

Evidence for the Immediate Use of Verb Control Information in Sentence Processing

JULIE E. BOLAND, MICHAEL K. TANENHAUS, AND SUSAN M. GARNSEY

University of Rochester

When a verb is followed by an infinitival complement, the particular verb determines whether its subject or object is the understood subject of the infinitive. Thus, the verb "controls" the interpretation of the infinitive (e.g., *John promised/persuaded Mary to wash*). Frazier and colleagues have argued that verb control information is not immediately accessed and used in sentence processing based on whole-sentence comprehension times. The studies reported here examined the use of verb control using an on-line plausibility monitoring task. Subjects immediately detected incongruities that depended upon their having correctly used control information, indicating that verb control information is rapidly accessed and used. It is argued that the results support an approach to language comprehension that emphasizes the importance of lexical representations in rapidly integrating many of the different sources of linguistic and nonlinguistic knowledge that need to be coordinated during language comprehension. © 1990 Academic Press, Inc.

The lexical representation of a word, especially a verb, provides the reader or listener with considerable information about how that word combines syntactically and semantically with other words in the sentence and discourse (Marslen-Wilson, Brown, & Tyler, 1988; Tanenhaus & Carlson, 1989; Tanenhaus, Garnsey, & Boland, in press; Tanenhaus, Carlson, & Trueswell, 1989; Tyler, 1989). However, there is little consensus about how and when lexical representations are used in sentence processing. Some researchers have argued that the use of lexical information is delayed such that initial syntactic decisions are made

without reference to relevant combinatory lexical information (Frazier, 1987, 1989; Mitchell, 1987, in press), while others have suggested that this information provides for rapid and relatively seamless communication among parsing, discourse context, and structurally relevant real-world knowledge (Marslen-Wilson et al., 1988; McClelland, 1987; Tanenhaus et al., 1989; Tanenhaus & Carlson, 1989; Tyler, 1989). Thus, the issue of when combinatory lexical information is accessed and used is directly relevant to the ongoing debate about the modularity of the language processing system (Fodor, 1983; Marslen-Wilson & Tyler, 1987; Tanenhaus, Carlson, & Seidenberg, 1985).

This article examines the time course of the use of verb control information, which is a particular type of combinatory lexical knowledge, in sentence processing. Control information determines how particular verbs influence interpretation of the understood subjects of infinitival complements. So, for example, the **subject** of the verb *promise* is also the understood subject of the infinitive in *John_i promised Mary_i to wash himself*, while the **object** of the verb *persuade* controls the interpretation of its infinitive in *John persuaded Mary_i to*

This research was supported in part by NIH grant HD-22271 and NSF grant BNS-8617738. We would like to thank Greg Carlson and Gary Dell for their helpful insight and suggestions, John McCrary for help with the statistical analyses, and Janet Nicol for several helpful discussions as well as for providing us with her materials. We would also like to thank Gail Mauner and an anonymous reviewer for many helpful comments. Susan M. Garnsey is now at the Department of Psychology, University of Illinois at Champaign-Urbana. Requests for reprints should be sent to Michael K. Tanenhaus, Department of Psychology, Meliora Hall, University of Rochester, Rochester, NY 14627.

wash herself. For ease of exposition all phonologically unrealized linguistic elements will be called gaps. Each gap will be marked with a “_” and have a common subscript with its “filler,” which is the noun phrase that is associated with the gap when the sentence is correctly interpreted. When a gap has been associated with its filler, they are said to be “coindexed.”

In a sentence with a “controlled” infinitive complement, either the subject or the object of the matrix verb is understood as, i.e., controls the interpretation of, the implicit subject of the infinitive. Some examples of verb control are shown below. Sentence (1a) illustrates the use of a “subject control” verb (*promise*), and sentence (1b), an “object control” verb (*tell*).

- (1) a. The girl_i promised her brother
—_i to sing.
b. The girl told her brother_j —_j to sing.

