positions in Experiment 1

		Word position			
Target	Context	It	Injured/missed	Several	Bollards
Selecting	Antecedent	0.5 (412)	0.8 (572)	1.6 (435)	78.9 (621)
	No antecedent	0.5 (402)	6.3 (607)	2.1 (470)	76.1 (688)
Nonselecting	Antecedent	0.5 (408)	0.8 (504)	0 (442)	4.8 (624)
	No antecedent	0 (404)	0.5 (511)	0 (440)	4.6 (637)

Note. Numbers in parentheses indicate the mean judgment times (ms) when subjects responded "yes."

$P = .002$) and a significant interaction between the two ($F1(1,47) = 4.8$, $P < .04$; $F2(1,31) = 10.4$, $P = .003$)—planned comparisons revealed that these effects and the interaction were due to more "no" responses to selecting verbs in the no-antecedent condition than in the antecedent condition (6.3% vs. 0.8% available responses; $F1(1,47) = 8.8$, $P < .005$), $F2(1,31) = 18.8$, $P = .0001$). At position three, the adjective, there was a marginal effect of verb ($F1(1,47) = 19.3$, $P = .0001$; $F2(1,31) = 1.4$, $P > .2$), with the selecting verb conditions tending to engender more "no" responses than the nonselecting verb conditions (1.8% vs. 0% available responses). There were no other differences at this position (all $F < 1.0$). At the noun, there was a significant main effect of verb—77.5% of available responses to the selecting verbs were "no" responses, compared with 4.7% for nonselecting verbs; $F1(1,47) = 624$, $P = .0001$; $F2(1,31) = 609$, $P = .0001$. There were no other significant differences at this position (all $P > .2$).

Similar analyses were carried out at each word position on the judgment times for occasions when participants responded "yes" (see Table 1). There were no differences in "yes" times at the pronoun (all $F < 1$). At the verb, there was a main effect of verb type, with nonselecting verbs being responded to faster than selecting verbs (507 ms vs. 590 ms; $F1(1,47) = 15.6$, $P = .0003$; $F2(1,31) = 6.4$, $P < .02$). Planned comparisons for selecting verbs revealed that the difference between the no-antecedent case and the antecedent case (607 ms vs. 572 ms) tended toward significance on the by-subjects analysis ($F1(1,47) = 3.9$, $P < .06$), but failed to reach significance on the by-items analysis ($F2(1,31) < 1$). At the adjective, there were no main effects nor interactions. Planned comparisons revealed, nonetheless, that the difference for selecting verbs between the no-antecedent and antecedent contexts (470 ms vs. 435 ms) was marginally significant ($F1(1,47) = 4.7$, $P < .04$; $F2(1,31) = 3.1$, $P < .09$). The differences at the final noun did not approach significance. There were no other significant main effects, interactions, or pairwise differences at these first four word positions.

As expected, there were more "no" judgments at selecting verbs in the no-antecedent conditions. There were virtually no such judgments in any of the other conditions. When participants judged that the verbs did made sense, there was some limited indication that judgments were longer in the no-antecedent condition for selecting verbs only.

Discussion

Boland et al. (1995) observed more "no" responses on the verb when their wh-fillers were implausible recipients of the role that was made available by the verb and correspondingly fewer "no" responses when the wh-filler was a plausible recipient of that role. In Experiment 1 an equivalent effect was found: there were more "no" responses on the verb when it had been preceded by a context that did *not* introduce a plausible antecedent for its Theme/Patient role than when it had been preceded by a context that *did* introduce a plausible antecedent. For verbs whose selectional restrictions admitted plausible antecedents from either context, there was no effect of context (and a negligible proportion of "no" responses). The filler items were designed to ensure that participants could not have anticipated, on the basis of any combination of context and target verb, which judgment would subsequently prove appropriate when the postverbal referring expression was encountered. Moreover, given the manner in which a "no" response would terminate a trial, participants in fact experienced more plausible continuations after the verb than implausible ones.

The magnitude of the effect found in Experiment 1 was relatively small. In this regard, it is noteworthy that even on trials which did not engender a "no" response at the selecting verb, there was some limited evidence of a processing cost associated with the failure to find an antecedent which could plausibly be referred to, subsequently, in postverbal grammatical object position. It is unclear why judgment times to nonselecting verbs were, overall, faster than those to selecting verbs—this may reflect some processing cost associated with selectional restriction of the referential domain. However, the difference should be interpreted with caution

given that it relies on a between-items comparison (although the difference in length across the two types of verb of 0.1 characters probably cannot account for this difference).

Boland et al. interpreted their plausibility effects to indicate that readers made use in their experiments of the verbs' argument structures and their associated thematic information to assign roles to wh-fillers before syntactic information was available to uniquely identify which role assignment was intended. If the same criteria regarding behavioral outcome are applied here as were applied in the Boland et al. case (regarding the sensitivity of the stop-making-sense task to thematic role assignments at the verb—see below), we would conclude that in Experiment 1 also, we had evidence of thematic information at the verb being used to assign (or at least evaluate alternative assignments of) roles to discourse antecedents. In Experiment 1, unlike in the Boland et al. case, these antecedents were not marked syntactically as potential recipients of those roles—they constituted potential recipients by virtue of being the only entities in the context to which the event denoted by the subsequent verb could apply. Of course, this event need not necessarily involve any previously introduced entity, as the text in (10) demonstrates.

(10) A car was driving downhill when it suddenly veered out of control.
In its path were some dustbins and a row of bollards.
It injured several people who were standing nearby.

Thus, the processor need not attempt, at *injured* in that final sentence, to assign the Patient role to a previously introduced entity (an attempt which would fail in the case of this example). In which case, why, and on what basis, did participants respond "no" at the target verb in these examples?

One interpretation of these data is that the processor projects, at the verb, the upcoming postverbal referring expression and attempts to establish, given the thematic criteria (selectional restrictions) imposed by the verb, whether there are any discourse antecedents with which it could be coreferential. When there is no such antecedent, participants respond "no." This is not to say that the processor is, in such cases, unable to proceed—the ease with which the target sentence in (10) above can be interpreted is testimony to that. Rather, the stop-making-sense judgment task is sensitive to the ease with which anaphoric dependencies can be established between the projected referring expression and the discourse antecedents (if any such antecedents exist—if there are no discourse antecedents, as in *a runaway car yesterday injured . . .*, no anaphoric dependencies have to be considered, and *injured* would, presumably, prove unproblematic for the processor). That such sensitivities exist has been demonstrated elsewhere (see Garrod & Sanford, 1994, for review); for instance, Murphy (1984) found that establishing a new discourse referent produced longer sentence comprehension times than referring to an already existing referent. At issue then is not whether such sensitivities exist, but rather at what point during the comprehension process these anaphoric dependencies are computed.

