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ABSTRACT

A study investigated differential processing of adjectival and verbal passives in English, and the implications for linguistic theory. The subjects, 30 native-English-speaking college students, were presented with word triples in which one member was an adjective, one an adjectival passive, and one a verbal passive, and with three two-sentence passages for each triple, constructed so the last word of each passage could be any of the three words in the triple. Reading time and response times to probe and comprehension questions were recorded. Results showed that the responses to the binding probe, when the sentence contained a verbal passive, were different from responses to the same probe in the other two constructions, suggesting that the language processor treats verbal passives differently from superficially similar adjectives and adjectival passives. The direction of the effect is consistent with a government binding analysis of verbal passives that incorporate noun phrase movement and bound trace. Additional implications are examined and further research to extend these findings is recommended. (MSE)

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Processing Binding in Passive Sentences

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PROCESSING BINDING IN PASSIVE SENTENCES*

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A number of researchers working within a variety of theoretical frameworks have noted the distinctions between verbal passives, illustrated in (1), and adjectival passives, as in (2) (Bresnan, 1982a; Levin & Rappaport, 1986; Wasow, 1977).

1a. The girl was kissed.
b. The equations were studied.
c. The cart was pushed.

2a. The girl was surprised.
b. The equations were complicated.
c. The cart was stained.

Verbal and adjectival passives can be distinguished first by the subtle semantic differences between them: The sentences in (1) describe events, while those in (2) have a more stative reading. The two types of passives can also be differentiated by the sentential environments in which they can appear. Adjectival passives can appear in exactly those environments where adjectives can appear, but the appearance of verbal passives is much more restricted (Levin and Rappaport, 1986; Wasow, 1977). For example, both adjectives and adjectival passives can appear as prenominal modifiers, while verbal passives cannot. This contrast can be seen in the phrases in (3), which contain, in order, a prenominal adjective, adjectival passive, and verbal passive:

3a. the happy/surprised/*kissed girl
b. the long/complicated/*studied equations
c. the heavy/stained/*pushed cart

Similarly, adjectival passives can appear as the complements of verbs such as "seem" and "appear" that select for adjectival rather than verbal complements. Verbal passives cannot appear in this environment:

4a. the girl appeared happy/surprised/*kissed
b. the equation seemed long/complicated/*studied
c. the cart looked heavy/stained/*pushed

Government Binding Theory (Chomsky, 1981), using the evidence illustrated in (3-4) and other examples of similarities between adjectival passives and adjectives (Levin and Rappaport, 1986; Wasow, 1977), has argued that adjectival passives are adjectives and are distinct from the verbal passive construction. In the GB analysis (Chomsky, 1981), the adjectival passive participle is derived from the base form of the verb via a rule of adjecival passive formation that produces the necessary morphological and category changes. Verbal passives undergo no category changes; here the passive construction is produced through NP movement, as in (5). The d-structure representation of "John was kissed" is shown in (5a); the NP "John" receives a thematic role of THEME in this position but must move in order to receive Case, as shown in (5b). In GB theory, movement leaves behind a trace that is coindexed with the moved element, indicated by [e] and subscripts in (5b).

5a. [e] was kissed John
b. John_i was kissed $[e]_i$

While the exact nature of the adjectival passive formation rule is a topic of some controversy (see Levin and Rappaport, 1986, for discussion), the details need not concern us here. The crucial point is that in the GB analysis, adjectival passives are in the same category as adjectives, and that they are formed in a manner that is distinct from the way in which verbal passives are formed.

In contrast to the GB analysis, the Lexical Functional Grammar (LFG) analysis of passives (Bresnan, 1982) agues that both adjectival and verbal passives are formed by lexical rule. In this framework, passivation is accomplished (roughly) as follows: verbal passive constructions are formed from a lexical rule that takes as its input the base form of the verb and changes the morphological and lexical form of the word. Adjectival passives are created by a different lexical rule in which the participle form of the verb undergoes a category change from verb to adjective. Again the details of these rules are less important for this discussion than the overall approach: In an LFG analysis, both verbal and adjectival passives are formed through lexical rules, without any NP movement.

If a measure could be found that was sensitive to processing of the trace of NP movement, as in (5b), then these two conflicting analyses of passive constructions might be distinguished with psycholinguisitc data. Given such a measure, the Government Binding analysis of passives would suggest that processing of verbal passives, which contain a bound trace, should differ from processing of similar sentences containing adjectival passives or adjectives, because neither of these two constructions contains any movement trace. On the LFG account,

however, a measure sensitive to the presence of traces should find no differences among sentences containing verbal passives, adjectival passives, and adjectives, as none of these three constructions contain a trace according to this analysis.

