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INTRODUCING COGNITIVE GRAMMAR[1]

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It has been taken for granted in transformational linguistics that transformational grammars are abstract objects which are represented somehow in the mind, but which are utilized only in an extremely indirect way in actually producing and understanding sentences. However, psycholinguistic studies in the past decade have shown transformational grammars to be so remote from actual production and recognition as to be just about indiscernible. Fodor, Bever, and Garrett, in _The Psychology of Language_, which is as orthodox a transformationalist treatment of the subject as one can find, put the case as follows:

> We have proposed a model which does not posit a very intimate relation between the form in which grammars represent linguistic structure and the form in which sentence recognizers do. In particular, we have seen that both the theoretical and experimental arguments for a perceptual model in which the grammar is concretely recognized appear dubious.
>
> -- page 368

Given that Fodor, Bever and Garrett take "grammars" to be "transformational grammars" of the standard type, we would not dispute their conclusions. However, if one gives up on transformational grammars and instead assumes a version of relational correspondence grammars as outlined below, we believe that there is a direct and intimate relation between grammars and mechanisms for production and recognition. In fact, we suggest that _grammars are just collections of strategies for understanding and producing sentences_. From this point of view, abstract grammars do not have any separate mental reality; they are just convenient fictions for representing certain processing strategies. Likewise, abstract transformational derivations are just convenient fictions for representing aspects of linguistic structure. From our perspective, linguistic structure is fully determined by the cognitive representation of meaning, the form of the linguistic signal, and the processing mechanisms that relate the two. The remainder of this paper is an attempt to show how such a conception of grammar might be actualized in a primitive and highly tentative (but we hope suggestive) way.

Incidentally, the idea that grammars are just collections of processing strategies is by no means novel. It is implicit (so far as we can tell) in Hilary Putnam's convincing rebuttal to Chomsky's argument for the innateness of purely linguistic structure. The proposal is made more or less explicitly in two papers by William Watt. In the case of recognition, various proposals of this sort are formalized in works in the field of artificial intelligence, especially in recent work by William Woods, Ron Kaplan, Martin Kay, and others. Our ideas were directly inspired by the Woods-Kaplan work on Augmented Transition Network Grammars (ATN's). Bever, Langendoen, and Kimball have also investigated processing strategies. Our dissatisfaction with their basic theoretical assumptions (although not the problems they address) will be evident throughout this work.

There is a single characteristic shared by all the diverse approaches mentioned above which both unifies them and distinguishes them from the traditional approach; the concept of incremental processing. Rather than operating on whole structures, transforming one into another, these approaches all construct structures a piece at a time, modifying and expanding them as more and more of the signal is considered. It is this procedure we would like to use as the defining characteristic of left-to-right grammar, or, less chauvinistically, cognitive grammar. Thus a cognitive grammar is one which attempts to characterize and explain grammatical phenomena in an incremental, signal-driven fashion.

We can distinguish two main types of cognitive grammars; perception grammars, where the signal is the spoken or written sentence and the incrementally constructed structure is the semantic content, and production grammars, where the signal is the progressively more detailed intended semantic content and the incrementally constructed structure is the surface utterance. It is our contention, which we hope to motivate in the balance of this paper, that it is possible to construct perception and production grammars for English which are related to each other in a principled way, and which are furthermore directly related to a grammar which looks very much like an abstract well-formedness grammar based on a relational model *à la* Keenan, Comrie, Postal, Perlmutter, and Johnson.

By way of a concrete introduction to the concepts discussed above, we will present a small part of a perception grammar for English and exemplify the use of that grammar by analyzing the sentence

(1) The aardvark was given a bagel by Irving.