If the judgment task employed here is tapping processing during the initial analysis of these sentences, the data would suggest that people can, and do, fill thematic roles predictively in the manner outlined earlier (or at least can evaluate alternative antecedents with respect to their thematic fit with the verb). If, on the other hand, the judgment task taps more strategic, reflective, task-dependent processes, then the data suggest that people *can* predictively evaluate the anaphoric and thematic relations investigated here, but only when there are strategic reasons for doing so. This point is revisited in the General Discussion. There is, however, a further reason for interpreting the data from Experiment 1 with caution. It concerns not the task itself, but rather the fact that participants were expected to process target sentences which had a high likelihood (50%) of violating the selectional restrictions of the verb. This may itself have engendered reading strategies which do not reflect normal reading. Experiment 2 rectifies this problem by avoiding any such selectional violations; all the postverbal continu-

ations were plausible in respect of the thematic fit between the verb and its arguments.

Experiment 2 also differed from Experiment 1 in that it used a variety of different sentence types to explore the same role assignment phenomenon, including the dative and filled-gap constructions described earlier, but as in Experiment 1, the potential recipients of the target roles were introduced in the context.

EXPERIMENT 2

Experiment 2 used modified versions of the Boland et al. (1995) stimuli. Context–target pairs were devised for a number of different target constructions. Each will be described in turn.

(11) Datives

Plausible antecedent context and target

Hank parked his van outside the local military base.

He delivered some machine guns to the military base and left.

Implausible antecedent context and target

Hank parked his van outside the preschool nursery.

He delivered some machine guns to the military base next door.

If, in (11), the Recipient role associated with *delivered* is assigned to *preschool nursery* (when preceded by the implausible antecedent context), there should be evidence of an anomaly when *machine guns* is subsequently encountered. Note that although delivering machine guns may be slightly implausible in the context of parking outside a preschool nursery (see Discussion), the thematic fit of *machine guns* to the Theme role associated with *delivered* is entirely compatible with *military base* in the Recipient role. Thus, subjects could not strategically anticipate, in Experiment 2, a "no" judgment based on any anticipated incompatibility between the direct object and the subsequent indirect object.

Boland et al. used verbs that permitted either nonalternating dative constructions (as in the one above) or which permitted alternating dative constructions also (e.g., "she granted generous maternity leave to them"/"she granted them generous maternity leave"). All the verbs were used in their nonalternated form. The present study also included both types of verb and also presented them only in their nonalternated form. The possibility of an alternated form means that the processor cannot predict at the verb which role will be assigned at the immediately following postverbal position. Consequently, any role assignments made at the verb (other than Agent) could not be made on the basis of which role is due next, but would need to take into account the plausibility of the alternative assignments.

In addition to the dative constructions, the filler-gap constructions employed by Boland et al. (1995) were modified to create context–target pairs such as the following (and in the absence of any true gaps, the term "filled-gap" is replaced by "filled-role").

(12) Filled-roles

Plausible antecedent context

The twins listened to their father talking to their mother.

Implausible antecedent context

The twins listened to their father talking about their mother.

Target

He asked them to be especially nice to her.

The same discourse entities are introduced in both contexts in (12); in structural terms, all should be equally accessible (across the two context conditions, but not necessarily within a context—see below). However, whereas the mother is a plausible candidate for whoever "he asked" in the plausible antecedent case (after all, he was talking to the mother, so it is plausible that the asking took place within the talking event), the mother is a less plausible candidate for whoever was asked in the implausible antecedent case (the father was less likely to be talking to the mother). If contextually driven thematic role assignments are sensitive to the real-world (or rather, discourse world) availability of candidates, the processor should assign to the mother, at the verb *asked* in the target sentence, the role associated with whoever was being asked in the talking-to-their-mother context, but not in the talking-about-their-mother context. Thus, the subtle change between the two contexts, between *to* and

about, should be reflected in increased "no" judgments on the target pronoun when the father was heard talking *to* the mother than when he was heard talking *about* her (because, contrary to expectation, the direct object in the to-their-mother case does not refer to the mother). *The twins* were introduced into the scenarios described in (12) to ensure that the postverbal pronoun could successfully refer to somebody other than the target antecedent ("their mother")—in the talking-about-their-mother context, there is thus a plausible antecedent for the being-asked role when the target verb *asked* is encountered. According to Gernsbacher's "Advantage of First Mention" (e.g., Gernsbacher, Hargreaves, & Beeman, 1989; Gernsbacher, 1990), *the twins* should be particularly salient as an antecedent for *them* in both cases. Of course, this salience could mean that they are assigned the Benefactive role at *asked,* in which case there should be no evidence of an anomaly in either of the two context conditions at *them.*

Finally, Experiment 2 followed Boland et al. (1995) in including also structures devised to demonstrate, among other things, that the stop-making-sense task is sensitive to the subtleties of the alternative role assignments that are made available at the target verb. Boland et al. used structures as follows.

(13) a. Which child did your brother remind _ to watch the show?
b. Which movie did your brother remind _ to watch the show?

In (13a) *child* is a plausible Benefactive for the object control verb *remind,* whereas in (13b), *movie* is not. However, the verb *remind* signals more than just the Benefactive role; it signals also a "generalized Theme" associated with the verb in the (optional) upcoming infinitival complement (cf. "Which movie did your brother remind you to watch _ ?"). Boland et al. (1995) found that in (13b) no anomaly was registered until *to* and beyond. They proposed that the implausibility of *movie* in the Benefactive role does not cause an anomaly because of the availability at the verb of an alternative role which *movie* can instead be assigned. This finding is important because it is an example of a potential anomaly which is not detected (suggesting that the task does not simply force readers to make commitments earlier than they would otherwise). Experiment 2 attempts to replicate this same effect with context–target pairings as shown in (14).

(14) Object control
Context
Mike quickly chose a video.
Transitive target
He ate his sandwich in the TV room.
Object control target
He reminded his brother to get some popcorn.

For both targets, the video introduced in the context is an implausible Patient (in the transitive target) or an implausible Benefactive (in the object control target). If the Boland et al. (1995) results generalize to these context–target pairings, an anomaly at the verb should be observed in the transitive case but not in the object control case.

Method

Participants. Twenty-four members of the University of York were paid £2 to participate in the experiment, which lasted approximately 30 min.

Apparatus. The same apparatus was used as in Experiment 1.