One way to find a measure that might be sensitive to processing binding would be to ask whether binding is similar to some other linguistic operation, and then look to see whether there is some psycholinguistic measure that has been used to test this other operation. The binding relationship between an an NP-trace is a coreference relationship in the syntax. Other coreference relationships besides binding exist, most obviously coreference between nouns and overt anaphoric expressions. A number of psycholinguistic studies exist on the effects of processing pronominal reference (Chang, 1980, Corbett and Chang, 1983; Leiman, 1982; MacDonald, 1986). The most common experimental paradigm in these experiments is to present sentences such as the ones in (6), where the pronoun is coreferential with one of two names in the sentence.

6a. At the carnival, Tommy guided Ruth through the maze, and the creepy fake monsters terrified him at almost every turn.

b. At the carnival, Tommy guided Ruth through the maze, and the creepy fake monsters terrified her at almost every turn.

At some point after the subject has heard or read the pronoun in the sentence, the sentence is interrupted and a probe word is shown on a computer screen. The subject must make some sort of response to the probe, such as name it aloud or press a key indicating whether the probe has occurred in the sentence. Subjects are generally faster at making a response to the probe word when it matches the referent of the pronoun. Figure 1 presents data from an experiment reported by MacDonald (1986), in which subjects read sentences such as in (6). Subjects saw a probe word 1/2 second after they had read the pronoun and pressed a key to indicate whether the probe had been in the sentence. When the probe word was Tommy, subjects were faster making this judgment if they had been reading (6a), which contained a pronoun ("him") coreferential with "Tommy"; they were much slower making the jugment if they had been reading (6b), which contained "her". Conversely, subjects were faster to judge that the probe Ruth had been in the sentence if they had been reading (6b), which contained a pronoun coreferential with "Ruth", compared to their

1

responses after reading (6a). The interpretation of these and similar results (Chang, 1980; Leiman, 1982) has been that the presence of a pronoun can strengthen the mental represenation of its referent, and this strengthening effect is reflected in

faster response times to probes in these experiments.

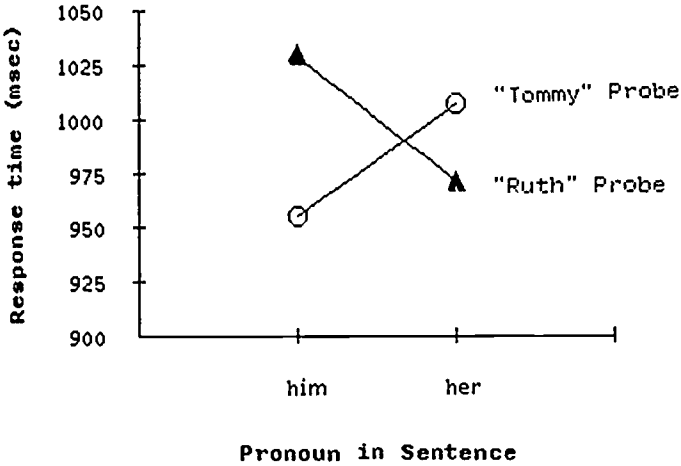

Figure 1. Time to judge whether probe word was in the sentence

These measures of coreference might provide a clue to studying the processing of binding. Although the computation of pronominal reference is presumably carried out at a discourse level of representation, it is possible that the processing of binding, which is a coreference relationship in the syntax, might produce similar effects to those found with pronominal reference. If we can tap processing of binding with the probe task described above, then we can test the different predictions of the GB and LFG analyses of passive constructions. For example, the GB prediction for responses to the probe John in the sentences in (7) is that responses to the probe John should be faster in the verbal passive (7c) than in the adjective construction in (7a) or the adjectival passive in (7b), because the bound trace in (7c) should strengthen the representation of "John" in the same way that an overt pronoun strengthens its antecedent.