In sentence (1a), the subject of *promise* is understood as the subject of the infinitive, i.e., the girl is promising her brother that she will sing, whereas in sentence (1b), the object of the matrix verb is understood as the subject of the infinitive, i.e., the girl is telling her brother that he should sing. We are following standard linguistic convention and distinguishing true infinitive complements from purpose or rationale clauses such as in *Mary told her brother the joke to make him laugh*. These clauses appear freely after most verbs regardless of control properties and can be paraphrased as “for the purpose of . . .” or “in order to . . .”

Most control verbs have unambiguous control properties. Verbs that require a direct object before an infinitive phrase, such as *force* in (2b), are typically object control verbs. Verbs that do not allow an object before the infinitive, like *start* in (2a), are always subject control verbs. Only a few verbs like *promise* are transitive, yet subject control.

- (2) a. The girl_i started —_i to sing.

- b. The girl forced the woman_j —_j to sing.

Some verbs have ambiguous control properties. For example, *beg* is used as a subject control verb in sentence (3a) and as an object control verb in sentence (3b).

- (3) a. The girl_i begged —_i to sing for the woman.
b. The girl begged the woman_j —_j to sing.

Although *beg* has ambiguous control properties, only the subject control interpretation is possible in (3a) because *beg* is used intransitively. In (3b) both the subject and object control interpretations are possible, but the object control interpretation is preferred. There is a strong preference for the object control interpretation whenever a control verb is used transitively. In (3b) it is clear that *beg* is being used transitively at the first word following the verb, but in Wh-questions such as those in (4a), both the transitivity and the control relationship can remain ambiguous for several words.

- (4) a. Subject control: Which woman_i did the girl_j beg —_j to sing for —_i?
b. Object control: Which woman_i did the girl beg —_i —_i to sing?¹

The ambiguity arises because *woman* is a filler that must be associated with some ob-

¹ In (4b), the first gap is an object gap (“trace” in the terms of the Government and Binding linguistic theory) and the second is a subject gap (“PRO” in Government and Binding terminology). (4a) also contains an object gap, but it is at the end of the sentence and is a prepositional object. Government and Binding Theory differentiates between trace and PRO since it analyzes object gaps as the result of movement and subject gaps as generated in deep structure. In addition, PRO has its own thematic role while trace shares a thematic role with an overt noun phrase; the two kinds of gaps occur in different environments, and they are subject to different constraints. We should note, though, that current linguistic theories disagree about whether or not there is actually an empty syntactic category associated with the understood subject of an infinitive phrase (see Sells, 1985).

ject gap in the sentence. In (4a), the object gap follows the preposition, *for*, and *the woman* is understood as the object of the preposition. Since *beg* is being used intransitively, only the subject control interpretation is possible. In (4b) however, the object gap follows the verb, *beg*, and *the woman* is interpreted as the direct object of the verb. Since *beg* is being used transitively, the object control interpretation prevails.

Frazier, Clifton, and Randall (1983) used sentences like those in (5), which are a longer and somewhat more complex version of those in (4).

- (5) a. Subject control: Everyone liked the woman_i (who_i) the little child_j begged —_j to sing those stupid French songs for —_i.
 b. Object control: Every one liked the woman_i (who_i) the little child begged —_i —_i to sing those stupid French songs.

Sentences were presented one word at a time, with each word centrally displayed on a CRT for 300 ms. As quickly as possible after the last word was presented, subjects responded "got it" or "missed it" to indicate whether or not they had understood the sentence. The important result was that subjects understood sentences like (5a) faster than sentences like (5b). Frazier et al. reasoned that if subjects committed themselves to a single interpretation (either subject of object control), reading times should be long when the disambiguating phrase (in the above example, this is the presence or absence of *for*) did not match the chosen interpretation. They accounted for the subject control advantage by proposing that comprehenders adopt a "most recent filler" (MRF) strategy in which the most recent potential filler is initially associated with a gap. In both (5a) and (5b) above, the MRF strategy will assign *the little child* to the subject gap in the infinitive phrase, i.e., the child as the singer. This is the correct assignment in (5a), the subject control sentence, but in (5b) the woman, not the child,

is singing. The temporary misassignment of *child* to the subject gap causes a "garden path," which is corrected when verb control information becomes available.