Materials. Sixteen context–target items using nonalternating dative verbs were devised which mirrored the items in (11) above. Sixteen further items were devised using alternating datives. All the items were presented in their nonalternated form. The first 5 words of each target consisted of the sequence pronoun–verb–determiner–adjective/noun–noun (the 4th and 5th words could either be a noun–noun compound or an adjective followed by a noun); the crucial effects were expected on the adjective/noun and noun. These 32 targets ranged in length between 8 and 15 words. A further 16 items were devised which mirrored the filled-role items in (12) above. The first 5 words of each of these targets consisted of the sequence: pronoun–verb–pronoun–"to"–verb (the crucial effects were expected on the second pronoun). These target sentences were all 9 words long. Sixteen

transitive/object control items were devised of the form shown in (14) above. They were all 8 words long. The object control verbs averaged 7.8 characters, and the transitive verbs 6.2 characters. The 64 experimental items were embedded amongst a further 48 fillers. All were plausible. Sixteen of these used object control verbs. The fillers varied in similarity to the different experimental items.

Design. There were two versions of each experimental passage: for the datives and filled-role constructions, these were "plausible antecedent" and "implausible antecedent." For the object control constructions, these were "transitive target" and "object control target." The design was a fully factorial repeated measures design. Two stimuli sets were constructed with each item represented in each set in just one of its two versions. Each participant was thus exposed to all items and to all experimental conditions, but never saw more than one version of any individual item.

Procedure. The procedure was identical to that used in Experiment 1. There was, however, some modification to the examples that were given to participants to explain what was meant by "not making sense"—the examples (and explanation as given to the participants) were as follows (the first two appeared in the instructions and the next three in both the five-trial practice phase and the debriefing that followed).

(15) Mary was talking to her mother.
She told him she'd been unhappy.
(The word "him" is anomalous)
John was talking to his mother.
He told her it had been unhappy.
("It" is introduced out of the blue)
Jake parked his car in the supermarket car park.
He locked the banana and went in.
(Bananas are unlikely things to be locked)
A lecturer was talking to some students about the course.
He encouraged her to ensure she came to each lecture.
(The "her," and subsequent "she," appear from nowhere, so to speak)
The politician defended himself during the debate.
He denied the lights were true.
(The "lights" appear as if from nowhere . . .)

Results

Results will be reported separately for the dative constructions, the filled-role constructions, and the object control constructions.

Datives. The mean numbers of "no" responses, expressed as a percentage of the remaining available responses, are given in Table 2. The cumulative data are shown in Fig. 2. Overall, 75% of the dative constructions preceded by implausible antecedent contexts were judged implausible, compared with 24% when preceded by plausible antecedent contexts. Only the data across both the alternating and nonalternating dative verbs are reported, although the patterns reported below apply also to the individual subsets.

Separate one-way analyses of variance were performed at each of the first eight word positions on the percentage remaining response data. Although the majority of targets were more than eight words long, to include them would have confounded unavailability of responses at a particular position due to participants having responded "no" at previous positions and unavailability due to fewer items being available at successively later positions. There were no significant differences in the number of "no" judgments in any of the first three word positions ("he delivered some"), although at word position three the by-items analysis approached significance ($F2(1,31) = 3.5$, $P < .08$). At the next word ("machine") there were more "no" judgments following the implausible antecedent condition than following the plausible antecedent contexts (12.7% vs. 2.4%: $F1(1,23) = 20.5$, $P = .0002$; $F2(1,31) = 11.2$, $P < .003$). The same was true at the following word ("guns")—30.1% vs. 5.1%: $F1(1,23) = 61.8$, $P = .0001$; $F2(1,31) = 23.7$, $P = .0001$. This plausibility effect persisted into the following words (but not the postprepositional determiner in position seven).

Separate one-way analyses of variance were also performed at each word position on the judgment times for "yes" responses (see Table 2). There were no significant differences in any of the first four word positions ("he delivered some machine"). At the fifth word ("guns") the

TABLE 2

Percentage of Remaining "No" Responses, for Each of the Word Positions in the Dative, Filled-Role, and Object Control Constructions of Experiment 2

Target	Context	Word position								
		He	delivered	some	machine	guns	to	the	military (base)	
Datives	Plausible antecedent	0 (441)	0.5 (525)	0.8 (497)	2.4 (609)	5.1 (669)	0.6 (462)	4.1 (551)	2.1 (500)	
	Implausible antecedent	0.3 (434)	0.5 (532)	2.9 (503)	12.7 (647)	30.1 (763)	13.6 (528)	7.1 (507)	20.2 (789)	
		He	asked	them	to	be	especially	nice	to	her
Filled-role	Plausible antecedent	1.0 (503)	0.5 (586)	25.4 (860)	14.4 (520)	6.9 (545)	4.8 (474)	5.4 (659)	2.4 (540)	35.6 (1109)
	Implausible antecedent	0 (505)	0.5 (579)	8.5 (581)	3.1 (516)	3.3 (514)	0.6 (544)	8.1 (678)	4.7 (470)	23.7 (868)
		He	reminded	his	brother	to	get	some	popcorn	
Object control	Object control verb	0 (440)	2.6 (550)	4.7 (532)	3.6 (719)	1.1 (460)	1.9 (490)	2.7 (491)	14.3 (844)	
		He	ate	his	sandwich	in	the	TV	room	
	Transitive verb	0 (446)	14.6 (660)	12.2 (508)	16.3 (672)	9.2 (504)	2.1 (479)	3.7 (525)	20.5 (847)	

Note. Numbers in parentheses indicate the mean judgment times (ms) when subjects responded "yes."

difference between the plausible and implausible antecedent contexts was significant on the by-subjects analysis only (669 ms vs. 763 ms: $F1(1,23) = 5.0$, $P < .04$; $F2 < 1$). The only difference in subsequent word positions was at word eight ("military"), with faster "yes" responses in the plausible antecedent contexts (500 ms vs. 789 ms: $F1(1,23) = 46.3$, $P < .0001$; $F2(1,31) = 20.8$, $P < .0001$).

Filled-role constructions. The mean numbers of "no" responses, expressed as a percentage of the remaining available responses, are given in Table 2, with the cumulative data shown in Fig. 3. Overall, 66% of target sentences preceded by plausible antecedent contexts were judged implausible, compared with 42% when preceded by implausible antecedent contexts.

Separate one-way analyses of variance were performed at each word position on the percentage remaining response data. There were no significant differences in the number of "no" judgments in either of the first two word positions ("he reminded"); all $F < 1$. At the next word ("them") there were more "no" judgments following the plausible antecedent condition than following the implausible antecedent contexts (25.4% vs. 8.5%: $F1(1,23) = 20.6$, $P = .0001$; $F2(1,15) = 20.2$, $P = .0004$). The same was true at the following word ("to")—14.4% vs. 3.1%: $F1(1,23) = 9.4$, $P < .006$; $F2(1,15) = 16.2$, $P < .002$. There were no significant differences in later word positions.