7a. John was happy.
b. John was delighted.
c. John was kissed [e]
i i

Given LFG's claim that there is no movement in formation of the verbal passive, the LFG analysis makes different predictions

concerning the processing of (7a-c). On this analysis, there should be no differences in responses to John in any of the three sentences. Should the experiment find differences between verbal passives and the other two constructions, the results would be more consistent with the Government Binding analysis of passives than with Bresnan's (1982) analysis. Note, however, that Bresnan does distinguish between adjectives, adjectival passives, and verbal passives in the lexicon, and thus could in principle predict some differences in (7a-c). If any differences are found using the probe task, is thus crucial to determine whether these differences are the result of the processing of binding relationships or are the result of other processes that might be incorporated into an LFG-compatible model of language processing.

EXPERIMENTAL METHOD

Materials

Fourteen word triples were constructed such that one member of the triple was an adjective, one an adjectival passive, and one a verbal passive, such as "furious/surprised/shot" (see Levin & Rappaport, 1986, and Wasow, 1977, for the tests used here to distinguish adjectival and verbal passives). The members of the triples were matched across these three experimental conditions for length and frequency of occurence in English (Kucera and Francis, 1967). Three two-sentence "passages" were written for each triple, so that any member of the triple could sensibly appear as the last word of each of the three passages for that triple. The topics of the passages were unrelated. The three passages for one triple are shown in sentences 8-10; the last word of each passage was either the adjective nervous, the adjectival passive worried, or the verbal passive photographed.

8. The journalism students were looking forward to the lecture.
   The guest speaker with the stained tie was _____
   Probes: students, speaker

9. The game wardens stopped the jeeps near the clearing.
   The shy antelopes at the watering hole were _____
   Probes: wardens, antelopes

10. The proud mother watched the recital with rapt attention.
    The young ballerina in the pink costume was _____
    Probes: mother, ballerina

The first sentence of each passage varied between 7-11 words

in length, while the second sentence was always 9 words in length. The third word of the second sentence was always a noun, and the ninth (last) word was always one member of the word triple for that passage. The two sentences were constructed so that the subject of the first sentence could be a plausible agent when the passage contained a verbal passive. For example, in the passage in (10), "mother" is the most plausible agent of the photographing in the version of the passage ending in "photographed". The presence of the first sentence thus created a more coherent discourse than would be possible with one-sentence stimuli.

Another function of the first sentence was to allow for more positions to be probed from each passage. Two probes were selected for each passage, the subject of the first sentence (Word 2 or 3), and the subject of the second sentence (always Word 3 of that sentence). For ease of exposition the probe from the second sentence will be termed the binding probe, as any effects of binding should be seen with this probe. The first sentence probe is called the agent probe, because that word is the logical agent of the activity described in the verbal passive construction. If the probe task does tap coreference in the syntax (binding), the GB analysis predicts faster responses for the binding probe when the last word of the sentence is a verbal passive, but it predicts that there should be no differences in responses to the agent probe, as this word is not in any binding relationship. In contrast, the LFG analysis predicts no differences in responses to either probe.

Sixty-six practice and filler passages were prepared, each containing a pair of sentences with a variety of syntactic constructions. All probes for filler passages either did not occur in the passage (the majority of probes), or were contained in the passage in some position other than the subject position of either sentence. Every probe that was not contained in a passage was an associate of a word that had occurred in the passage. This control on "false" probes forced subjects to pay close attention to the passages and refrain from making the probe recognition judgment merely on the familiarity of the concept being probed. A yes/no comprehension question was prepared for every passage, with "yes" as the correct answer for half of the questions for both experimental and filler passages. The questions for the experimental passages avoided reference the last word in the passage so that the same question could be used for a passage regardless of whether the passage ended in an adjective, adjectival passive, or verbal passive.

Procedure

Stimuli were presented on a computer screen such that subjects were able to read one sentence at a time. At the start

of each trial, the display was filled with three lines of dashes representing all nonspace characters of the stimulus sentences, probe word, and comprehension question. When subjects pressed a key with the left hand, the first sentence replaced the dashes on the top line of the display. A subsequent keypress replaced the first sentence with dashes and revealed the entire second sentence on the second line. A third keypress removed the second sentence and displayed the probe word in capital letters four spaces to the right of the end of the second sentence. Prior to this keypress, the probe word was always indicated by 11 dashes, regardless of word length, so that subjects would not have early information about the length of the word to be probed. Subjects judged whether the probe had occurred in the preceding two sentences and pressed a "YES" or "NO" key with the right hand. This response removed the probe and displayed a comprehension question on the bottom line. When subjects had pressed the "YES" or "NO" key in response to the question, the screen was cleared, and a new set of dashes indicated a new trial. Subjects were encouraged to read at a normal rate, and speed and accuracy were stressed for responses to both the probes and comprehension questions. Response times to the probe and comprehension question were recorded, as were reading times for each sentence. The purpose of collecting reading time and question-answering data was to ensure that all three constructions were equally easy to read and comprehend. Subjects saw an equal number of sentences in each of the 6 combinations of probe and sentence type conditions. They completed the experiment without a break in one 30 min session.

