REMARKS ON PROCESSING, CONSTRAINTS, AND THE LEXICON*

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Linguists have long recognized the desirability of embedding a theory of grammar within a theory of linguistic performance (see, e.g., Chomsky (1965:10-15)). It has been widely assumed by transformationalists that a unique model of a language user would include as one component some sort of generative grammar. Yet transformational grammarians have devoted relatively little energy to the problem that Bresnan (in press) calls "the grammatical realization problem": "How would a reasonable model of language use incorporate a transformational grammar?" When this question has been raised, little support could be adduced for the hypothesis that the operations of transformational grammar play a part in speakers' or hearers' processing of sentences (see Fodor, et al (1974; chapter 5)). Instead of concerning themselves with questions of processing, transformationalists have concentrated their efforts (at least in the last decade or so) on the problem of constraining the power of their theory. The goal of much recent research has been to construct as restrictive a theory of grammar as possible, within the bounds set by the known diversity of human languages (see, e.g., Ross (1967), Chomsky (1973), Bresnan (1976), Emonds (1976), and Culicover and Wester (1977) for examples of this type of research).

Computational linguists, on the other hand, have not explicitly concerned themselves very much with the problem of constraints (but see Woods (1973; 124-5) for an exception). Rather, their goal has been to find effective procedures for the parsing and processing of natural language. While this is implicitly a restriction to recursive languages, the computational literature has dealt more with questions of processing than with how to limit the class of available grammars or languages.

In previous papers (Osherson and Wasow (1976), Wasow (in press a, 1978)) I have argued for the legitimacy of the quest for constraints as a research strategy. I have argued that a theory that places limits on the class of possible languages makes significant empirical claims about human mental capacities, and can contribute to a solution to "the fundamental empirical problem of linguistics" (as Chomsky has called it) of how children are able to learn languages with such facility. I have tried to show that such psychological claims can be made, without making any assumptions about what role grammars play in performance. In short, I have argued that a theory of grammar can make significant contributions to psychology, independent of the answer to the grammatical realization problem.

Recent work by Joan Bresnan (in press) takes a very different position: she has suggested that transformationalists ought to pay more attention to the grammatical realization problem, and that considerations of processing suggest radical modulations in the theory of transformational grammar. Further, she argues that there is ample grammatical evidence for these modifications. In this paper I will suggest some extensions of her proposals, and will explore some of their empirical consequences. Further, I will argue that her framework makes it possible to impose rather restrictive constraints on grammatical theory. Thus, I will argue that the grammatical realization problem and the problem of constraining transformational theory, while logically independent, are both addressed by Bresnan's proposals. If I am correct in this, then Bresnan's "realistic transformational grammar" represents a major convergence of the concerns of transformational and computational linguists.

My presentation will consist of three parts. First, I will briefly sketch Bresnan's framework. Second, I will suggest some extensions of her proposals and point out some consequences of these extensions. Third, I will propose how her framework can be constrained, and indicate certain desirable consequences of my proposals.

The primary innovation of Bresnan's framework is that it eliminates a large class of transformations in favor of an enriched conception of the lexicon. The grammar that results is one that Bresnan claims is "far more realistic from a processing point of view than other versions of transformational grammar. She points out striking similarities between her proposals and recent computational and psycholinguistic work by Kaplan and Wanner, and she argues that Augmented Transition Networks can provide at least a partial answer to the grammatical realization problem within her framework.

1 will sketch very roughly what Bresnan's "realistic" transformational grammar is like. Rules like passive, dative, and raising rules, which are "structure-preserving" (in the sense that their outputs are structurally identical to independently required base-generated structures) and "local" (in the sense that the elements affected are always in the immediate environment of some governing lexical item, usually a verb), are eliminated from the transformational component and relegated to the lexicon. Lexical entries include, among other things, (strict) subcategorization frames and more abstract representations which Bresnan calls "functional structures" or "predicate argument structures". Subcategorization frames give the syntactic environments in which the lexical item may appear: these are expressed in terms of a basic set of grammatical relations, including "subject" and "object". These notions, while universal, are instantiated differently in different languages; for example, Bresnan takes essentially the structural definitions of "subject" and "object" proposed by Chomsky (1965: 71) as language-specific characterizations of these notions for English. Functional structures give a more abstract representation of the elements mentioned in the subcategorization frame, indicating what their "logical" relationships are. Thus, the
functional structure corresponds very roughly to the deep structure in the standard theory of transformational grammar; and the subcategorization frame corresponds even more roughly to the surface structure.