Analyses of the reaction time data (for "yes" responses—see Table 2) revealed that the only significant difference between the two conditions was at the postverbal pronoun ("them"), with responses in the implausible antecedent contexts being significantly faster than responses in the plausible antecedent contexts (581 ms vs. 860 ms: $F1(1,23) = 15.1$, $P < .0008$; $F2(1,15) = 8.3$, $P < .02$).

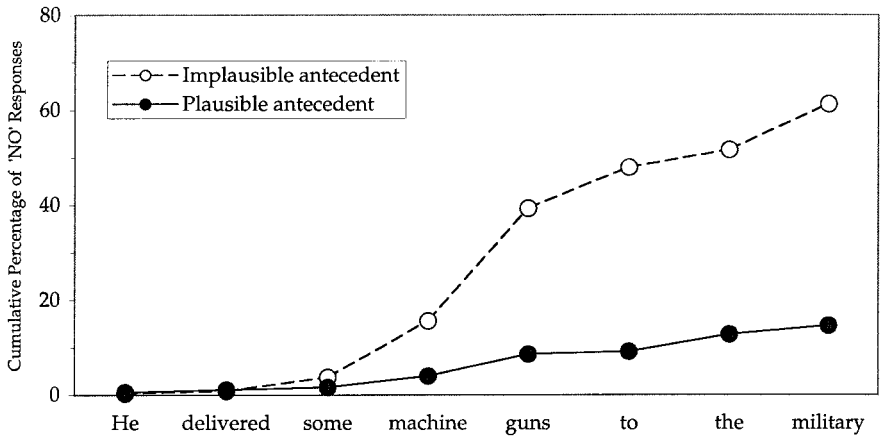

FIG. 2. The cumulative percentage of "no" responses for the dative constructions in Experiment 2.

Object control constructions. The mean numbers of "no" responses, expressed as a percentage of the remaining available responses, are given in Table 2, with the cumulative data shown in Fig. 4. Overall, 54% of transitive target sentences were judged implausible, compared with 27% of object control targets.

Separate one-way analyses of variance were performed at each word position on the percentage remaining response data. There were no "no" judgments made to the first word of the target sentences. At the next word ("reminded"/"ate"), planned comparisons revealed there were more "no" judgments in response to the transitive verb than in response to the object control verb (14.6% vs. 2.6%: $F1(1,23) = 20.3$, $P = .0002$; $F2(1,15) = 7.2$, $P < .02$). The same pattern held at the following word (the determiner—12.2% vs. 4.7%: $F1(1,23) = 6.4$, $P < .02$; $F2(1,15) = 4.7$, $P < .04$) and at the word after that (the postverbal noun)—16.3% vs. 3.6% ($F1(1,23) = 12.5$, $P < .002$; $F2(1,15) = 10.4$, $P < .003$). There was some hint of a difference in the following word, but no differences at all in subsequent word positions.

Reaction time data for "yes" responses (see Table 2) revealed a difference at the verb that was significant on the by-subjects analysis, with

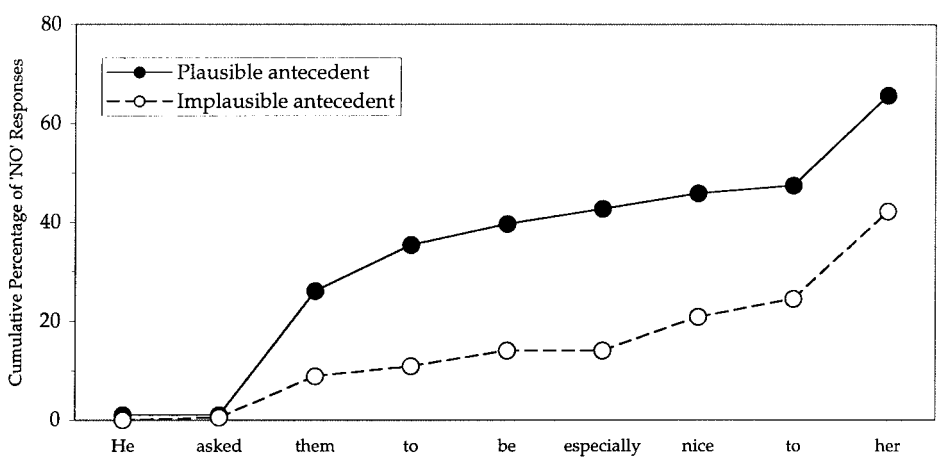

FIG. 3. The cumulative percentage of "no" responses for the filled-role constructions in Experiment 2.

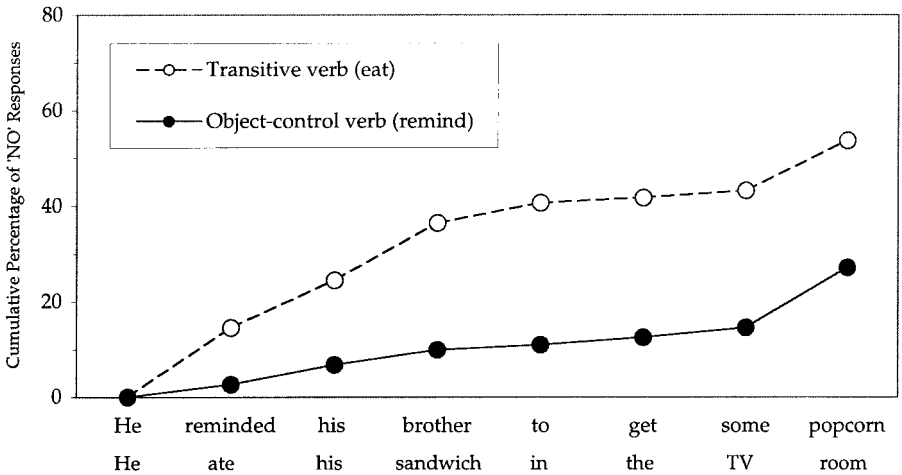

FIG. 4. The cumulative percentage of "no" responses for the object control constructions in Experiment 2.

faster responses to the object control verbs than to the transitive verbs (550 ms vs. 660 ms: $F1(1,23) = 12.5$, $P < .002$; $F2(1,15) = 2.1$, $P > .1$). There were no other differences at the other word positions.