The notion "current semantic hypothesis" is basic to this conception of recognition grammar. It derives from a similar approach used by William Woods and others in natural language recognition grammars for use on computers. Essentially what rules of grammar do is make hypotheses about the grammatical relations borne by elements in the surface utterance as they are processed. These hypotheses may later be changed under the influence of information derived from subsequent processing of further elements. Thus we would say that in processing sentence (1) above, we first hypothesize that the noun phrase the aardvark is the underlying subject. After encountering a verb in participle form with the auxiliary be, however, we change that hypothesis and consider it to be the direct object. Finally, on encountering another noun phrase, a bagel, we reconsider once more and decide that the aardvark is really the indirect object, and that a bagel is the direct object.

Hopefully even this rough description demonstrates the possibility of a relationship between this sort of processing grammar and relational grammar rules; we have first said 'subject goes to object', then 'object goes to indirect object', which are inverse analogues of the relational grammar rules of passive and dative respectively.

A formal statement of these and the other rules of our mini-recognition grammar can be found in the left-hand column of Table I. We will dicuss the other columns later. Let us emphasize right away that this is a primitive grammar; it is not meant to be complete either in scope or detail. It is intended only to demonstrate certain salient characteristics of a cognitive grammar, and thus many areas which would require extensive and detailed treatment in any adequate grammar are here glossed over or completely ignored. Specifically, the analysis of parts of the surface utterance as noun phrases is assumed, although such analysis requires a complex set of rules of its own. No attempt is made here to deal with problems of subordination of any kind. Nor are any semantic or pragmatic restrictions included. The prolific use of relations of a distinctively "Aspects" flavor (e.g., Aux and Type) is not intended as a commitment to a particular brand of linguistic theory, but rather derives from a desire to avoid areas of inquiry not central to the issue we are concerned with in this paper. In fact, it is only rules 9-11 which are central to our discussion; the others are required to give a complete grammar and are not our main concern.

The general form of the rules of the grammar is given in Figure 1. The semantic hypotheses are represented in relational terms. V designates the predicate of a sentence, A the auxiliary, T the type (i.e.,

	Background Relational conditions	
Conditions on current relational hypotheses		New relational hypotheses
Conditions on current analysis of surface string, where * indicates current element		

Figure 1 GENERAL FORM OF A RECOGNITION RULE

Question or Declarative), and the other capital letters the various relations borne by various terms to the predicate. Arabic numerals are variables over elements in the utterance. "*" always refers to the element of the utterance currently being processed. Ø is used to represent non-occurrence of any kind. The conditions symbolized in the lower left-hand quadrant should be interpreted as follows:

NP(x)	'x is a noun phrase'
M of (x) = y	'y is a marker of the role the NP(x) plays in the sentence'
FIRST(x)	'x is the first NP to be processed'
Verb(x)	'x is in the lexical category Verb' (same for PastPart(x) and Aux(x))

Figure 2 WHAT THE SYMBOLS MEAN

Thus Rule R3 can be read as saying that, provided the current element is a noun phrase whose (prepositional) marker is to and that some element is currently hypothesized to be the object, hypothesize that the current element is the indirect object.

The first six rules in the grammar represent a first approximation to the language-specific ordering rules, whose existence is postulated in relational grammar but which have not been investigated yet in any detail. They hypothesize the grammatical relations borne by elements based essentially on position in the sentence.[2] These rules alone will successfully recognize simple declarative sentences. The addition of rules R7 and R8 permit a discrimination between Yes-No questions and declaratives on the basis of the order of appearance of the auxiliary (if any) and the subject. Rule R7 states that if the current element has been hypothesized as the subject, and no element is currently hypothesized as the auxiliary, then the sentence is of type declarative. Rules R9, R10, and R11 introduce more complexity into the grammar, by recognizing passive sentences with or without overt agents and dative sentences.

At this point we would like to discuss briefly the notion of a derivation in this kind of recognition grammar. Essentially we view our rules as well-formedness conditions for a sequence of structures, each consisting of a set of semantic hypotheses and some contiguous portion of the utterance beginning at the beginning. Thus rule R5 says that the pair of structures given in Figure 3a is a well-formed pair, given an appropriate lexicon. "*" is always considered to refer to the last element of that portion of the utterance found in a given structure, and there is a global well-formedness condition on derivations which says that the portion of the utterance contained in each structure must be non-decreasing from structure to structure; that is, "*" must either stay in place or move to the right through the utterance.