What the standard theory did with local structure-preserving transformations Bresnan can do in either of two ways. Relationships like active/passive are handled by positing two separate lexical entries for active and passive verb forms. The productivity of this relationship can be accounted for by means of a lexical redundancy rule, which would say, in effect, that corresponding to the typical transitive verb there is an intransitive verb which looks morphologically like the perfect form of the transitive verb, and whose subject plays the same logical role (i.e., in the functional structure) as the object of the transitive verb. Bresnan's other way of replacing local structure-preserving rules is illustrated most clearly with the raising rules. Raising to object position, for example, is used to capture the fact that the NP which is syntactically the object of one clause is logically not an argument of that clause at all, but a subject of the subordinate clause. Bresnan expresses this simply in terms of the relationship between the subcategorization frame and the functional structure; that is, the object of the main clause plays no role in the functional structure of the clause, but is "pulled down" to play a role in the next clause down. In the interests of brevity I will not illustrate Bresnan's framework here. Rather, I will refer the interested reader to her paper, and go on to indicate my reasons for seeking to modify her proposals.

My primary motivation comes from some earlier work of mine (Wason (1977)), which argued against the elimination of local, structure-preserving transformations. My argument was based on the observation that there are two similar but distinct classes of linguistic relationships whose differences can be expressed rather naturally as the differences between transformations such as active/passive, and lexical redundancy rules: The clearest example of this is the English passive. It has often been suggested that some passive participles are adjectives and other verbs: I pointed out that adjectival passives and verbal passives differed in certain systematic ways. My central claim was that the passives of adjectival passives was always the deep direct object of the corresponding verb. For example, a passive particle which is demonstrably adjectival (e.g., because it is prefixed with un- or immediately follows seem) may not have as its surface subject the "logical" subject of a lower clause, the indirect object, or a chunk of an idiom: *John is un~nown to be a communist. *John seemed told the story. Advantage seemed taken of John. A verbal passive, in contrast, could have as its subject any NP which could immediately follow the corresponding active verb: John is known to be a communist; John was told the story; Advantage was taken of John. This, I claimed, would follow from the hypothesis that adjectival passives are formed by a lexical redundancy rule, whereas verbal passives are transformationally derived, if lexical redundancy rules are "relational", in the sense that they are formulated in terms of grammatical relations such as subject and object, whereas transformations are "structural", i.e., they are operations on phrase structure tree.

It is evident that my earlier position is inconsistent with Bresnan's recent proposals. My extensions of her ideas, developed in collaboration with Ron-Kaplan, are in part an attempt to capture within her framework the distinction my earlier paper sought to explicate in terms of the lexicon/ transformation contrast. They are also motivated by the very interesting comments of Anderson (1977). Anderson suggests that I was mistaken in claiming that the operative factor in formulating rules like the adjectival passive rule was the deep grammatical relation of the surface subject. Rather, he argues, it is thematic relations like "theme": "agent": "goal" and "source" (see Gruber (1965) and Jackendoff (1972)) which are "crucial". Assuming Anderson to be correct, an obvious modification of Bresnan's system suggests itself, which would permit the distinctions of my earlier paper to be captured. Let us suppose that the functional structure in lexical entries is a specification of which thematic relationships should be assigned to the elements mentioned in the subcategorization frame. Then, we may distinguish two types of lexical rules: those that make reference to thematic relations and those that do not. The former would correspond to rules that my earlier paper called lexical, and the latter to those that I called transformations. This is the extension of Bresnan's framework that I wish to propose. I will illustrate by formulating the two passive rules and the dative rule and applying them to a fragment of the lexicon of English.

My formalism is based on the assumption that the grammatical relations are given language-wide definitions in structural terms (at least in English) along the lines indicated by Bresnan, and that a verb's subcategorization frame merely indicates which relations it has, and what grammatical categories those relations are assigned to. (Thus, I differ from Bresnan in this respect, for she assumed that grammatical relations would be limited to NP's). I will adopt the following abbreviations: "SO" = (surface) subject; SO = (surface) object; "SOZ" = (surface) second object; "S1" = theme; "S2" = agentive; "S3" = goal; "4" = complement. The rule forming verbal passive participles from the corresponding active lexical entries can now be formulated quite simply as SS=SO. This is to be interpreted as follows: eliminate "SS" wherever it appears in the entry for the active verb (eliminating also any assignment it may have to a thematic relation) and change all occurrences of "SO" to "SS". The adjectival passive rule will differ from this in that it has an additional condition on it: if SO=1, then SS=SO. This condition insures that the SO is "local", in the sense that it bears a thematic relation to the verb. The dative rule also has a "localness" condition: if SO=2, then SS=SO. 2. Let me illustrate these rules with a simple example, namely the verb sell. The basic lexical entry I posit for this verb includes the following information: SS=NP, SO=NP, SO2=NP; SS=2, SO=3, SO2=1. This, I claim, is among the information that must be included in a representation of sell in such uses as They sold John two cars. Applying the verbal passive rule to this entry, we get the following: SS=NP, NN=NP, SS=3, SO=NP, SO2=NP; SS=2, SO=3, SO2=1. This verb appears in examples like John was told two cars. Since the original entry for sell did not meet the condition SO=1, the adjectival passive rule is not applicable; correspondingly, forms like *John was unsold two cars are impossible. The condition for application of dative, SO=1 is met, so we can derive an entry in which SS=NP, SO=NP, SS=2, SO=1. This corresponds to examples like They sold two cars. Notice that this last entry does satisfy the condition on the adjectiva passive rule, so we can derive the following entry for a passive participle for sell: SS=NP, SS=1. This corresponds to examples like Two cars were unsold.