Discussion

The pattern of "no" judgments in response to the dative constructions suggests that by the time the sentential position associated with Theme was encountered, the Recipient role (associated with a later sentential position) had already been assigned to an entity that had been introduced in the prior sentential context. An anomaly was observed at the indirect object (receiving the Theme role) only when its referent was an implausible Theme *given that discourse entity as Recipient.* There was some indication also that even when participants responded "yes" at the indirect object when the context introduced an implausible Recipient, reaction times were slower than when the context introduced a plausible Recipient. It could be argued, however, that the increased "no" judgments on "machine guns" in the context of parking a van at a school nursery and then delivering the machine guns (albeit to the military base next door) reflects the implausibility of the scenario as a whole and not the implausibility of any specific role assignment. Thus, as one reviewer pointed out, the same anomaly might be found on "machine guns" in (16) below.

(16) Hank parked his van outside the preschool nursery. He saw some machine guns . . .

Such a finding would not be problematic for the present account because although the verb *saw* does not assign a Recipient role to *nursery* in the same way that *delivered* would, it could in principle assign a Locative role to *nursery.* Of course, because the locative is not specified as part of the verb *saw's* argument structure, it cannot be considered an implicit argument (cf. Mauner, Tanenhaus, & Carlson, 1995). Nonetheless, the grammar does specify an optional adjunct, and if the processor can predictively activate representations corresponding to forthcoming arguments, it may also predictively activate representations corresponding to forthcoming adjuncts (cf. Altmann, Garnham, van Nice, & Henstra, 1998). As Mauner et al. (1995) observed, the encoding of implicit arguments may support important aspects of text coherence—the predictive activation of representations corresponding to forthcoming arguments, as well as forthcoming adjuncts, may play a similar role.

With regard to the filled-role constructions ("The twins heard their father talking to/about their mother. He asked them . . ."): When the context introduced a plausible recipient for the

role associated with the postverbal object, an anomaly was observed when the postverbal pronoun did not refer to that discourse entity. There was no equivalent anomaly when that discourse entity was not a plausible recipient. One interpretation of these data, then, is that by the time the postverbal pronoun was encountered in the target sentence, the processor had "assumed" that the mother in the talking-to-their-mother context was the person being asked and that when an alternative role assignment was signaled by the pronoun, an anomaly arose. In the implausible antecedent case ("talking about their mother"), the slight anomaly seen there (8.5% "no" responses on the pronoun) might reflect the expectation that the pronoun refer to some third party that was implied by the verb but was not explicitly expressed (cf. Mauner et al.'s (1995) evidence that the "implicit arguments" of a verb can be represented semantically and can be available for subsequent anaphoric reference even when not expressed).

It is possible that the effect observed on the pronoun is not indicative of the prior assignment at the verb of the Experiencer role (whoever was being talked to), but rather is indicative of a difficulty in resolving the pronoun *when it is encountered*—that is, it is indicative instead of the sensitivities of the anaphoric resolution process to prior discourse structure (cf. Garrod & Sanford, 1994). Thus, it may be harder to establish the appropriate anaphoric dependency if there exists some other discourse entity which could plausibly, given the situation described in the context, receive the same role as the actual anaphor. However, for this to be the case, either this alternative role assignment must *already* be encoded by the time the pronoun is encountered or else it has to be "discovered" during the pronominal resolution process. If the latter is true, it would appear that the plausibility of the alternative assignment can interfere with the resolution process even when number mismatch, for example, between the pronoun ("them") and the alternative ("their mother") might be expected to rule out such interference. Nonetheless, these data are open to alternative interpretations, and we return to these in the General Discussion.

The transitive/object control structures ("He ate/reminded his . . .") demonstrate that the stop-making-sense judgment task is indeed sensitive, as Boland et al. (1995) found, to the subtleties of the alternative roles that might be made available at the verb. Both target sentences were preceded by a context which did not introduce a plausible antecedent for the role associated with the grammatical object of the target verb ("Mike quickly chose a video"). Whereas an anomaly was observed at *ate* in the target sentence "He ate his sandwich in the TV room" (replicating the effect found with transitives in Experiment 1), there was no evidence of any equivalent anomaly at *reminded* in the target sentence "He reminded his brother to get some popcorn," because *remind* introduces an additional role which a video could fill—the generalized Theme role in a potentially upcoming complement. Of course, a degree of caution is required in interpreting these data—the crucial comparisons in these cases are between *different* verbs (although the reaction time advantage of the object control verbs is unlikely to be a simple length effect, as they were 1.5 characters longer than the transitives). Nonetheless, if participants in the stop-making-sense task were adopting a strategy of responding "no" simply because there was nothing in the context that the verb could apply to, we would not expect this result.

GENERAL DISCUSSION

Experiments 1 and 2 present data converging on the view that, in sufficiently constrained contexts, the thematic role associated with whatever is about to appear in object position will be assigned, at the verb, to whatever prior discourse entity can plausibly fill that role. In essence, it does not matter whether it is a wh-filler construction that places a constraint on which entity should be considered a candidate for an upcoming role or whether it is a prior discourse context—nothing distinguishes the two constraints, according to the constraint-satisfaction approach, except their probabilistic strengths (relative to each other and relative to the other constraints that are applied as the discourse unfolds). By what mechanism does the context

influence the assignment process? And what would happen if, unlike in the constrained contexts used here, more than one potential antecedent were introduced in the context? This second question is related to a third, more pragmatic, one: Are the effects reported here just a peculiarity of the highly constrained contexts that were employed in these studies or is there some underlying principle at work here which should generalize to less constrained contexts?

It was suggested earlier that in order to accommodate these data one need simply propose that the processor projects, at the verb, upcoming argument structure and immediately attempts to establish anaphoric dependencies between the noun phrases that are projected within that structure and the discourse context. The present data suggest that in establishing these anaphoric dependencies, the processor takes into account thematic criteria associated with the verb. Projection of structure is not in itself a novel idea (cf. Fodor & Frazier, 1980; Gibson & Hickok, 1993; Gorrell, 1993); however, under the current interpretation, what is projected is *interpreted* structure.

Within a probabilistic constraints approach to sentence processing, a verb's argument structure represents the predictive contingencies that hold between a verb and other elements at particular positions relative to that verb within the sentence. If such contingencies are acquired through experience of the contexts (sentential and otherwise) in which individual verbs might occur (cf. the kind of predictive learning exhibited by Elman's (1990) recurrent network), and if the referring expressions in the different argument positions commonly refer to existing discourse entities, it follows that there may exist contingencies between a verb's argument structure and the extrasentential contexts within which a verb may tend to occur. For example, verbs of eating may tend to occur in contexts (linguistic or real-world) which introduce, before the verb is introduced, whatever will be the object of the eating. This contingency, between verbs of eating and the contexts in which such verbs tend to occur, would then form the basis for contextually driven role assignments of the kind observed in Experiments 1 and 2—if the processor predictively activates representations as a function of these contingencies (cf. Elman's network), it would predictively activate, at the verb, some representation of which discourse entities could be referred to next.