Figure 3b gives a shorthand form of the derivation of sentence (1) using the grammar we have been discussing. A derivation is successful provided it ends with a structure whose * is #, the end of the sentence, and furthermore, a predicate has been found and sufficient relations hypothesized to satisfy the set of arguments required by that predicate.

$$\frac{\text{S(1),}\quad \text{T(DCL),}\quad \text{A(2)}}{\text{[the aardvark] = 1, NP(1), [was] = 2, AUX(2)}} \quad \xRightarrow{\text{R5}}$$

$$\frac{\text{O(1), T(DCL), A(2), V(3), S}(\Delta)}{\begin{array}{ccc}\text{[the aardvark] = 1,} & \text{[was] = 2,} & \text{[given] = 3} \\ \text{NP(1),} & \text{AUX(2),} & \text{PastPart(3)}\end{array}}$$

Figure 3a A PAIR OF SUCCESSIVE ANALYSES IN A DERIVATION

	S(1)	T(DCL)	A(2)	V(3)
[the aardvark] = 1 NP(1) M of (1) = Ø		[was] = 2 AUX(2)	[given] = 3 Verb(3) PastPart(3)	

R1 * = 1 R7 * = 1 R5 * = 2 R6 * = 3

O(1),S(Δ)	CH(4)	O(4),IO(1)	CH(5)	S(5)
[a bagel] = 4 NP(4) M of (4) = Ø		[by Irving] = 5 NP(5) M of (5) = <u>by</u>		#

R9 * = 3 R4 * = 4 R10 * = 4 R4 * = 5 R11 * = 5 * = #

Figure 3b SHORTHAND VERSION OF A SAMPLE DERIVATION

Though these are recognition rules, strictly speaking, their content matches the content of certain rules that have been proposed as rules of abstract grammar. For instance, as we noted above R10 is clearly closely related to the dative rule as proposed in relational grammar. Our principal claim is that <u>all</u> of the recognition rules we have discussed (and any recognition rules of this general form) can be related directly and in a principled way to rules of an abstract grammar. The kind of abstract grammar we have in mind is correspondence grammar, as described by G. Lakoff (1970 and 1973), with the addition of the apparatus of relational grammar. Examples of such rules are given in column 2 of Table I. The general form of such rules is given in Figure 4. In an abstract relational grammar, these rules each characterize a well-formed pair of successive stages in a derivation. Each stage is a labelled dependency diagram of the sort characterized by relational grammars. Condition I of a correspondence rule (see Figure 4) corresponds to the input condition of a transformation; condition II corresponds to a condition on the output of a transformation. For example, rule A10 is our version of the relational grammar dative rule. It says that a possible pair in a well-formed derivation may have as its first member a

AE	'Affected Element'	The most significant thing which is different between the first and second members of the pair.
SS	'Surface Signal'	The element whose appearance in the utterance signals that this rule has applied.

COND Conditions on both members of the pair which are necessary for the application of this rule; these conditions are unaffected by the rule.

I Conditions on the first member of the pair.

II Conditions on the second member of the pair;

a = relational conditions
b = surfacy conditions

In addition to the notations explained in Figure 2, P(x,y) is a precedence relation which partially orders the dependency diagrams. It may be read as 'x precedes y'.

Figure 4 GENERAL FORM OF A CORRESPONDENCE RULE

dependency diagram containing a direct object and an indirect object, and as its second member a dependency diagram in which the term which is the direct object in the first member is a chômeur not marked by a preposition and the term which is the indirect object in the first member is the direct object. The affected element is that which remains a term, the indirect object. But the surface signal is the occurrence of the second unmarked NP after the verb. For example, compare (2) and (3).

(2) John gave the dog a bone.
(3) John gave the dog to Susan.