Subjects

Subjects were 30 undergraduates enrolled in psychology classes at Carnegie Mellon University who participated as part of a course requirement. All subjects were native speakers of English. An additional 5 subjects were tested but were not used in the final analyses because of error rates on comprehension questions over 20%.

RESULTS

Response times to the probe, to the question, and reading times to the second sentence were analyzed. Prior to analysis, all incorrect probe responses (error rate 4%) and incorrect comprehension question responses (6.8% error rate) were removed. Extremely long responses in each task (reading, probe judgment, question comprehension) were also removed, using a two-step procedure. First, all responses over three times the grand mean

for each task were removed. Next, means and standard deviations were calculated for each subject for each task, and all scores more than 3.5 standard deviations over the subject's mean were removed. This procedure removed less than 3% of the responses for each task.

Reading times in the second sentence did not differ across the adjective (2.951 seconds), adjectival passive (3.005 seconds), and verbal passive (2.941 seconds) conditions, $F < 1$. Response times to the comprehension questions (1.717, 1.748, and 1.666 seconds to the adjective, adjectival passive, and verbal passive conditions, respectively) also did not differ across sentence type, $F(2, 58) = 2.25$, $p > .11$.

Response times to the probes are shown in Figure 2. Statistical analyses indicated that responses to the agent probe in the adjective sentence, the adjectival passive sentence, and the verbal passive sentence did not differ from one another, $F < 1$. That is, the line indicating agent probe responses in Figure 2 cannot be distinguished from a flat line. Responses to the binding probe revealed a different story: responses in the verbal passive condition were faster than in the adjective condition, $F(1, 29) = 9.63$, $p < .005$, and there was a trend for the binding probe responses to be faster in the verbal passive condition compared to the adjectival passive condition, $F(1, 29) = 3.46$, $p < .08$. Responses to the second sentence probe did not differ in the adjective and adjectival passive conditions, $F(1, 29) = 1.35$, $p > .25$.

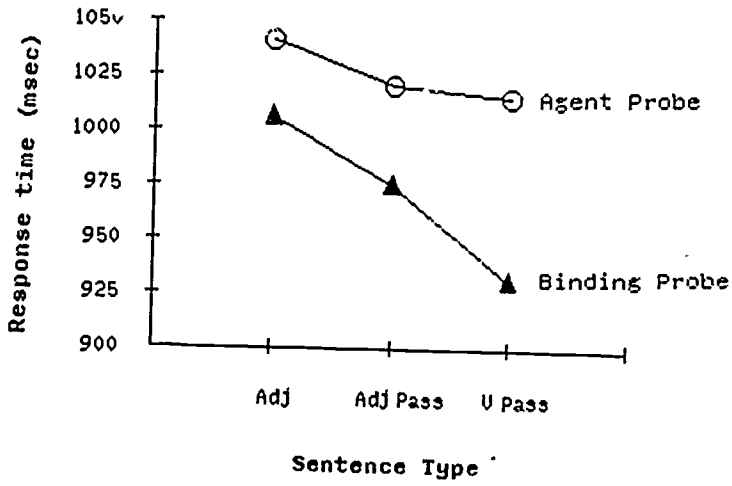

Figure 2. Response time to binding and agent probes

DISCUSSION

Responses to the binding probe when the sentence contaied a verbal passive were different than responses to the same probe in the other two constructions. This result suggests that the language processor treats verbal passives differently than it treats the superficially similar adjective and adjectival passive constructions. The direction of the effect (that is, that responses were faster in the verbal passive condition) is entirely consistent with a GB analysis of verbal passives incorporating noun phrase movement and a bound trace. The LFG analysis, in contrast, has no account of why this difference should exist. The results in the agent probe condition further support the claim that that binding relationships in the verbal passive construction produce strengthening effects for the element that binds the trace. There were no differences for the agent probe across any of the three sentences, despite the fact that in the verbal passive condition, the agent probe matched a word that was very integral to the understanding of the action described by the verbal passive. This result suggests that the probe task was not sensitive to general integration of the components of the discourse; therefore, the results of for the binding probe cannot be attributed to any such general integration effects.