Within this framework, the encoding of the contingencies between one thing and another things, and the contexts in which they can cooccur, encodes also the *relationship* between the things—the contingencies define the conditions in which those things can find themselves and the conditions which then result. The activation of representations reflecting the encoding of these contingencies thus corresponds to the "recognition" of the appropriate relationship and, as such, to the assignment of a particular role associated with the verb to its object. It follows, then, that the predictive activation at a verb of alternative representations for what can occur in subsequent object position corresponds to the representation of alternative role assignments. This situation is little different, in fact, from the one during lexical access when the acoustic input is compatible with more than one lexical entry. There, we see evidence that representations corresponding to the alternative entries are activated (reflecting, in effect, a range of predictions regarding how the input will subsequently unfold in time) until such time as the input rules out all but a single alternative (e.g., Marslen-Wilson, 1987; Zwitserlood, 1989). Thus, although the predictive activation of multiple alternatives must, according the view developed here, correspond to multiple (and simultaneous) role assignments, only a single alternative—a single assignment—will remain once the referring expression in object position has been reached.

In principle, this last claim could be cast within the structure-projecting account; when a forthcoming noun phrase is projected at the verb, the referential processes that establish anaphoric dependencies between that projection and the context may establish dependencies to more than one thematically appropriate alternative. At issue, however, is the *mechanism* by which such dependencies are computed. The predictive contingency account provides such a mechanism.

Recently, Liversedge, Pickering, Branigan, and van Gompel (1998) proposed an alternative mechanism for contextual influences on thematic role assignments. They proposed that a context could introduce constituents which were sufficiently underspecified as to invite further specification in a subsequent sentence. For instance, in "the gardener wondered where to plant the shrubs," *where* is assigned an adjunct Locative role, but is otherwise semantically vacuous. Subsequently, on encountering "the shrubs were planted by . . .," the earlier Locative role is still available given its earlier underspecification, and the by-phrase is therefore interpreted as a locative (ordinarily it would be interpreted as an agentive). The present account goes further in that, with the exception possibly of the filled-role constructions, the plausible antecedents were not assigned thematic roles in the context which then recurred in the subsequent targets. These antecedents were plausible recipients of roles associated with the target verb, but they had not already received equivalent roles in the context.

The account developed here rests quite substantially on the claim that the data reflect normal comprehension processes. There are, however, two broad reasons for interpreting the present data with caution. First, and as mentioned at the outset, the stop-making-sense judgment task could well tap late or strategic processes which do not reflect normal sentence comprehension. In this case the data would indicate that people *can* assign thematic roles predictively, but only in circumstances where, for example, it was strategically advantageous to do so. It is unclear, nonetheless, why the more naturalistic reading replications of the Boland et al. (1995) data (cf. Pickering and Traxler's 1998 study and other reading measures reported in Boland et al. 1995) should not generalize to the contextual cases described here: if the judgment task in Boland et al. (1995) tapped early, nonstrategic, processes as evidenced by the alternative measures, why should it *not* tap such processes when the sentences are embedded in context? One reason might be that the target sentences in Experiments 1 and 2 were distinguished from the context sentences that preceded them in terms of presentation and task requirements and that this compromised the generalizability of the task. This would imply, however, that the same task applied to sentences presented in the absence of any explicit context (with all the referential infelicities which that implies) is *more* representative of normal processing than when applied to sentences in context (however distinct). Nonetheless, the judgment data *are* open to alternative interpretations, even if, as stated at the outset, one reason for the adoption of the judgment task here was to demonstrate that the same behavioral phenomena found by Boland et al. (1995) could be found in the absence of obligatory syntactic dependencies between the verb, its arguments, and their antecedents—indeed, the proportions of "no" responses obtained in Experiment 2 are comparable to those observed for the equivalent constructions (transitives, datives, filled-gap) in the original Boland et al. studies.

The second caveat concerns the fact that the data for the different constructions employed in Experiments 1 and 2 are open to alternative interpretations, even supposing that the task does reflect normal comprehension processes. For example, the filled-role data could be interpreted as reflecting anaphoric processes involved in the identifying the antecedent of the postverbal pronoun, without postulating any predictive role assignments at the verb itself. The case for predictive assignments rests on *convergence* of the data on a single hypothesis capable of explaining the range of patterns observed in Experiments 1 and 2.

While further research is clearly needed to both verify and extend the present results, the account that has been developed to explain the mechanism by which context can drive thematic role assignments makes a variety of empirically testable predictions other than the ones tested here. For example, Allopenna, Magnuson, and Tanenhaus (1998) have demonstrated that if participants are asked to "pick up the candy" in a real-world context in which candy is the only item in front of them whose spoken name starts with /k/, their eyes move to the candy sooner than if a competitor item whose name also starts

with /k/ (e.g., *candle*) is present in the context as well. The present account makes the straightforward prediction that if participants were instructed to "eat the candy," the probability of fixating on the candy would rise at the verb *eat*, with no equivalent rise in fixation probability on the competitor candle (and the opposite pattern, with an increase at the verb in fixations on *candle* should arise in response to, e.g., "light the candle"). If it could be shown that selectional restrictions could *not* influence eye movements in the predicted fashion, constraint-based theories of sentence processing would themselves require considerable theoretical constraint. The challenge for any theory of sentence processing is to understand the nature of, and constraints on, thematic role assignment. The data presented here constitute just one more constraint on the development of these theories.

APPENDIX 1: THE EXPERIMENTAL ITEMS USED IN EXPERIMENT 1

Each item consists of three sentences. The first sentence is identical across the four conditions. The second sentence introduces a plausible antecedent or an implausible antecedent, and the final target sentence contains either a nonselecting or a selecting verb.

A young toddler was running around his playroom. It was empty except for some chairs in one corner and some pet cats/flowers in the other. He bumped/chased a chair that he had run into before.

A pop star carrying only a microphone walked on stage at the start of his concert. The stage was bare except for a couple of guitars/loudspeakers and two stools. He moved/played a stool with a fair amount of effort.

A faith healer was at work in his room. It was bare except for a couple of patients/incense burners and some large candles in the corner. He touched/healed a candle that had a crack in it.

A soldier fired some live ammunition into a room by mistake during a training exercise. Several officers/computers were inside with a lot of sophisticated monitoring equipment. He checked/wounded some equipment but it seemed to work OK.

A surgeon entered an operating theatre to transplant a kidney from one patient to another. Except for the transplant patients/operating tables and a row of scalpels, the theatre was empty. He examined/reassured a scalpel that was quite blunt and useless.

A keen amateur gardener was clearing out his greenhouse. Soon, all that was left were a few small plants and some old knives/stone slabs on the floor. He inspected/sharpened a plant that looked particularly stunted and old.