The occurrence of "a bone" in (2) -- the second unmarked NP after the verb -- perceptually signals the occurrence of the dative rule.

Similarly, in A9 (our version of passive) the affected element is the direct object in condition I and the subject in condition II. But what signals the application of passive is the verb in its past participial form. Thus, given the substring of (1) "The aardvark was", there is no signal of passivization; the signal first appears in the substring "The aardvark was given". Incidentally, this is the first time, to our knowledge, that the notion of "surface signal" has been suggested in the theory of generative grammar. We think it is an important notion, worthy of considerable attention, especially in the area of universal grammar.

We should note, incidentally, that we were forced to split passivization into two parts, rules 9 and 11. It seems to us somewhat ironic that this formulation, though given in relational grammar terms, seems to share much with Chomsky's third-generation formulation of passive (which is why we have used the symbol Δ in his honor). The reason we were forced to do this is that in a recognition grammar which is strictly left-to-right, you can't process something you haven't gotten to yet; in this case, the by-phrase. Another way of interpreting the use of Δ is as an expression of a constraint imposed by the Keenan-Comrie hierarchy. That is, Δ marks an unfilled relation which must be filled. Our formulation of passive is thus different in this respect from that of Perlmutter and Postal. In their passive rule, the direct object ousts the subject, which is retired to chômeurhood by a general principle. In our rule, the subject abdicates and the direct object is promoted to subjecthood by a general principle. It is clear that our dative rule could be cast in a similar form, as could any relation-changing rule. From the point of view of abstract grammar, there seems to us to be no difference between these two approaches. However, the fact that processing considerations forced us to this formulation of passive suggests to us that our approach of abdication and subsequent promotion may be the best way of stating relation-changing rules in general.

Rules A1 - A8 impose ordering relations on the surface forms. If we compare these abstract rules with their corresponding recognition rules, an interesting difference emerges. First consider R2, the object recognition rule. The expression 'V(1)' in R2 indicates the presence of a predicate by the point in the derivation where the rule applies. In other words, the predicate must be processed before the direct object NP, which is represented by * in R2. Since there is no implicit correlate of processing in the abstract grammar, an overt indication of processing order must be provided. Traditional transformational grammar provides an ordered base and transformations which utilize and modify that order. We think this is too strong. We propose instead the P-relation, which is introduced by rules. Thus, in A2, we introduce the P-relation between the predicate and the direct object to reflect what is in R2 a consequence of left-to-right processing. Moreover, we are limiting the use of the P-relation by permitting the surface signal only to be the second argument of the relation. This reduces the two-place P-relation to a one-place relation, which is equivalent to the notion "processed".

Now consider rule R7, which states that if you have processed a subject, but have not processed an auxiliary, then the sentence is declarative. The notation 'A(Ø)' in R7 indicates that there is no auxiliary present at the time the subject is being processed. This is translated into abstract grammar as condition IIa in rule A7: $A(1) \supset -P(1,2)$. This says that if there is an auxiliary in the (declarative) sentence, it doesn't precede the subject.

The general form of the correspondence between the rules of the recognition grammar and the rules of the abstract grammar is given in Figure 5.

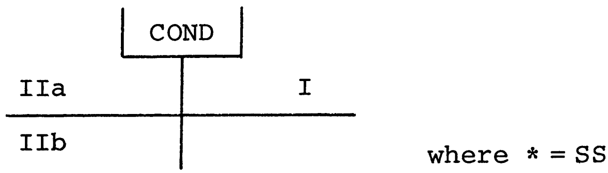


Figure 5   RELATION BETWEEN A RECOGNITION RULE AND A CORRESPONDENCE RULE

In accordance with the discussion above, the appearance of 'R(n)' -- where R is any relation and n is any number -- in the part of a recognition rule reserved for conditions on current or background relational hypotheses corresponds to a 'P(n,SS)' in condition IIa of the corresponding abstract rule. When 'R(Ø)' appears there, a corresponding '$R(n) \supset -P(n,SS)$' appears in condition IIa.