Let us now turn to some more complex examples. Specifically, I now want to look at several different verbs which share the same strict subcategorization frame, namely, SS=NP, SO=NP, SO2=VP. The verbs in question differ from one another along two dimensions, namely, the assignment of thematic relations, and control properties. Let me illustrate by the latter phrase is quite simple: the understood subject of the VP in the SO position will be the SS in some cases and the SO in others. I will represent this in the functional structure by assigning a thematic relation not simply to SO, but to SO2(SS) or SO2(SO), depending on the control properties. 

My assignments of thematic relations are intended to reflect certain intuitions about the semantic roles of the various elements, but I cannot, in general, provide empirical arguments
Consider first persuade. The functional structure for this verb in examples like They persuaded John to leave could be $SS=1, SO=1, SO2(SS)=4$. The passive rule yields an entry whose functional structure $SO2(SS)=1$, for example like John is persuaded to leave. Notice that this passive may mimic that analysis by assigning to believe a functional structure in which the SO bears no thematic relation.\(\text{8}\) $SS=2, SO2(SS)=1$. These are the assignments for examples like I believe John to be at home. The verbal passive rule will apply, yielding the functional structure $SO2(SS)=1$, for example like John is believed to be at home. Since neither the condition on the adjectival passive rule nor that on the dative rule is met, we can predict the non-occurrence of examples like *John seems believed to be at home* and *I believe to be at home*. The next verb I wish to consider is tell, which standard transformationalists would not distinguish in any relevant way from persuade. For reasons noted above, I assign tell the functional structure $SS=2, SO=3, SO2(SS)=1$, as in examples like We told John to bring the beer. Applying the verbal passive rule we get $SS=3, SO2(SS)=1$, covering examples like John was told to bring the beer. On the adjectival passive rule is not satisfied, so we cannot derive *John seemed told to bring the beer*. Notice now that the condition for applying the dative rule is met. Applying the rule results in the following functional structure: $SS=2, SO=1$. This structure is ill-formed, since there is no controller. Accordingly, examples like *We told to bring the beer* are ill-formed. Finally, consider how *John promised to mow the lawn*. This is exactly like *tell*, except that the controller is the subject, not the object, i.e., the functional structure is $SS=2, SO=3, SO2(SS)=1$. If we try to apply either passive rule, we will get the following functional structure: $SS=3, SO2(SS)=1$. This is ill-formed for the same reason that the dative of tell was, namely, lack of a controller. The corresponding examples are also impossible: *John was promised to mow the lawn* or *John seemed promised to mow the lawn*. Dative, however, can apply, yielding an entry whose functional structure is $SS=2, SO(SS)=1$. This corresponds to examples like I promised to mow the lawn.

I hope that this fragment of the lexicon suffices to show that my proposed modification of Bresnan's system permits an elegant and natural account of a number of syntactic distinctions, including some which have not been discussed in the literature onpromise and tell. For reasons that I would like to emphasize is that my proposals provide a rather straightforward account of Visser's (1973; 2118) observation: "A passive transform is only possible when the complement relates to the immediately preceding (pro)noun." In my terminology, passive will be impossible when the active has a complement controlled by the SS, as in the case of promise, for passivization will always lead to an uncontrolled complement. Thus, to take another standard example of Visser's generalization, we can account for the distinction between strike and regard much as we accounted for the difference between promise and tell. Both will have the following subcategorization frame: $SS\rightarrow NP, SO\rightarrow NP, SO2\rightarrow AP$. Their functional structures will include the assignments $SS=2$ and $SO=1$: they will differ in that regard will have $SO2(SS)=4$, while strike has $SO2(SS)=4$. These assignments are for examples like John regards Mary as pompous. If we apply passive to regard we get $SS=1, SO2(SS)=4$, which is ill-formed, as is *Mary is struck as pompous*. Notice, incidentally, that this example illustrates that, in the system I advocate here, constituents other than VPs can serve as predicates and be subject to control.