A policeman was sent to some cellars where two runaway girls were reportedly hiding out. The cellars seemed deserted except for the girls/some rats and a few stray dogs. He ignored/handcuffed a dog that was sniffing around very noisily.

A repairman was called out to a house late one night and was directed to the utility room. All he could see there were a few plants and two dilapidated looking washing machines/cats. He moved/repaired a plant that was lying in the corner.

Sally was having a comfortable evening at home. She got up to get some wine/magazines and to look through some video cassettes. She chose/sipped a video that had been on special offer.

A dog was sniffing around inside an open cupboard looking for food. There wasn't much inside; just some rusty pipes and an open tin of dog food/a bag of old nails. It nudged/devoured some pipes that were covered in thick mould.

Cathy was preparing breakfast. There wasn't much in her fridge except for a bag of mushrooms/jug of milk and a bottle of water. She got/fried some water and poured it into a glass.

A policeman walked into a room and looked round suspiciously. There were just a couple of men/bags in the room, lying on some rugs. He noticed/arrested a rug with a very large blood stain.

A nurse carrying various syringes walked into one of the rooms off the main ward. She was surprised to see several women/dolls and some garden gnomes lying on the bed. She lifted/injected a gnome and carried it to a chair.

A mother carrying a bottle of milk went into the baby room. It was empty except for a playpen in which lay two tiny babies/teddy bears and some toy animals. She stroked/fed a toy that she was given as a child.

A restaurant chef opened up his fridge as he started to make lunch. He was surprised to find it empty except for a pile of spoons and a few potatoes/empty dishes. He washed/baked some spoons that were particularly old and dirty.

Tommy was thirsty. He opened the fridge, but inside there was just some cake and some apple juice/chocolate. He tried/drank some cake but thought it had gone off.

A rock musician was getting ready backstage. His dressing room was empty except for some guitars/towels and a few photographs. He dropped/tuned a photograph that had been handed to him.

A car was driving downhill when it suddenly veered out of control. In its path were some pigeons/dustbins and a row of bollards. It missed/injured several bollards that came close to being destroyed.

Mike was looking through his larder. It was empty except for a variety of old broken cups and some stale biscuits/

mouldy boxes. He took/ate some cups and went back into the kitchen.

John opened up his tool bag. There were just a couple of spanners in it and several biscuits/screws. He removed/ate a spanner that was covered in thick grease.

A game hunter entered a small clearing, with his gun raised and ready. There were just a few rats/some old tin cans in the center, and some bones lying nearby. He kicked/killed a bone that he thought was a snake.

A music student was practicing a piece for an upcoming audition. She was practicing in front of two large stage lights beside her teachers/some loudspeakers. She noticed/impressed a light that was flickering on and off.

A guest at a dinner party was thirsty. The only things within reach were a couple of jugs of water/flower arrangements and some ornate candles. She toppled/poured some candles that then made a terrible mess.

Mrs. Green was preparing lunch. She looked at the bread/plates and the jars that were in her cupboard. She got/cut some jars that were right at the top.

A motorcyclist suddenly lost control of his bike. He headed toward several street lights and a group of children/some railings. He missed/scared a light that he managed to swerve around.

Giles had just finished dining in an expensive restaurant. He ordered some brandy/chocolates and cigars. He enjoyed/drank a cigar every so often after his meals.

A student was studying hard. He was surrounded by books/ashtrays and coffee cups. He grabbed/read a cup that had dropped under his chair.

Paul was preparing his dinner. He'd bought some cheese and some eggs/biscuits. He ate/boiled some cheese and then drank a cold beer.

A professor was waiting to be interviewed on a popular science program. He took a packet of cigarettes/some notes and a bag of sweets out of his pocket. He inspected/lit some sweets that smelled of mint and liquorice.

Jack was waiting for the school bus. He took some coins and some chewing gum/a box of matches out of his pocket. He examined/chewed some coins that had been given to him.

A veterinary surgeon was at work in his surgery. In front of him were some cats/notes and some reference books. He inspected/vaccinated a book that was lying near his table.

Fred carelessly bumped against a table at the local village fete. There were some delicate vases/bin liners and two plastic bottles filled with water on the table. He bought/damaged some water that looked like it was fizzy.

APPENDIX 2: THE EXPERIMENTAL ITEMS USED IN EXPERIMENT 2

There were three sets of constructions; datives, filled-role, and object control.

Datives. The first context–target pair constitutes the plausible antecedent condition and the second the implausible antecedent condition.

Hank parked his van outside the local military base. He delivered some machine guns to them and left./Hank parked his van outside the preschool nursery. He delivered some machine guns to the military base next door.

Carol was sitting beside an undergraduate student. She explained an intricate theorem to him in detail./Carol was sitting beside a toddler. She explained an intricate theorem to his father.

Churchill had always been very impressed by the elder statesman. Churchill attributed the privacy law to him in 1933./Churchill had always been very impressed by his army cook. Churchill attributed the privacy law to the brother of the cook.

The city hospital was doing very well. People donated much more blood to it this year./The political party was doing very well. People donated much more blood to the hospital following its campaign.

Harriet stood up in front of the uneasy pupils. She distributed the science exams to them straight away./Harriet stood up in front of the car salesmen. She distributed the science exams to their children to see how they would do.

John arrived late at the campus party. He contributed some cheap liquor to it that evening./John arrived late at the public library. He contributed some cheap liquor to the party he went to later that night.

The chief executive had a junior assistant working under him. He delegated the routine typing to him quite often./The chief executive had a senior manager working under him. He delegated the routine typing to his secretary quite often.

A doctor was in his surgery checking a patient. He administered some pain killers to her very gently./A doctor was in his surgery checking his goldfish. He administered some pain killers to a patient when she came in.

A barrister was in discussion with some lawyers. He entrusted some important documents to them in confidence./A barrister was in discussion with some criminals. He entrusted some important documents to their lawyer.

A manufacturer of hi-tech microscopes was chatting with two biologists. He demonstrated an electron microscope to them very effectively./A manufacturer of hi-tech microscopes was chatting with two cleaners. He demonstrated an electron microscope to some people later on.

A witness to a violent robbery was sitting with a detective. She described the armed thieves to him in detail./A witness to a violent robbery was sitting with her baby. She described the armed thieves to the detective that was questioning her.

The President had to select someone for an honorary post. He appointed a young student to it somewhat controversially./The President had to select someone for the vice

presidency. He appointed a young student to an education committee and then made his decision.

Suzanne has a very temperamental husband. She introduced the new ambassador to him at dinner./Suzanne has a very temperamental parrot. She introduced the new ambassador to the original owner of the parrot.