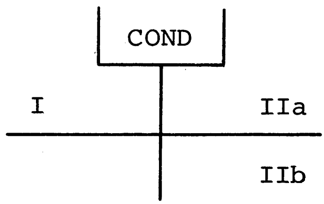
To exemplify the use of the abstract rules, we have provided an abstract derivation of sentence (1) in Table 2 at the end of the paper. This is to our knowledge the first formal derivation in relational grammar terms to appear, and should be perused bearing its novelty in mind.

Though we know nothing whatever about production, for the sake of completeness we submit for the reader's consideration a set of production rules. Figure 6 gives the general form of such production rules, a sampling of which are found in column 3 of Table 1.

Conditions on relations persistent from semantic structure or on present relational commitments derived therefrom	New derived relational commitments
	Future constraints on surface elements

Figure 6   GENERAL FORM OF A PRODUCTION RULE

Such rules might be interpreted as expressing the method by which that portion of the utterance produced up to a given point, together with the speaker's intentions at that point, constrain the balance of the utterance. Figure 7 gives the correspondence between these rules and rules of the abstract grammar. The P-relation translates in a way similar to that given for the recognition rules.



where * = AE

Figure 7 RELATION BETWEEN A PRODUCTION RULE AND A CORRESPONDENCE RULE

This should be shown clearly in the examples provided. The question of production is so wide open at this point that our proposal can only be seen as an extremely tentative working hypothesis.

What we have done so far is to define very primitive versions of recognition and production grammars and to re-define abstract grammars of a relatively primitive sort in such a way that each rule of an abstract grammar uniquely characterizes a recognition rule and a production rule, and conversely. From this perspective, an abstract rule of grammar is simply another way of organizing the content of a recognition rule and/or a production rule. In this scheme of things, what mental reality do abstract grammars have? Only the mental reality of the corresponding recognition and production rules. They have no independent mental reality at all. Abstract grammars in such a theory are merely convenient fictions. Correspondingly, the derivations characterized by abstract grammars are also convenient fictions and are claimed in our theory to have no mental reality. Only the sets of computations characterized by the corresponding processing grammars are claimed to be psychologically real.

Perhaps at this point we ought to make clear some things that we are *not* claiming. We are not claiming that *all* perceptual strategies for natural language correspond to production strategies and/or abstract rules of grammar. For example, Bever and Kaplan have proposed strategies to account for why it is easier to process the following (b) sentences than the corresponding (a) sentences.

(4) a. The boat floated down the river sank.
b. The boat taken down the river sank.

(5) a. I told the man that my mother knew in 1968 the story.
b. I told the man that my mother knew the story in 1968.

Both of the (a) cases are garden-path sentences that require re-processing. Bever has suggested that "floated down the river" in (4a) is first processed as the main clause predicate, and then re-analyzed as a reduced relative clause. Kaplan has suggested that the that-clause in (5a) is first processed as a complement, and then re-analyzed as a relative clause. Both claims are subsumable under the recognition principle:

(6) Process so as to minimize islandhood.

As Ross has shown, main clauses are less islandy than complements, which are less islandy than relatives. We have as yet no way of stating (6) in terms of recognition rules. Indeed, it seems to be a principle governing the application of recognition rules, rather than a rule itself, just as Ross' island constraints govern the application of transformations. We have as yet no reason to believe that (6) corresponds to any principle of abstract grammar and/or production. The theory we have outlined thus far takes no stand on the issue.