This concludes my suggestions, for modifying Bresnan's framework. I hope I have succeeded in indicating how a grammar which makes extensive use of the lexicon in place of syntactic transformations can handle an array of syntactic facts in a satisfying manner. Next, I wish to argue that a system of the sort outlined here can be effectively constrained in reasonable and interesting ways. Intuitively, it seems quite plausible that such a system would be easy to constrain, for by drastically reducing the role of transformations, it opens the way for reductions in the power of transformations. A number of candidate constraints on transformations come to mind. For example, within Bresnan's framework one might plausibly argue that no transformation can create new grammatical relations (e.g., there will be no "subject-creating" transformations like passive or raising to subject), or that no transformation can change the words in the sentence morphologically (e.g., there will be no nominalization, agreement, or case-marking transformations)—cf. Frame (1978). Various ways in which lexical items might be constrained also come to mind: most immediately, it seems to me that many of the "laws" of relational grammar proposed by Postal and Perlmutter in recent years could be translated straightforwardly into the kind of framework discussed here. In this paper, however, I would like to consider the consequences of a constraint on transformations modeled on the Freezing Principle of Culicover and Wester (1977). My proposal depends on distinguishing two classes of transformations: root transformations (Emonds (1976)), and what I will call unbounded rules. Root transformations are rules like English subject-auxiliary inversion in questions, which apply only to main clauses; unbounded rules are transformations (e.g., wh-movement) which involve a crucial variable, i.e., they move something over a variable or they delete something under identity with something on the other side of a variable (see the contributions by Chomsky, Bach, Bresnan, and Partee in Culicover, et al (1977) for discussion of whether unbounded rules are truly unbounded). The constraint I wish to propose, which I will call the interaction constraint is the following: once a rule of one of these classes has applied to a given structure, no further rule of the same type may apply to that structure. More specifically, when a transformation applies, the smallest constituent containing all of the affected elements becomes frozen, in the sense that no further transformations of the same type may analyze it. This means, in effect, that there will be no interactions among root transformations, nor among unbounded transformations (though a root transformation may interact with an unbounded rule, as in the case of English wh-questions). I believe that there are several desirable consequences of prohibiting such interactions.

First of all, let me mention a somewhat conjectural reason for advocating the interaction constraint. As noted above, a very similar proposal emerged from the learnability studies of Wester, Culicover, and Hamburger; they were able to prove...
that a class of grammars in which nodes were frozen under similar conditions was learnable by a fairly simple learning device. Hence, it seems plausible to conjecture that the interaction constraint might be useful in devising a learnability proof for some version of Bresnan's theory. In any event, it seems that the interaction constraint would make the language-learner's task easier from the perspective of a program of research, and I have hence felt free to ignore many important issues. The primary point I wish to make is that the study of language appears to have progressed to a point where the concerns of the transformational and the concerns of the computational linguist need not conflict, and indeed may be addressed by a single theory.

I have sketched a version of transformational grammar which seems to hold considerable promise. There are a number of problems with this approach which I am aware of and undoubtedly many more I am blissfully ignorant of. What I have presented here was intended, more than anything else, as an indication of a program of research, and I have hence felt free to ignore many important issues. The primary point I wish to make is that the study of language appears to have progressed to a point where the concerns of the transformational and the concerns of the computational linguist need not conflict, and indeed may be addressed by a single theory.

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Footnotes

1. No rigorous definition of these notions has ever been offered in the literature, and certain problems with the way they have been used have been pointed out (e.g., Hat and Brame (1976)). I do not wish to commit myself to an interpretation of the claims which have been made in the literature about these notions, and my notation below is intended to reflect this. I do, however, believe that those who have discussed thematic relations are onto something important.

2. Obviously, there is more to forming passives than this; for example, I ignore morphology.

3. These familiar with Postal and Perlmutter's version of relational grammar will recognize the resemblance of last sentence to the Relational Annihilation Law. Notice by the way, that my preface rules say nothing about the by phrase. I am assuming, with Bresnan (in press), that there is an independent rule assigning agent status to the objects of some by phrases. This rule would operate not only in passives, but also in examples like The symphony was by Berlioz.

4. Notice that I am formulating the dative rule "backwards", that is, with the double object construction as the input. My rule says nothing about the prepositions in and for because I assume that the functional role of their objects will be covered by separate rules, as is the case with by. Examples like John's gift was to Mary and This present is for you tend to credit my assumption.

5. This is to be understood as saying that the SO2 will be treated as a predicate, with its own assignments of thematic relations, and with the element in parentheses treated as if it were the SS of that predicate.

6. Jane Robinson has suggested to me that it might be more appropriate semantically to treat the subject of believe as 3. This would be perfectly compatible with my analysis.

7. My treatment here ignores anaphora rules like VP deletion and sluicing. I am assuming that these rules are not transformations, but a separate category of rules, subject to their own unique conditions (see Wasow (in press b) for discussion).

8. As given, my argument does not take into account root transformations or specified deletions (see Wasow (in press a)). 1: is quite trivial, however, to extend the argument to cover these cases.

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