Structural priming: Purely syntactic?

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Abstract

In a series of experiments, Bock and colleagues have demonstrated that subjects show a reliable increase in the use of particular syntactic constructions after having heard and repeated that construction in an unrelated sentence. Aspects of the data seem to indicate that it is syntactic constituent structure, independent of meaning, that underlies the facilitation in these situations. In this study we investigate whether more semantic factors might also lead to priming, and specifically whether the assignment of a semantic role to a particular participant in a prime sentence can increase the probability of a target sentence whose structure allows a similar assignment. To test this we replicate Bock's study and include a further set of primes (*provide-with* primes) which have the syntactic constituent structure of the dative, but share semantic role assignment with the ditransitive. If syntactic priming were triggered by constituent structure alone, primes like this would lead to more dative responses, relative to a ditransitive prime. If semantic involvement were crucial, on the other hand, this prime should elicit more ditransitive responses. In this study we find significantly more ditransitive responses following the *provide-with* sentence than following a dative prime, and no difference between the *provide-with* and ditransitive primes, suggesting that semantic factors indeed play a role.

Introduction

Two current views of the mechanics of sentence comprehension posit very different roles for structural information in the comprehension of a sentence. On the one hand are accounts that place primary importance to syntactic considerations (for example, (Frazier, 1979; Frazier & Rayner, 1982; Rayner, Garrod, & Perfetti, 1992), claiming that initial parsing decisions are made on the basis of syntactic information and parsing heuristics alone. On the other hand, a growing body of evidence suggests that even initial hypotheses involve the interaction of multiple sources of information, whether structural, semantic, or pragmatic (Ford, Bresnan, & Kaplan, 1982; MacDonald, 1993; MacDonald, Pearlmutter, & Seidenberg, 1994; MacWhinney & Bates, 1989; St. John & McClelland, 1990; Tanenhaus & Carlson, 1989; Trueswell, Tanenhaus, & Garnsey, 1994).

Despite the data favoring the interactionist approach, there remains evidence that other information can be overridden by syntactic regularities. One set of data that offers strong evidence for the independence of syntactic information has come from the phenomenon of syntactic priming ((Bock, 1986; Bock & Loebell, 1990; Bock, Loebell, & Morey, 1992). Bock and associates have found that subjects show a reliable increase in the use of particular syntactic constructions after having heard and repeated that construction in an unrelated sentence. In these tests, subjects were given a series of spoken sentences interspersed with semantically unrelated simple line drawings, and asked to describe the pictures in a single sentence without using pronouns. For example, when shown a picture that could be described with either ditransitive (e.g. *John gave the dog a biscuit*, with two noun phrases following the verb) or prepositional dative sentences (*John gave a biscuit to the dog*, with one noun phrase followed by a prepositional phrase) subjects were significantly more likely to describe it with a ditransitive if it had been preceded by an unrelated ditransitive.

Aspects of the data suggest that the priming is due entirely to syntactic processes, and independent of semantics. One piece of evidence crucial to this interpretation is the finding that prepositional locatives like (1) below, which have the same syntactic form as prepositional datives, but somewhat different semantics/pragmatics, prime prepositional datives like (2) (Bock & Loebell 1990).

(1) *The widow drove an old Mercedes to the church.*
(*church* = locative)
(2) *The widow gave an old Mercedes to the church.*
(*church* = benefactive)

These results can be interpreted as showing that conceptual dissimilarity has no effect on structural priming.

Note, however, that the semantics of the two constructions are not all that dissimilar. Although in (1) the object of *to* is a locative, while in (2) it is a benefactive, there is considerable linguistic evidence showing that both these roles are subsumed under the larger category of *goal* (Jackendoff 1972; Lakoff and Johnson 1980; Goldberg 1995).There are cases such as *The widow sent a package to the church* , where the argument *church* falls some-

where intermediate between a pure locative and a pure benefactive. In addition there is a substantial evidence for a general metaphor, TRANSFER OF POSSESSION as PHYSICAL TRANSFER, that involves transfer of possession without physical transfer, and involves the prepositions *to, from* and *away.* (e.g. *She received the house from her mother's estate. / He gave the house away.*) Thus it is not entirely clear from these data whether the priming is due only to form-based factors, or to a combination of form and meaning.