The primitive theory that we outlined above requires strict left-to-right processing and makes no mention at all of memory. We view these as shortcomings of the theory which we hope to overcome in future versions. Overall sentence processing has basically a "left-to-right" character, since information is processed as it is received. But that does not mean that sentence processing takes place one word at a time, as the words are received. Phonetic information is received continuously, and studies indicate that it is stored and processed in chunks, and that morphological, syntactic, semantic, and pragmatic information may all be used just in figuring out what the words are. This indicates that principles at all linguistic levels are accessed simultaneously to "see what fits". It is for this reason that we have set up our grammars as well-formedness grammars. As such, they do not commit us to strict left-to-right processing. They are consistent, as they are now formulated, with the position that incoming information is processed in chunks (even overlapping chunks). To provide for such processing, the concept of a "recognition derivation" would have to changed, but the rules we have so far postulated could be left intact. What we envision is a theory in which the overall, but not strict, left-to-right orientation of processing is imposed by the continuous reception of phonetic information, chunk storage and processing, and the shift from short-term to longer-term memory. We have nothing whatever to say about any of these matters. All we have done with respect to recognition is to formulate some more-or-less plausible-looking recognition rules that generate and change hypotheses about what is being said and to show their relation to the study of abstract grammar.

We have also said nothing thus far about simultaneous or parallel processing, or about semantic and pragmatic conditions on the application of grammatical rules. We view these as factors to be included in future versions of the theory. Sentence (1) is a case where such additions seem to be needed. One might plausibly argue that, on perceiving the substring "The aardvark was given..", one would be likely to guess, for semantic reasons, that "The aardvark" would ultimately turn out to be the indirect object rather than the direct object, simply because animate objects are more likely to be indirect than direct objects of "give". The probability would be even higher for a substring such as "Susan was given...", since humans are unlikely to be given to anybody. Such observations are not necessarily in conflict with our claims, though they might appear to be, since they might be taken as a challenge to the claim that "The aardvark" in (1) is ever given an intermediate analysis as a direct object.

The apparent conflict arises from a confusion between two sorts of hypotheses: semantically and pragmatically conditioned hypotheses about the ultimate role of a noun phrase in semantic structure, on the one hand; and syntactically motivated tentative hypotheses for use in figuring out grammatical structure, on the other. So far we have talked only about hypotheses of the second sort. But any hypothesis that "Susan" will ultimately turn out to be an indirect object is clearly of the first sort. Our ultimate intention is to include hypotheses of the first sort in cognitive grammars, and to extend the notion of a derivation to permit such hypotheses to be made simultaneously or in parallel with grammatical hypotheses. It will still be necessary in such cases, however, to use the syntactic derivational process discussed above to validate such pragmatic hypotheses, or invalidate them as would be the case in sentences such as "Susan was given in marriage to Seymour".

Perhaps the most important aspect of what we are claiming is that the idea of linguistic generalization that is implicit in studies of abstract grammar is basically right. The idea is that (i) the same rules needed to handle relatively simple sentences will handle complex sentences due to their recursive application; and (ii) if you have the "right" rules -- the mentally real rules -- then you shouldn't have to state the same rule twice in a grammar. This is in conflict with certain processing approaches to linguistic analysis. The typical reasoning behind such approaches goes like this: One thing people have lots of is long-term memory. But short-term memory and processing capacity is at a premium. If mentally real grammars are collections of processing strategies, these strategies should be such as to minimize the use of short-term memory and processing capacity. And if that takes more long-term memory, that's fine. There's lots of it. Therefore, we should not worry about "capturing generalizations". If you need to "say the same thing twice" -- or even three times or thirty-seven times in order to state processing rules that will minimize the use of short-term memory and processing capacity, then that's fine. All other things being equal, non-general rules that minimize short-term memory and processing capacity are psychologically real, while general rules that fail to minimize short-term memory and processing capacity are not psychologically real.

We are not prepared to accept such a position. To our knowledge, there is no solid evidence whatever that there is a necessary conflict between linguistic generalizations and the minimization of short-term memory and processing capacity. We believe that the assumption that such a conflict existed came out of the widespread belief that transformational grammar provided the right framework in which to state linguistic generalizations. We agree that there is a conflict between transformational grammar and any processing theory with reasonable claims to psychological reality. Our solution is to abandon transformational grammar and instead adopt some version of cognitive grammar as the appropriate framework for the statement of general linguistic principles.