Ted was walking along with his college advisor. He expressed his political ambitions to him rather shyly./Ted was walking along with his two-year-old. He expressed his political ambitions to his mentor who was walking with them.

A doctor was looking up the address of the local hospice. He referred a dying patient to them somewhat reluctantly./A doctor was looking up the address of the local plumbers. He referred a dying patient to that plumber's homeopath.

Jack knew the local farm very well. He delivered some live sheep to them last week./Jack knew the local swimming pool very well. He delivered some live sheep to the abattoir next door.

Bill was always very generous with his school friends. He lent his new pencils to them this morning./Bill was always very generous with the local business. He lent his new pencils to the manager's son this morning.

David enjoyed the swans he encountered. He tossed old bread crumbs to them if possible./David enjoyed the crowds he encountered. He tossed old bread crumbs to the pigeons as well.

Nancy spent the afternoon with her supervisor. She showed her doctoral thesis to him rather nervously./Nancy spent the afternoon with her three-year-old nephew. She showed her doctoral thesis to his father rather nervously.

The Chief Inspector had two policewomen in his office. He granted generous maternity leave to them that day./The Chief Inspector had two policemen in his office. He granted generous maternity leave to their female colleague.

Harold was wondering what to do about his favourite clerks. He awarded a large bonus to each of them at Christmas./Harold was wondering what to do about his favourite exhibits. He awarded a large bonus to each of the salespeople responsible for them.

The local priest was always very kind toward the families he worked with. He gave a warm smile to all the families on Sunday./The local priest was always very kind toward the charities he worked with. He gave a warm smile to all the charity workers on Sunday.

Janet was watching an elephant closely. She tossed some fresh hay to it rather nervously./Janet was watching a whale closely. She tossed some fresh hay to the cattle on the boat.

Jeff managed to visit the last companies on his list. He gave his latest drawings to them for consideration./Jeff managed to visit the last monuments on his list. He gave his latest drawings to the architects for consideration.

Henry spent a lot of time with his neighbour. He loaned his sharp axe to him this morning./Henry spent a lot of time with his child. He loaned his sharp axe to his child's teacher this morning.

Tom was negotiating with a local client. He sold some diamond earrings to her and also a silver necklace./Tom was negotiating with a traffic warden. He sold some diamond earrings to a client whose car she was ticketing.

Ken fulfilled his promise to the terrorists. He gave the large ransom to them on the following day./Ken fulfilled his promise to his daughters. He gave the large ransom to their kidnappers at midnight.

Tim was in court with his two ex-wives. He offered the alimony payments to them as advised./Tim was in court with his two brothers. He offered the alimony payments to his ex-wife as advised.

Andrea wrote a card for the infant. She sent a little rattle to him when she was in Ohio./Andrea wrote a card for the politician. She sent a little rattle to his baby when she was in Ohio.

A doctor was rummaging inside his case while the nurse looked on. He handed the syringe needle to her before leaving./A doctor was rummaging inside his case while the baby girl looked on. He handed the syringe needle to her mum before leaving.

Amelia had included her niece in her last will and testament. She willed her wedding gown to the adolescent before dying./Amelia had included her nephew in her last will and testament. She willed her wedding gown to his wife before dying.

Alice was surrounded by playmates. She handed her ice cream to them and put her hands in the air./Alice was surrounded by gangsters. She handed her ice cream to her little child and put her hands in the air.

Filled-Role Constructions. The first alternative listed in the context sentence corresponds to the plausible antecedent condition and the second to the implausible antecedent condition.

Mike's grandparents heard him talking to/about his daughter. He reminded them to take their grandchild out tonight.

The team saw the Olympic coach arguing with/about a female athlete. He persuaded them to leave the room straight away.

We overheard Sue talking to/about her brother. She invited us to drive her to the pub.

The young woman listened to the dean being rude to/about the boys. He instructed her to avoid following their bad example.

The film producers heard the director in discussion with/discussing an actress. He forced them to provide another one pretty quickly.

You watched the nurse querying the drugs with/for the patient. She asked you to help count all the tablets.

You heard the detectives asking a question to/about the suspect. They invited you to help the suspect defend himself.

You listened to the social worker reporting to/about some parents. He advised you to introduce the changes on Monday.

Jack stood by as Martha complained to/about the policewomen. She asked him to drive her to her home.

James was reading while his mother talked sternly to/about his sisters. She urged him to avoid being tempted by drugs.

The children stood around while the doctor talked to/about their mother. He pressured them to let her have the operation.

The squad listened to the coach being supportive to/about the female runner. He encouraged them to follow him round the track.

You heard the salesclerk shout at/about the vandals. She told you to report the vandals right away.

The twins listened to their father talking to/about their mother. He asked them to be especially nice to her.

The boys listened as the wizard warned/warned of the girl. He advised them to leave the city that night.

Mary's parents listened as Richard spoke so convincingly to/about her. He persuaded them to keep a diary for her.

Object Control/Transitive Constructions

Mike quickly chose a video. He ate his sandwich in the TV room./He reminded his brother to get some popcorn.

The football manager was worried about some pieces of equipment. He drank his beer and soon calmed down./He persuaded his team to avoid them all.

Sue was looking forward to the dance. She ironed her skirt and put it on./She invited her friend to go with her.

The chief executive was thinking about the report. He sacked his secretary for being too sloppy./He asked his secretary to be less sloppy.

The director rewrote the screenplay first thing in the morning. He fried some eggs and had his breakfast./He forced the actors to work over Christmas.

The nurse was rushed off her feet with all the chores that needed seeing to. She inoculated some children who had just arrived./She implored the administrators to employ more staff.

The lawyer toyed with his mug. He bit his sandwich and chewed it noisily./He instructed his client to plead not guilty.

The policeman went up to the door. He handcuffed the thief and drove him away./He convinced the thief to give himself up.

Martha was disappointed with the film. She sipped her wine and watched another film./She persuaded her friend to get another one.

Jane quickly washed a large plate. She bit her lip and started to cook./She urged her child not to drop it.

The salesman described the new car. He chewed some gum all through his talk./He pressured some clients to try it out.

The team coach liked the toffee with the team logo printed on it. He sharpened his pencil while chewing a toffee./He encouraged the squad to adopt the logo.

The salesclerk was talking about the latest spate of thefts. She licked her ice cream while she talked./She told her manager about them straight away.

The children listened to the story. They kissed their father and asked for another./They persuaded their father to tell them another.

The sorcerer looked at the crystal. He drank the potion he'd made with it./He advised his assistant to avoid touching it.

Jack looked in the direction of the chair. He vaccinated the dog that was asleep there./He persuaded its owners to have it cleaned.

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