When confronted with ambiguous control information (as with *beg*), comprehenders are forced to either resort to a heuristic like the MRF strategy for the initial filler-gap assignment, or delay filler-gap assignment until unambiguous information is available. But even when Frazier et al. (1983) used verbs with unambiguous control properties, as shown below in (6), subjects understood the sentences with subject control verbs faster than those with object control verbs.

- (6) a. Subject control: Everyone liked the woman_i (who_i) the little child_j started —_j to sing those stupid French songs for —_i.
 b. Object control: Everyone liked the woman_i (who_i) the little child forced —_i —_i to sing those stupid French songs.

In fact, having unambiguous control information did not reduce the recent filler advantage, a result replicated by Clifton and Frazier (1986). Frazier et al. argued that subjects continued to use the MRF strategy, even when the strategy led to a filler-gap assignment that was incompatible with the control properties of the verb. They concluded that the parser does not have access to verb control information when it initially associates the filler with a gap, providing support for modularity within the sentence processing system. Further, they argued that the delayed use of verb control information is consistent with the representational framework adopted in the Government and Binding Theory (Chomsky, 1981), but not with alternative linguistic theories, a point that has been vigorously debated (Crain & Fodor, 1985; Fodor, 1988; Ford & Dalrymple, 1988).

The ability of the MRF strategy to explain the Frazier et al. (1983) data has been questioned (Fodor, 1988; Ford & Dalrym-

ple, 1988). Rather than detailing the various arguments, we will simply note that the Frazier et al. evidence for delayed use of verb control information is indirect. Longer end-of-sentence response latencies for distant filler sentences than for recent filler sentences are taken as evidence that readers misassigned the most recent filler to the subject gap. What is lacking is direct evidence about when subject gaps in infinitive complements are interpreted and when control information is used.

In order to determine when the subject gap is interpreted, we used an "embedded anomaly" logic which has proved useful in a series of studies investigating the processing of sentences with filler-gap dependencies (Boland, Tanenhaus, Carlson, & Garnsey, in press; Garnsey, Tanenhaus, & Chapman, 1989; Tanenhaus et al., 1985; Tanenhaus, Boland, Garnsey, & Carlson, 1989; Tanenhaus et al., in press). In general terms, the embedded anomaly approach manipulates the plausibility of a fronted Wh-phrase (a salient filler) for a particular gap or potential gap in the sentence. Since sentences with implausible fillers are only implausible if the filler is associated with the subject gap, the point at which plausibility effects occur indicates when the filler has been associated with the gap. In the present experiments, we manipulated plausibility of a fronted direct object as the implicit subject of an infinitive phrase.

Compare sentences (7a) and (7b).

- (7) a. The cowboy signalled the outlaw
 ___to surrender his weapons quietly.
 b. The cowboy signalled the horse
 ___to surrender his weapons quietly.

It is plausible for cowboys to signal both horses and outlaws, but sentence (7b) is less plausible than (7a) because horses cannot surrender. The subject gap must be correctly interpreted in order to notice this. If *cowboy* is incorrectly assigned to the gap, the sentence appears plausible since cowboys can surrender. We assume that real world knowledge can be used to assess

plausibility as interpretations are built. The MRF strategy predicts that *horse* will be correctly associated with the subject gap in (7b). However, if *horse* is fronted, as in the Wh-question, *Which horse did the cowboy signal to surrender his weapons quietly?*, the MRF strategy predicts that *cowboy* will initially be associated with the subject gap since it will be closer to the gap. Thus, the reader would be unaware of the oddity until the mistaken analysis was corrected.

Our experiments address two questions. The first is a test of the MRF strategy: will plausibility effects in the recent filler versions precede plausibility effects in the distant filler versions? The second question concerns when verb control information is used: how early will plausibility effects occur? The second issue is independent of the first since plausibility effects could be equally late in both types of sentences, indicating that verb control information guides initial coindexing but that it becomes available relatively late in processing.