It should be clear from the above discussion that we reject summarily the putative distinction between "acceptability" and "grammaticality", as proposed by Chomsky and more recently defended by Bever, Fodor, Langendoen, Kimball, and others. The study of cognitive grammar is part of the study of cognitive capacity as a whole. This includes at least the representation of knowledge, memory, processing strategies and mechanisms, reasoning, principles of social interaction, and whatever other abilities or knowledge enable one to use language. It is important to recognize the distinction between a grammar, which is a collection of rules for use in processing, and perception and production mechanisms, which employ a grammar to do processing. Grammars are language-specific (though all grammars may share certain universal principles), whereas the perception and production mechanisms which make use of these grammars are common to all normal human beings.

Finally, cognitive grammar should be viewed as another extension of the proper domain of linguistic inquiry. The force of the generative semantics movement was to integrate semantic, and later pragmatic, considerations into the study of syntax. In that spirit, we view this paper as the beginning of the integration of processing considerations into the generative semantics paradigm.

Footnotes

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(2) We have adopted the view that there is a general principle which prevents such rules from operating if the relation in question is already filled, rather than including such a restriction in each rule; e.g., we do not need to add "and no element has previously been analyzed as V" to R6.

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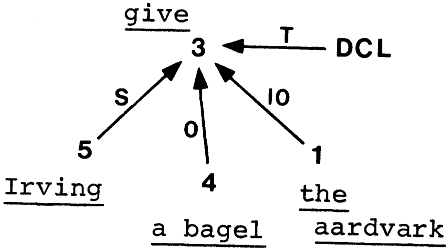
TABLE 1

RECOGNITION GRAMMAR	ABSTRACT GRAMMAR	PRODUCTION GRAMMAR
R1: S(*) NP(*) M of * = Ø FIRST(*)	A1: Subject AE: 1 SS: 1 COND: I: S(1) II:a. b. NP(1) M of 1 = Ø FIRST(1)	P1: S(*) NP(*) M of * = Ø FIRST(*)
R2: CH(Ø) V(1) O(*) NP(*) M of * = Ø	A2: Object AE: 2 SS: 2 COND: V(1) I: O(2) II:a. b. NP(2) M of 2 = Ø P(1,2) CH(3) ⊃ -P(3,2)	P2: CH(Ø) V(1) O(*) NP(*) M of * = Ø
R3: O(1) IO(*) NP(*) M of * = to	A3: Indirect Object AE: 2 SS: 2 COND: O(1) I: IO(2) II:a. b. NP(2) M of 2 = to P(1,2)	P3: O(1) IO(*) NP(*) M of * = to
R4a: V(1) M(*) = Ø CH(Ø) CH(*) NP(*)	A4a: Unmarked Chômeur AE: 3 SS: 3 COND: V(1) M(3) = Ø I: CH(3) II:a. b. P(1,3) CH(2) ⊃ -P(2,3) NP(3)	P4a: V(1) M(*) = Ø CH(Ø) CH(*) NP(*)

RECOGNITION GRAMMAR	ABSTRACT GRAMMAR	PRODUCTION GRAMMAR
R4b: V(1) M(*) ≠ Ø CH(*) NP(*)	A4b: Marked Chômeur AE: 2 SS: 2 COND: V(1) M(2) ≠ Ø I: CH(2) II:a. b. P(1,2) NP(2)	P4b: V(1) M(*) ≠ Ø CH(*) NP(*)
R5: V(Ø) A(*) Aux(*)	A5: Auxiliary AE: 2 SS: 2 COND: I: A(2) II:a. b. Aux(2) V(1) ⊃ -P(1,2)	P5: V(Ø) A(*) Aux(*)
R6: S(1) V(*) Verb(*)	A6: Predicate AE: 2 SS: 2 COND: S(1) I: V(2) II: a. b. Verb(2) P(1,2)	P6: S(1) V(*) Verb(*)
R7: A(Ø) S(*) T(Dcl)	A7: Declarative S AE: 2 SS: 2 COND: S(2) I: T(Dcl) II:a. b. A(1) ⊃ -P(1,2)	P7: A(Ø) S(*) T(Dcl)