There is good reason for thinking that semantic factors do play a role in syntactic priming. Bock et al. (1992) found that mapping an inanimate entity onto subject in a prime sentence predisposed mapping an inanimate entity onto the subject in the target. The priming was demonstrated even when the target was active but the prime was passive, indicating that semantic aspects of the priming did not require identical syntactic forms. In the current experiment we follow up on this idea, using different prime and target frames, and controlling for the animacy of the subject argument.

Experiment

In the experiment described below we replicate the Bock and Lobell (1990) ditransitive experiment, but include a third prime condition, the 'fulfilling' frame (Levin, 1993), exemplified in example (3):

(3)   *The officers provided the soldiers with guns.*

Sentences like that in (3) share aspects of both the ditransitive and prepositional dative: the syntax is that of the prepositional dative (NP V NP PP); but the order of semantic roles parallels the ditransitive (<agent, recipient, theme>).

Our hypothesis is that the semantic similarity between the 'provide-with' form and the ditransitive will lead to an increase in ditransitive responses after a 'provide-with' prime. Since the two differ in their syntactic form, the predicted effect would not be attributable to strictly syntactic processes, and would argue that semantic factors as well as form-based factors influence the priming effect.

Methods

Materials for the experiment included 10 pictures of events that could be equally well described with prepositional object constructions or ditransitive paraphrases (a man giving a present to a child, a butler serving a drink to his employer, a woman teaching math to a group of students, and so on) Each picture was matched with three prime sentences: (1) ditransitive, (2) dative (3) provide-with. Intransitive sentences were used as an additional condition in order to assess preferences for the two alternative forms after a minimally related sentence type.

Prime/target pairs were chosen to avoid any semantic relationship between the picture and the prime sentences. The experiment also included 20 each of repeated filler sentences and pictures, and 20 each of non-repeated filler sentences and pictures for a total of 120 filler items. Filler pictures depicted intransitive or simple transitive actions (such as a woman on a swing, or a boy drinking a glass of water). Filler sentences represented a variety of syntactic types. Four experimental lists were constructed. To avoid perseveration of priming effects from earlier sentences, which is known to be long-lasting, prime type was between subjects.

Each list contained 10 priming sentences followed immediately by the target picture from the same stimulus set. In addition to the test and filler items, each list was preceded by a set of 10 practice items, and a number of warm-up trials was inserted before the first trial of the experiment. On each list, test prime/target pairs were preceded by an average of 12 fillers.

Table 1: Example stimulus set

Prime type	Examples
ditransitive dative	His editor offered Bob the hot story. His editor promised the hot story to Bob.
provide-with	His editor credited Bob with the hot story.
intransitive	Sasha always dawdles over lunch.
Target Picture	*A man hands a woman a box of candy.*

Procedure. Subjects were tested individually, seated in front of a computer terminal in a sound-attenuated room. On each experimental trial the computer screen displayed either a picture or an empty frame. When the empty frame appeared, the experimenter read a sentence aloud. The cover story used in Bock and Lobell (1990) was adopted here: Subjects were instructed that their task was to remember whether the picture or the sentence was new or repeated in the course of the experiment; as a memory aid, they were to repeat verbatim each sentence that the experimenter read, or to describe each picture in a full sentence.

Picture descriptions were cued by the experimenter, who presented the subject with NP-V sentence fragment (The girl painted ...; The man gave...). The presentation of the subject NP did not affect the choice of the dative or ditransitive form, since both took the same subject. It did, however, constrain the interpretation of the picture toward one that could be described with the dative or ditransitive. This was important in the present context, since each of the events in the test pictures contained two human participants, and could well be described with a simple transitive (e.g. *The girl got a birthday present from her dad).*

Each session was recorded onto audio cassette and the responses of each subject to the target pictures were transcribed following the experimental session.

Subjects. 48 subjects participated in the experiment. These were right-handed undergraduates between the ages of 17 and 27 (21 male, 27 female). Subjects were recruited from the Psychology and Cognitive Science department subject pools, and received course credit for participating.

Data from one subject was lost due to experimenter error. Two others were dropped, one for being a non-native speaker of English, and one who failed to complete the task. This left of total of 45 subjects overall, with 11 in each prime condition and 12 on the intransitive list.

Results

Scoring procedure: Adopting the scoring procedure of Bock & Loebell (1990), there were 204 scorable responses among the 330 possible responses to the target pictures (62%). Of the scorable responses, 32% were in the ditransitive condition, 38% in the dative, and 30% in the provide condition.

Analysis: Again following Bock and Loebell (1990), the two dependent variables were the numbers of ditransitives and double-object responses given by each subject (in each cell). Single-factor ANOVAs were performed. In the overall analysis there was a main effect of prime type $(F_1(3,41)=3.131, p<.05; F_2(3,27)=8.991, p<.001)$.

Table 2 gives the mean percentage of ditransitive picture descriptions in each prime condition. Confidence intervals (.05) are shown in parenthesis. There were 32% more ditransitive responses after ditransitive primes than after dative primes (and conversely 32% more dative responses after dative primes than after ditransitive primes). In addition, were 28% more ditransitive responses after provide-with primes than after datives.

Table 2: Subject Means

prime:	% ditransitive responses	%difference from ditransitive prime
ditransitive	87	
dative	55	32 ± (14)
provide-with	83	4 ± (14)

Planned comparisons were run to test the experimental hypothesis. T-tests showed significantly fewer ditransitive responses and more dative responses after dative prime than after either ditransitive (p < .01 for both subjects & items) or *provide-with* primes (p < .05) but no difference in the percentage of ditransitive responses after ditransitive and *provide-with* primes (p > .1).

Finally, we tested whether there was a significant difference between ditransitive and prepostional object re-

sponses following an intransitive prime. In the items analysis the ditransitive mean was 56%, while the prepositional object was 44%. This difference is not significant (p > 1) confirming that Bock's finding of no independent preference for either clause type was also true of our items. Although in the subjects analysis the difference was larger, again it did not reach significance (p =.092). We will return to this point in the general discussion.

Discussion

The present experiment indicates that the mapping of semantic features to syntactic positions in a prime sentence has an effect on the production of a target sentence. This finding is especially striking in light of the fact that a purely syntactic account of such priming would have expected target sentences to be produced with a matching syntactic form.

Other explanations for these effects are possible, of course. In earlier work looking at the active/passive alternation, Bock has shown independent effects of both animacy (a semantic factor) and structure on syntactic priming. Given the facts of the ditransitive alternation it is hard to tease apart the effects of animacy order from those of the mapping of conceptual features like thematic roles to syntactic positions – other than in exceptional cases, the object one of a ditransitive must be animate, as is the direct object of the provide-with construction. Given this, it is reasonable to ask if animacy order is what leads to the effects we find here.

In the current experiment there are three prime conditions: One in which both animacy and structure are consistent with the ditransitive, one in which both are consistent with the prepositional dative, and a third which pits the two against each other: animacy is consistent with the ditransitive while structure is consistent with prepositional dative. If indeed these should show independent, additive effects, then the third condition should be influenced by both, resulting in behavior somewhere between the other two prime conditions. However, this is not the case. Instead, the third condition patterns closely with the ditransitive, and is significantly different from the prepositional dative.

Given these results, one would have to conclude either that the earlier animacy account is incorrect, or, more plausibly, that what is operative here is a different factor, the order of expression of coarse semantic roles.

It should be noted that in the present experiment the responses in the prepositional dative condition are significantly different from those in the ditransitive, but the datives do not 'prime' dative picture descriptions in the sense that a strong majority of responses after this prime are dative. In fact, only 55% of the responses are. While this does not affect the results, it is an interesting point and worth investigation. One explanation consistent with

the current data is that the ditransitive may serve as the default construction for many speakers, from which they are primed away in the prepositional dative condition. If this were true, a purely structural account would predict that subjects should equally be primed by the structure of provide-with condition. However, this was not the case. Even on this account, then, semantics must still be involved: The structural prime only has an effect only when it combines both the syntax and the semantics of the prepositional dative.

The coarse mapping of conceptual features to syntactic positions demonstrated to affect priming in this experiment can account for much of the existing data on "syntactic" priming, including the ability of locative 'to' constructions to prime dative 'to' discussed above: in both cases the theme appears as object and the goal appears in a prepositional phrase marked by *to*. The finding that benefactives (*Pat baked a cake for Chris*) prime datives (*Pat served a cake to Chris*) (Bock 1986), can be accounted for similarly, since in both cases the theme argument appears as direct object. The distinction between benefactives and goals/recipients is apparently not strong enough to prevent the priming.

More work is required to fully account for the priming of passives by intransitive locatives such as *The priest was standing by the stained glass window* (Bock & Loebell 1990). As this example illustrates, the Bock and Loebell study used locative sentences that contained the same *be* auxiliary and preposition *by* that appear in passives. Experiments are being designed to determine whether expressions that have the same syntactic form but different morphemes, such as *The priest might stand near the stained glass window*, actually prime passives as predicted by a purely syntactic account. It may be that some conceptual or morphological overlap is required for structural priming. (See also Dell et al. (in press) for a model of this locative data that in the spirit of the present analysis.).

Thus it seems that "syntactic priming" may be fundamentally influenced by elements of conceptual features or semantic roles. This suggests that rather than being purely syntactic, the phenomenon might be at the level of the mapping between semantics and syntax.

Acknowledgments

References

Bock, K. (1986). Syntactic persistence in language production. *Cognitive Psychology, 18*, 355-387.

Goldberg, Adele E. 1995. *Constructions: A Construction Grammar Approach to Argument Structure*. Chicago: U of Chicago Press.

Bock, K., & Loebell, H. (1990). Framing sentences. *Cognition, 35*(1), 1-39.

Bock, K., Loebell, H., & Morey, R. (1992). From conceptual roles to structural relations: Bridging the syntactic cleft. *Psychological Review, 99*(1), 150-171.

Ford, M., Bresnan, J., & Kaplan, R.M. (1982). A competence-based theory of syntactic closure. In J. Bresnan (Ed.), *The mental representation of grammatical relations* (pp. 727-796). Cambridge, MA: MIT Press.

Frazier, L. (1979). *On comprehending sentences: Syntactic parsing strategies*. Bloomington, Indiana: Indiana University Linguistics Club.

Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology, 14*, 178-210.

Goldberg, Adele E. 1995. *Constructions: A Construction Grammar Approach to Argument Structure*. Chicago: U of Chicago Press.

Jackendoff, Ray. 1972. *Semantic Interpretation in Generative Grammar*. Cambridge, MAss: MIT Press.

Lakoff, George and Mark Johnson. 1980. *Metaphors We Live By*. Chicago: U of Chicago Press.

Levin, B. (1993). *English verb classes and alternations: A preliminary investigation*. Chicago: University of Chicago Press.

MacDonald, M.C. (1993). The interaction of lexical and syntactic ambiguity. *Journal of Memory and Language, 32*, 692-715.

MacDonald, M.C., Pearlmutter, N.J., & Seidenberg, M.S. (1994). Lexical Nature of Syntactic Ambiguity Resolution. *Psychological Review, 101*(4), 676-703.

MacWhinney, B., & Bates, E. (1989). *The crosslinguistic study of sentence processing*. Cambridge, England: Cambridge University Press.

Rayner, K., Garrod, S., & Perfetti, C.A. (1992). Discourse influences during parsing are delayed. *Cognition, 45*, 109-139.

St. John, M., & McClelland, J.L. (1990). Learning and applying contextual constraints in sentence comprehension. *Artificial Intelligence, 46*, 217-257.

Tanenhaus, M., & Carlson, G. (1989). Lexical structure and language comprehension. In W.D. Marslen-Wilson (Ed.), *Lexical representation and process* (pp. 505-528). Cambridge, MA: MIT Press.

Trueswell, J., Tanenhaus, M., & Garnsey, S. (1994). Semantic influences on parsing: Use of thematic role information in syntactic disambiguation. *Journal of Memory and Language, 33*, 285-318.