EXPERIMENT 1

In Experiment 1, we used a word-by-word sense-monitoring task to compare sentences in which the MRF strategy predicts initial misassignment with sentences in which the MRF strategy predicts correct initial assignment. Frazier et al. (1983) used object control verbs for their distant filler sentences and subject control verbs for their recent filler sentences. We manipulated filler distance by comparing question (distant filler) and declarative (recent filler) versions of object control sentences.

The four experimental conditions and the critical word positions are described for a sample sentence set in Fig. 1. In the first two conditions in Fig. 1, the sentences become implausible at *surrender*, because *horse* is an implausible subject. In the two declarative conditions the correct fillers, *horse* and *outlaw*, are the most recent fillers for the subject gap (subject of *to surrender*). Therefore, correct initial assignment is predicted by both the MRF strategy and the position that verb control information is

CONDITION		Critical Word Positions					
		V1 or N	to	V2	V2+1*	V2+2*	V2+3*
<i>Implaus-Quest</i>	Which horse did the cowboy	signal	to	surrender	to	the	authorities
<i>Implaus-Declar</i>	The cowboy signalled the	horse					
<i>Plaus-Quest</i>	Which outlaw did the cowboy	signal					
<i>Plaus-Declar</i>	The cowboy signalled the	outlaw					

FIG. 1. A sample sentence set from Experiment 1 is shown with critical word positions specified. The four condition names indicate the sentence type (declarative or question) and the plausibility of the filler as the subject of V2, which is the same as the overall plausibility of the sentence. *The last three words were either a noun phrase, a prepositional phrase, an adverbial phrase, or a noun phrase followed by an adverbial.

used immediately. However, in the two question conditions *horse* and *outlaw*, respectively, are the correct fillers but not the most recent. (*Cowboy* is more recent.) The MRF strategy predicts correct initial assignment of *horse/outlaw* to the object gap (Clifton & Frazier, 1986), but predicts that *cowboy* will be incorrectly assigned to the subject gap. Corrective reassignment occurs when verb-control information becomes available. Because *cowboy* is a plausible subject of the infinitive, delayed detection of the implausibility of the implausible questions compared to the implausible declaratives would support the MRF hypothesis. If verb control information is used to select the filler for the subject gap, there should be no delay in implausibility detection in the Wh-question compared to the simple declaratives. If verb control information is used immediately, the plausibility effect should be at, or shortly after, the embedded verb in both sentences.

Method

Materials. Experiment 1 used 28 sentence sets of the form illustrated in Fig. 1. The full set appears in Appendix A. The sentences were constructed using 28 object control verbs. None of them could be used as subject-control verbs. Sentence completion norms were collected for a set of object control verbs. Verbs were selected from this set using the following criteria: they were never used as a subject control verb, they were virtually always used transi-

tively, and in most of responses they were used with an overt or implied infinitive complement. (Details are available from the authors). All of the critical sentences had a transitive matrix verb, followed by either an object NP (declarative conditions) or a gap (question conditions), an infinitive VP with a subject gap, and either a prepositional phrase, an adverbial phrase, or a noun phrase three words in length. Both the subject gap and the object gap were coindexed with the object NP. All sentences were plausible up to the embedded verb. The subject of the matrix verb was always plausible as the subject of the embedded infinitive. In the implausible conditions, the object noun phrase was not a good Agent for the infinitive verb, so the implausible sentences became implausible when the embedded verb was read.

The four conditions were counterbalanced across four lists such that one version of each sentence appeared on each list and equal numbers of sentences in each condition occurred on all lists. A variety of distractor sentences were constructed using non-control verbs and ordered semirandomly with the critical sentences. Each list consisted of 28 critical sentences and 52 distractor sentences for a total of 80 sentences. Half of the critical sentences and six of the distractor sentences were anomalous; the remaining 60 sentences on each list were plausible.

Subjects. Thirty-two male and female undergraduates completed the experiment either in partial fulfillment of course require-