While conclusions from any single experiment must remain tentative, we can rule out several other alternative explanations of the results with an examination of some of the experimental controls employed. First, the data cannot be explained by general differences in processing load across the three sentence types, because reading time and question-answering time did not differ across the conditions. The overall reading rate for the second sentence in the passage was about three words per second, a very normal rate. This result discounts any explanations based on strategies in two ways. First, the reading rate indicates that the subjects' reading was not disturbed by the fact that they expected a probe word at the end of the second sentence. Second, the fact that the subjects read the sentences at a normal rate indicates that they they did not spend time developing special strategies to predict what probe might appear. Given all these controls, it is highly unlikely that the obtained results could stem from differences in processing difficulty for the three sentences, nor is it probable that the results are due to some peculiar reading or response strategy that subjects developed in the course of the experiment.

These results are quite promising and suggest several avenues for future research. First, the effect should be investigated with binding in other syntactic constructions, and in fact recent work has found similar effects with NP-trace in raising and control constructions, as well as the verbal passive construction (Bever and McElree, to appear). The effect should

not be limited to empty categories produced through NP-movement, and so the null pronominal PRO and the trace of wh-movement should also produce effects. Bever and McElree (to appear) found that PRO produced similar, but weaker, effects compared to constructions containing an overt pronoun or an NP-trace. Using a somewhat different experimental method, Clifton and Frazier (to appear) have found tentative evidence that wh-gaps also produce strengthening effects.

We can also investigate further how the language processor initially assigns a structure to adjectival passives--recall that in the research reported here, response times in the adjectival passive condition were intermediate between adjective and verbal passive response times. While we should not make too much of null results (recall that adjectival passives did not differ significantly from the other two conditions), it is tempting to suggest that subjects sometimes posit a verbal passive structure (with a bound element) for the adjectival passives. It is not clear that this strategy of positing the structure containing the trace as a first resort (and later deleting the trace if necessary) is necessarily preferable to a strategy where a trace is not assumed initially (so that in some cases the language processor would later have to go back over the structure and insert a trace).[3] If the processor does use a first resort strategy, however, it may be possible to change the processor's performance by giving it early information indicating that a passive construction is unambiguously adjectival or verbal. For example, in Hebrew adjectival passives and verbal passives are morphologically distinct (Borer and Wexler, 1987). If perceivers can use the morphological information to distinguish the two types of passives (a likely assumption) then according to the GB analysis, we should not see any differences between adjectives and adjectival passives in the probe task used here. If the slight differences found in the study reported here were reproduced in Hebrew, however, then some other aspects of processing of passive constructions would need to be explored.

Finally, we can examine the time course of the strengthening effects that result from the binding relationship. Work in anaphoric reference at a discourse level finds facilitation effects beginning 250-500 ms following the anaphoric reference and changing in strength over time (Dell, McKoon, & Ratcliff, 1983; Leiman, 1982; MacDonald, 1986). If the process whereby the bound element strengthens the representation of its antecedent is analogous to the process in which a pronoun strengthens its referent, then we should find that the strengthening effects of binding change over time as well. This is not to say that the time course of facilitation from binding and coreference should be identical; when confronted with coreference in the discourse, the language processor makes a guess as to the correct referent based on pragmatic considerations, while syntactic relationships determine unambiguously which elements must be bound. The probe

task nonetheless seems to offer great promise for investigations of coreference, bot in binding and in pronominal reference.

FOOTNOTES

* Thanks are due to Robin Clark for valuable discussions during the development of this study and helpful comments on an earlier version of this paper. I am also grateful to Howard Kurtzman for additional helpful comments on that same earlier version.

1. This figure actually represents responses to 90 sentences with structures similar to those in (6), all with different probe names, rather than just responses to the two names Tommy and Ruth.

2. An F value of 1 or less indicates results entirely consitent with chance variations. If F is greater than 1, then p, the probability that the results would be obtained by chance, is reported. The accepted value for statistically significant results is $p < .05$; that is, the obtained results would be expected to occur by chance less than 5% of the time.

3. The Marcus Parser (Marcus, 1980) uses this strategy, where morphological information indicates the presence of a passive, so that traces are not posited after adjectives. For a discussion on the general desirability of positing gaps as a first (or last) resort, see Clifton and Frazier (in press) and references cited there.

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