RECOGNITION GRAMMAR	ABSTRACT GRAMMAR	PRODUCTION GRAMMAR
R8: S($\varnothing$) A(*) T(Q)	A8: Subject-Verb Inversion AE: 2 SS: 2 COND: A(2) I: T(Q) II:a. b. S(1) $\supset$ -P(1,2)	P8: S($\varnothing$) A(*) T(Q)
R9: A(2) V(*) S(1) | S(Δ) O(1) PastPart(*) be(2)	A9: Passive AE: 1 SS: 3 COND: A(2) V(3) I: S(Δ) O(1) II:a. S(1) b. PastPart(3) be(2)	P9: A(2) V(3) S(Δ) O(*) | S(*) PastPart(3) be(2)
R10: O(1) CH(*) | O(*) IO(1) M of * = $\varnothing$	A10: Dative AE: 1 SS: 2 I: IO(1) O(2) II:a. O(1) CH(2) b. M of 2 = $\varnothing$	P10: O(2) IO(*) | O(*) CH(2) M of 2 = $\varnothing$
R11: S(Δ) CH(*) | S(*) M of * = by	A11: Δ Introduction AE: 1 SS: 1 I: S(1) II:a. S(Δ) CH(1) b. M of 1 = by	P11: S(*) | S(Δ) CH(*) M of * = by

TABLE 2



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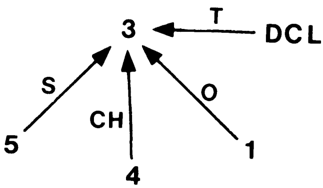

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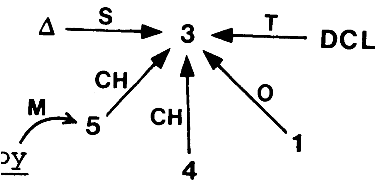

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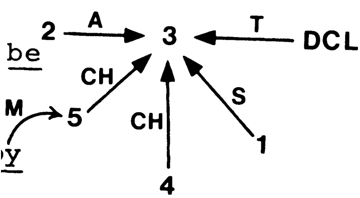

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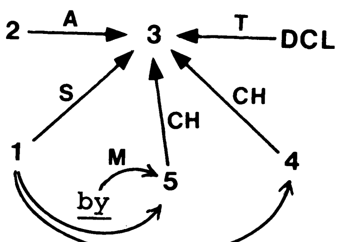

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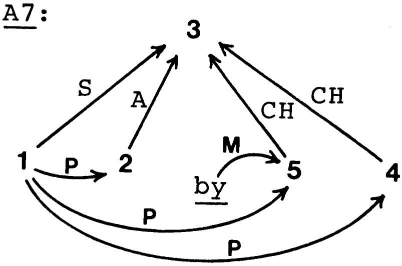

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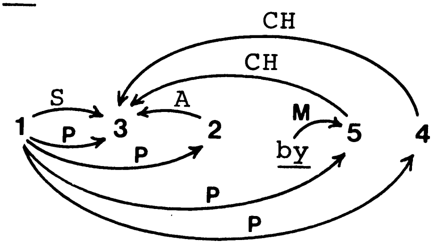

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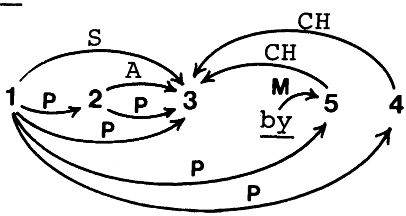
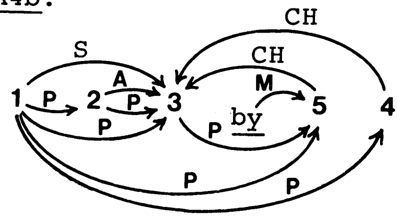


A4b:



A4a: