

1 A Realistic Transformational Grammar

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The Realization Problem

More than ten years ago Noam Chomsky expressed a fundamental assumption of transformational grammar: "A reasonable model of language use will incorporate, as a basic component, the generative grammar that expresses the speaker-hearer's knowledge of the language." This assumption is fundamental in that it defines basic research objectives for transformational grammar: to characterize the grammar that is to represent the language user's knowledge of language, and to specify the relation between the grammar and the model of language use into which the grammar is to be incorporated as a basic component. We may call these two research objectives the grammatical characterization problem and the grammatical realization problem. In the past ten years linguistic research has been devoted almost exclusively to the characterization problem; the crucial question posed by the realization problem has been neglected—How *would* a reasonable model of language use incorporate a transformational grammar?

If we go back to the context in which Chomsky expressed this assumption about the relation of grammar to language use, we find that it is couched within an admonition: "A generative grammar is not a model for a speaker or a hearer. . . . No doubt, a reasonable model of language use will incorporate, as a basic component, the generative grammar that expresses speaker-hearer's knowledge of the language; but this generative grammar does not, in itself, prescribe the character or functioning of a perceptual model or a model of speech-production" (1965, p. 9). In retrospect, this caution appears to have been justified by the rather pessimistic conclusions that have since been drawn in

This chapter discusses research in progress by the author, which is likely to be modified and refined. Some matters have been simplified to make exposition easier. A fuller account is planned in Bresnan (in preparation). The ideas presented here owe much to my association with members of the MIT Workshop on Language and Cognition during the past two years. I would like particularly to thank Morris Halle for his constant encouragement and George Miller for his unfailing interest in new ideas. I am also grateful to the John Simon Guggenheim Memorial Foundation for the Fellowship that enabled me to work on these ideas from August 1975 to August 1976 under the freest possible conditions. To my friend Mary MacDonald, who provided those conditions—as well as the realistic point of view of the language teacher—I also give many thanks.

literature. In their review of this literature, Fodor, Bever, and Garrett (1974) conclude that the experimental evidence tends to support the psychological reality of grammatical *structures*, but that the evidence does not consistently support the reality of grammatical *transformations* as analogues of mental operations in speech perception and production. In particular, the derivational theory of complexity—the theory that the number of transformations operating in the grammatical derivation of a sentence provides a measure of the psychological complexity in comprehending or producing the sentence—cannot be sustained.

These conclusions have invited the inference that it is a mistake to attempt to “realize” a transformational grammar within a model of language use. This view seems to be shared by a good number of linguists and psychologists, perhaps for different reasons. Some linguists may believe that the realization problem is uninteresting at this point because—to put it bluntly—psychology has not yet provided anything like a reasonable model of language use, with or without grammar. And a number of psychologists may have concluded that no model of language use that incorporates a transformational grammar, or indeed any kind of grammar, is reasonable.

However, it is possible to take a different view of the matter. If a given model of grammar cannot be successfully realized within a model of language use, it may be because it is psychologically unrealistic in significant respects and therefore inadequate in those respects as an empirical theory of the human faculty of language. From this point of view, previous attempts to realize transformational grammars as models for a speaker or hearer are valuable and informative. By showing us in what respects grammars may be psychologically unrealistic, they can guide us in our efforts to construct better theories of grammar. To take this position is to take seriously Chomsky’s “realist interpretation” of transformational grammar.

Accordingly, the proper conclusion to draw about the familiar model of transformational grammar presented in Chomsky’s *Aspects of the Theory of Syntax* (1965) may simply be that it is psychologically unrealistic. Linguistic research by Chomsky and many others on the characterization problem has shown the *Aspects* model to be inadequate in significant ways as a theory of language, and the model has undergone important changes. I will argue that these new developments in transformational linguistics, together with independent de-

velopments in computational linguistics and the psychology of language, make it feasible to begin to construct realistic grammars.

Let me explain briefly what I consider a realistic grammar to be. First, such a grammar must be psychologically real in the broad sense. This sense of "the psychological reality of linguistic concepts" has been very well expressed by Levelt (1974):

A linguistic concept is psychologically real to the extent that it contributes to the explanation of behavior relative to linguistic judgments, and nothing more is necessary for this. Although the term [psychological reality of linguistic concepts] is misleading, it does indeed have content in that it refers to the question as to whether constructions which are suited to the description of one form of verbal behavior (intuitive judgments) are equally suited to the description of other verbal processes (the comprehension and retention of sentences, etc.). (vol. 3, p. 70)

A realistic grammar must be not only psychologically real in this broad sense, but also realizable. That is, we should be able to define for it explicit realization mappings to psychological models of language use. These realizations should map distinct grammatical rules and units into distinct processing operations and informational units in such a way that different rule types of the grammar are associated with different processing functions. If distinct grammatical rules were not distinguished in a psychological model under some realization mapping, the grammatical distinctions would not be "realized" in any form psychologically, and the grammar could not be said to represent the knowledge of the language user in any psychologically interesting sense.

Clearly, these are strong conditions to impose on a linguistic grammar. But their value is correspondingly great. Theoretical linguistics has greatly advanced our understanding of the abstract structure of human languages. Under the conditions imposed, these advances could be brought directly to bear on the experimental investigation of human cognition.

Toward a More Realistic Transformational Grammar

The familiar *Aspects* model of transformational grammar is depicted schematically in Figure 1.1. This model has three essential characteristics. First, the meaning, or semantic interpretation, of a sentence is

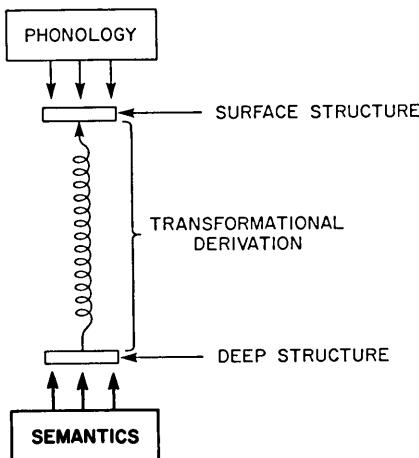


Figure 1.1 *Aspects* model of transformational grammar

determined from its deep structure. Second, the pronunciation, or phonetic interpretation, of a sentence is determined from its surface structure. And third, the role of transformations is seen as converting the semantically relevant level of linguistic description into the phonetically relevant level. As Figure 1.1 suggests, transformations bear the central and primary descriptive burden of the grammar. The helical line connecting deep structure to surface structure represents the transformational cycle introduced in Chomsky (1965).

Although subsequent research has shown that each of these properties of the model is incorrect, this is still the picture that many linguists and psychologists have of a transformational grammar, a fact that attests both to the intuitive appeal of the model and to its enormous fruitfulness in guiding linguistic research. In fact, in one successor to the *Aspects* model these essential features were carried over intact; I am referring to the generative semantics model of grammar, in which deep structure is identified with semantic representation. In the generative semantics model many lexical, semantic, and even pragmatic relations were treated as transformational relations.

I will be concerned, however, with a different line of linguistic research, known as the lexical-interpretive theory of transformational grammar. Within this line of research, the inadequacies of the *Aspects* model have been seen as calling for a basic reorganization and restructuring of the grammar. It is perhaps easiest to see the overall

effect of the changes by comparing Figure 1.1 with Figure 1.2. To visualize the changes from the *Aspects* model to the lexical-interpretive model, imagine that the transformational derivation has been contracted and rotated 90 degrees clockwise. Shortening the transformational derivation is compensated for by greatly enlarging the lexicon (which was invisible in Figure 1.1) and the semantic component. Rotating the transformational component expresses new relations among the semantic, syntactic, and phonological components. I will not be concerned here with the new phonological relations; for discussions of these I refer you to Halle (1973), Selkirk (forthcoming), and Bresnan (in preparation).

As the name “lexical-interpretive model of transformational grammar” indicates, nontransformational rules—lexical and interpretive rules—play a large role. Lexical, semantic, and pragmatic relations are distinguished from transformational relations and factored out of the transformational derivation. The rules of each subcomponent have distinguishing properties that have been the subject of much recent research. Here I can only briefly illustrate the division of labor among the components, focusing on the lexical rules and the surface interpretive rules of Figure 1.2. (For a fuller account, see Bresnan, in preparation.)

Lexical rules The existence of a class of lexical rules of word formation, differing from syntactic transformations, was postulated by Chomsky (1970a) and constitutes what is called the lexicalist

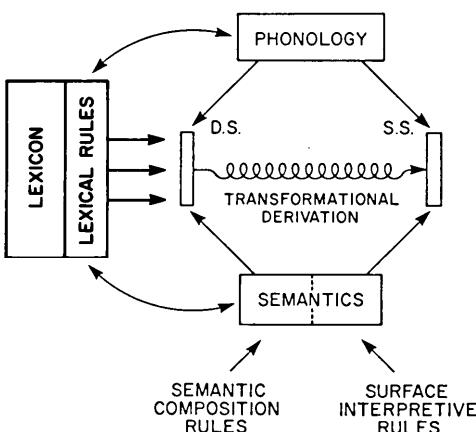


Figure 1.2 Lexical-Interpretive model of transformational grammar

the psycholinguistic hypothesis. A word-formation rule, plainly, is a regularity governing the formation of words. Examples of two word-formation rules studied by Dorothy Siegel (1974) are given in (1) and (2). (Rule (1) is an oversimplified representation of what are probably two distinct rules. In particular, the deverbal adjective formation involves not *-d*, but *-EN* (the past participle marker): compare *broken hearts* vs. **broaked hearts*.)

(1) Noun or Verb + *-d* = Adjective

Examples: $[_N \text{ salary}] + -d = [_A[_N \text{ salari}] \text{ ed}]$
 “a salaried employee”
 $[_V \text{ hurry}] + -d = [_A[_V \text{ hurri}] \text{ ed}]$
 “too hurried a manner”

(2) *un-* + Adjective = Adjective

Example: $un- + [_A \text{ happy}] = [_A \text{ un } [_A \text{ happy}]]$ “unhappy”

Rule (1) forms adjectives from nouns or verbs by suffixing *-d*. Rule (2) forms adjectives from adjectives by prefixing *un-*. (The negative *un-*, meaning “not,” must be distinguished from the verbal prefix *un-*, which indicates reversal of an activity, as in *to unbutton*; on this distinction, see Siegel 1973). Rule (2) applies only to adjectives: *un-* cannot be prefixed to a simple noun (**unsalary*) or to a simple verb (**unhurry*),¹ but it can be prefixed to adjectives that are themselves formed from nouns or verbs, as by rule (1): *unsalaried*, *unhurried*. These words therefore have the morphological analyses shown in (3):

- (3) $[_A \text{ un } [_A[_N \text{ salari}] \text{ ed}]]$
 $[_A \text{ un } [_A[_V \text{ hurri}] \text{ ed}]]$

Similarly, the adjectives formed by rule (2) can undergo further word-formation rules, such as the noun formations that yield the words in (4):

- (4) $[_N[_A \text{ un } [_A \text{ true}]] \text{ th}]$ “untruth”
 $[_N[_A \text{ un } [_A \text{ happy}]] \text{ ness}]$ “unhappiness”

The theoretical interest of these rules, pointed out by Siegel (1973), is that they express generalizations that are not adequately explained by transformations. Consider, for example, the conse-

¹ Osvaldo Jaeggli (personal communication) has observed that negative *un-* also appears with a few simple nouns in English, including *unconcern* and *unrest* (cf. example (4)).

quences of attempting to derive sentence (5) transformationally from a source like (6).

- (5) Antarctica is uninhabited.
- (6) Not [something inhabits Antarctica]

Two things must be done to (6): it must be passivized, and *not* (in the form of *un-*) must be prefixed to *inhabit*. Suppose that *not* is prefixed first, yielding (7)—

- (7) [something un-inhabits Antarctica]

—and that passivization then applies to (7) to yield (5). In this case we have given up the generalization expressed by rule (2) that *un-* is prefixed only to *adjectives*; by prefixing it to the verb *inhabit*, we have produced an active verb **uninhabit*, which is not only morphologically aberrant, but nonexistent. On the other hand, if we suppose that passivization is applied first, (8) results:

- (8) Not [Antarctica is inhabited (by something)]

Now *not-prefixing* is to apply to the passivized verb *inhabited*, but the result will still be morphologically aberrant, because in English a passive verb is itself a verb, not an adjective.

That passive verbs are indeed verbs can be demonstrated in a number of ways, but I will mention just one. English verbs are distinguished from adjectives (and from nouns) by their ability to take direct noun phrase complements. Compare:

- (9) a. Jeff *suspected Mary*. V NP
- b. *Jeff was *suspicious Mary*. *Adj NP
- c. Jeff was *suspicious of Mary*. Adj PP

In (9a) the verb *suspected* has the direct noun phrase complement, *Mary*, and the sentence is well-formed. But as (9b,c) show, the “object,” *Mary*, of the adjective *suspicious* must be mediated by a preposition. Now, unlike an adjective, a passive verb too may take a direct noun phrase complement:

- (10) a. Mary was *taught French*. V NP
- b. *Mary was *untaught French*. *Adj NP

Example (10a) shows us that, like a verb, passive *taught* can take a noun phrase complement; (10b) shows us that, like an adjective,

untaught cannot.² (It must be remembered that the syntactic differences between verb and adjective are manifested in different ways in other languages.) Thus it is clear that *untaught* is an adjective, a product of rules (1) and (2).

Now look again at (5), *Antarctica is uninhabited*. By employing rules (1) and (2), we can analyze the sentence directly as NP *be* Adj, parallel in structure to a sentence like *Jeff was suspicious*. By rule (1), $[_V \text{inhabit}] + -d = [_A[_V \text{inhabit}] \text{ed}]$: *Antarctica is* $[_A \text{inhabited}]$. By rule (2), *un-* + $[_A[_V \text{inhabit}] \text{ed}] = [_A \text{un} [_A[_V \text{inhabit}] \text{ed}]]$: *Antarctica is* $[_A \text{uninhabited}]$.

We see, therefore, that if we try to derive sentence (5), *Antarctica is uninhabited*, by using the passive transformation, we are forced to give up independently motivated morphological generalizations—the generalization expressed by rule (2), that *un-* is a prefix that derives adjectives from adjectives, and the generalization that passive verbs are verbs.

I will add only one final observation in support of this conclusion. (For further evidence see Wasow 1977 and Hust 1977.) The transformational analysis of a sentence like (5) employs a passive transformation, which presupposes an active source: the surface subject (*Antarctica*) must be the underlying object of an active verb (*inhabit*) as in (6). Since only verbs that can be followed by objects may be passivized, the transformational analysis therefore makes the prediction shown in (11), pointed out by Siegel (1973):

- (11) Prediction of transformational analysis:
Verbal root V in the form un-V-ed will be a transitive verb.

By contrast, the lexical analysis, which employs rules (1) and (2), does not make this prediction; the suffix *-d* of rule (1) can be attached to some intransitive verbs.

- (12) Some un-V-ed forms having intransitive verbal roots:
undescended, unhurried, untraveled, unsettled, unpracticed,
unarmed

An *undescended* testicle, for example, is a testicle that has not descended (into the scrotum); *descend* is an intransitive verbal root

² N. Ostler (personal communication) has observed three English adjectives that can have direct nominal complements: *worth*, *like*, and *near*, as in *It's worth a lot of money*, *He looks like her*, *This is nearer the truth*. But *like* and *near* are also used as prepositions, and *worth* is never used attributively: **a worth book*.

here. The other examples in (12) all have usages in which they cannot be plausibly derived from transitive verbs—for example, *We are still unsettled*, *A provincial person is untraveled*, *To the unpracticed eye*, . . . The evidence of these intransitive *un-* forms thus favors the lexical analysis over the transformational analysis.

The case of the so-called unpassive construction illustrates very well how research into nontransformational components of the grammar has provided new insights into the functioning of syntactic transformations. As a result of such research it appears that syntactic transformations do not play a role in word formation, and that we can therefore exclude from the class of possible transformations all those that involve the relabeling of syntactic categories, as by transforming verbs into adjectives, adjectives into nouns, and so on. (For further discussion of word-formation rules, see Chapter 2.)

At the same time, this research shows that other components of the grammar must take over some of the functions of transformations in the *Aspects* model. For example, one function of transformations has been to account for distributional regularities in selectional restrictions. A verb like *frighten* takes an animate object in the active:

- (13) a. ?John frightens sincerity.
- b. Sincerity frightens John.

But it takes an animate *subject* in the passive:

- (14) a. ?Sincerity is frightened by John.
- b. John is frightened by sincerity.

The passive transformation is intended to account for this relation by transforming (13a) into (14a) (Chomsky 1965). Notice, however, that an adjective like *undaunted* takes an animate subject, reflecting the selectional restrictions that hold for the object of the verbal root *daunt*:

- (15) a. ?John daunts nothing.
- b. Nothing daunts John.
- (16) a. ?Nothing is undaunted.
- b. John is undaunted.

Yet we can no longer invoke the passive transformation to account for this relation.

Another function of transformations in the *Aspects* model has been

to associate underlying grammatical functions, such as logical subject and logical object, with surface configurations of grammatical categories. In *The boy may be frightened by sincerity, the boy* is understood as the logical object of *frighten*, and *sincerity* is understood as the logical subject; these are the functional relations that obtain in the deep structure, before passivization applies. However, similar functional relations can be found in sentences like those in (17) and (18).

- (17) a. The boy was undaunted by defeat.
- b. His creative writing style is unfettered by the rules of composition.
- c. Her candor is unimpaired by tact.
- (18) a. This problem is not solvable by ordinary methods.
- b. This function is computable by a right-moving Turing machine with two states.

And these sentences, according to the lexicalist hypothesis, are not transformationally derived from active deep structure sources, because that would bring transformations into word formation. Their deep structures are quite similar to their surface structures.

We can now see why lexical rules must play a large role in the lexical-interpretive theory of transformational grammar. Morphological and semantic relations between words like *daunt* and *undaunted* must be expressed by means of these nontransformational rules. (See Aronoff 1976 and Anderson 1977.)

Surface interpretive rules The surface interpretive rules shown in Figure 1.2 include rules governing the possible relations between anaphoric elements, such as pronouns, and their antecedents. It has been known for some time that these anaphoric rules seem to apply to transformationally derived structures, as in (19).

- (19) a. Peter hates the woman who rejected him.
- b. The woman who rejected Peter is hated by him.
- c. The woman who rejected him is hated by Peter.
- d. He hates the woman who rejected Peter.

In the first three examples of (19) it seems possible to interpret *him* as referring to Peter, but this is not possible in the last example. To explain these facts, Langacker (1969) and Ross (1967a) independently

proposed conditions under which a pronominalization transformation could apply to both active and passive sentences, substituting a pronoun for a noun phrase identical to another, coreferential noun phrase. (For a fuller discussion of transformational approaches to pronominalization, see Bresnan, in preparation, and Wasow 1976.)

Recently, however, a new interpretive approach has been advanced by Lasnik (1976) and further developed in Reinhart (1976). The basic idea is to assume that pronouns are simply pronouns in deep structure: they are generated as noun phrases like other noun phrases. Then it is assumed that coreference between noun phrases is always possible, except under the following condition:

(20) The Noncoreference Rule:

Given two noun phrases NP_1 , NP_2 in a sentence, if NP_1 precedes and commands NP_2 and NP_2 is not a pronoun, then NP_1 and NP_2 are noncoreferential.

NP_1 "precedes and commands" NP_2 when NP_1 is to the left of NP_2 and is not in a subordinate clause from which NP_2 is excluded. This notion will be illustrated below. (See Lasnik 1976 and Reinhart 1976 for the more precise formulations.)

The Noncoreference Rule (20) is an interpretive rule in that it explicitly limits the possible interpretations of a transformationally derived sentence. Here is how it applies to the examples of (19). In (19a): *Peter* is NP_1 and *Peter* precedes and commands *him*, NP_2 ; but since *him* is a pronoun, rule (20) is inapplicable; therefore it is possible for *Peter* and *him* to be coreferential. In (19b): *Peter* is again NP_1 ; in this sentence *Peter* precedes but does not command *him*, NP_2 , because *Peter* is in a subordinate clause (*who rejected Peter*) that excludes *him*; so again rule (20) is not applicable and *him* can be coreferential with *Peter*. In (19c): Now *him* is NP_1 ; *him* precedes but does not command *Peter*, NP_2 , because *him* is contained in a subordinate clause (*who rejected him*) that excludes *Peter*; once again rule (20) does not apply and coreference is possible. Finally, (19d): *He* is NP_1 ; *he* precedes and commands *Peter*, NP_2 ; but since *Peter* is not a pronoun, rule (20) does apply here, thus stipulating that *he* (NP_1) and *Peter* (NP_2) cannot be coreferential.

A very important difference between the Noncoreference Rule and the previous transformational account is that when NP_1 and NP_2 do not meet the conditions for applying the rule, their coreference possibilities are free. This is illustrated in (21).

- (21) a. People who know Kennedy love Kennedy.
b. People who know Kennedy love him.
c. People who know him love Kennedy.

In all three sentences of (21) the first NP (*Kennedy* or *him*) precedes but does not command the second NP (*Kennedy* or *him*). Given the pronominalization transformation, we would have to say that its application in (21a) was optional. But now compare (22), where the situation is changed; in (22a) the second *Kennedy* does not seem to be coreferential with the first.

- (22) a. Kennedy said that Kennedy was happy.
b. Kennedy said that he was happy.

The pronominalization transformation does not explain this subtle contrast, but the Noncoreference Rule does: the first *Kennedy* in (22a) precedes and commands the second *Kennedy*, NP₂, and NP₂ is not a pronoun; therefore rule (20) applies and the two *Kennedy*'s are noncoreferential.

The contrast between (21a) and (22a) reappears in examples like (23a,b):

- (23) a. People who know Kennedy well are saying that the senator is happy.
b. Kennedy is saying that the senator is happy.

The fact that *the senator* can be coreferential with *Kennedy* in (23a), though not in (23b), follows from the Noncoreference Rule (20) and the fact that *the senator* is not a pronoun. If the pronoun *he* is substituted for *the senator* in (23b), the coreferential interpretation becomes possible, as predicted by (20).

These new results suggest that the interpretive account is descriptively superior to previous transformational accounts of pronominalization. But there is an even more important advantage of the new approach. Previous transformational theories have described coreference relations grammatically, assuming that the anaphoric relation between a pronoun and its antecedent should be specified by rules of the grammar, such as a pronominalization transformation. The new interpretive account drops this assumption. Consequently, since coreference relations are not the result of rules of sentence grammar, we are free to treat sentence-internal and inter-sentence coreference

in the same way. The transformational theory of pronominalization cannot do this, because pronominalization is a rule of sentence grammar and hence sentence-bound.

Thus, as Lasnik (1976) points out, the Noncoreference Rule (20) not only accounts for the absence of coreference between noun phrases within a sentence—

- (24) *He* finally realized that *Oscar* is unpopular.

—but in exactly the same way it also accounts for the failure of coreference within a discourse: within the second sentence of (25), as in (24), *he* and *Oscar* cannot corefer.

- (25) I spoke to *Oscar* yesterday. You know, *he* finally realized that *Oscar* is unpopular.

No pragmatic explanation for this persistent failure of coreference is apparent, for the second *Oscar* can be coreferential with *Oscar* in a preceding sentence:

- (26) I spoke to *Oscar* yesterday. You know, I finally realized that *Oscar* is unpopular.

And *he* can also be coreferential with *Oscar* in a preceding sentence:

- (27) I spoke to *Oscar* yesterday. You know, *he* finally realized that I am unpopular.

But if we assume, with Lasnik (1976), that coreference is a transitive relation, then the failure of coreference within the second sentence of (25) follows from the Noncoreference Rule (20).

This result—the unification of sentence anaphora with discourse anaphora—is a major advantage of the new interpretive approach over previous accounts. It accords with the view expressed by Stenning in Chapter 4:

Before trying to explain what are perceived as parts of sentence structure in a theory of sentence types, it is important that the same regularities be searched for at levels above the sentence. If they are found there, their explanation must be assigned there. From the present point of view, the sentence grammar should be seen as placing limitations on certain very general principles for the construction of quantificational and referential structures in texts and contexts.

In summary, just as the *Aspects* model of transformational grammar suggested to many that virtually the entire computational burden of relating meaning to surface form is borne by transformations, so the lexical-interpretive model should suggest the cooperating interaction of separate information-processing systems. Schematic as this overview has been, it allows a basic idea to be expressed very simply: As nontransformational relations are factored out of the transformational component, the transformational complexity of sentences is reduced, deep structures more closely resemble surface structures, and the grammar becomes more easily realized within an adequate model of language use.

The next section will show how this idea suggested by the lexical-interpretive model can be radically extended to yield a more realistic model of transformational grammar. But let us first anticipate a possible objection.

“Clearly,” the objection runs, “if you eliminate a lot of transformations, you may get a more efficient syntactic processing system, but this greater efficiency of one component is purchased by a greater inefficiency of the other components. So it is hard to see why the model as a whole will be more realistic.”

In answer to this objection, I must make explicit several assumptions. First, I assume that the syntactic and semantic components of the grammar should correspond psychologically to an active, automatic processing system that makes use of a very limited short-term memory. This accords with the assumptions of Chapter 3. Second, I assume that the pragmatic procedures for producing and understanding language in context belong to an inferential system that makes use of long-term memory and general knowledge. The extreme rapidity of language comprehension then suggests that we should minimize the information that requires grammatical processing and maximize the information that permits inferential interpretation. Finally, I assume that it is easier for us to look something up than it is to compute it. It does in fact appear that our lexical capacity—the long-term capability to remember lexical information—is very large.

The Active–Passive Relation

The minimal semantic information about verbs that must be represented in the lexicon is their logical argument structure: the intransi-

tive verb *sleep* is represented by a one-place relation and the transitive verb *hit* by a two-place relation, as in (28) and (29).

- (28) *x SLEEP*

- (29) *x HIT y*

Naturally, other semantic information will be represented as well: for example, concepts like agent, patient, or theme may be associated with the argument positions. (See Chapters 2 and 5, and Anderson 1977.)

Information about the syntactic contexts in which verbs can appear is not sufficient to represent their argument structure, for two verbs may have different types of argument structure in the same syntactic contexts. *Eat* and *sleep* provide an example. Both verbs can be used intransitively, as in *John ate* and *John slept*. Yet *John ate* implies that John ate something; the verb *eat* has a logical object even when it lacks a grammatical object. In this respect, the argument structure of *eat* differs from that of *sleep*. This simple observation raises the major question to be explored here: How are the logical argument structures of verbs related to their syntactic contexts?

A familiar answer to this question is the transformational one. In the case of verbs like *eat*, Chomsky (1964a) proposed a transformation of unspecified-object deletion that applies as in (30):

- (30) a. John ate something \Rightarrow
 b. John ate.

Given this transformation, the different argument structures of *eat* and *sleep* correspond to different deep structure contexts into which the verbs can be inserted: in deep structure, *eat* has a grammatical object, which corresponds to its logical object, but *sleep* does not. Generative semantics can be seen as an attempt to carry out consistently the program of identifying logical functions (for example, logical subject and logical object) with grammatical functions at a single level of deep syntactic structure.

But there is another way to establish a correspondence between the argument structure of a verb and its syntactic contexts. Instead of transforming the syntactic structure, it is possible to operate on the argument structure. For example, the argument structure of *eat* can be converted from a two-place relation into a one-place relation. A logical operation that has precisely this effect is the variable-binding



operation of quantification. The relation in (31a) is a two-place relation, whereas that in (31b) is a one-place relation.

- (31) a. $x \text{ EAT } y$
 b. $(\exists y) x \text{ EAT } y$

If (31b) is taken as the lexical argument structure for the intransitive verb *eat*, it is easy to explain both how *John ate* differs from *John slept* and how *John ate* is related to *John ate something*.

It is natural to provide (31b) as *lexical* information, because the intransitive use of otherwise transitive verbs is a property of individual verbs. It is a property of *eat*, but not of *hit*, for example:

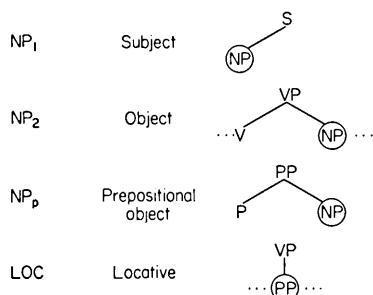
- (32) *John hit.

Entering (31b) in the lexicon, moreover, avoids the counterintuitive conclusion that *John ate* should require more grammatical processing than *John ate something* or *John ate it*. This follows from the assumptions stated earlier about the realization of the grammar.

In order to make the lexical association between argument structure and syntactic structure explicit, it is necessary to define a set of grammatical functions: subject, object, and so on. Otherwise there is no way to distinguish *John hit something* from *Something hit John*: in both sentences *hit* has the argument structure $x \text{ HIT } y$. A notation for referring to these grammatical functions is given in Table 1.1. The list is provisional and incomplete; other grammatical functions will be considered later.

As indicated in the table, NP_1 will refer to the NP immediately dominated by S; NP_2 will refer to the NP immediately dominated by VP and to the right of its V; NP_p will refer to the NP immediately dominated by PP, a prepositional phrase; and LOC will refer to a PP immediately dominated by VP. Although the set of possible grammatical functions for natural languages—subject, object, locative, and so forth—can be considered universal, the way in which they are mapped into particular languages will vary. In a language like English, having highly rigid word order and little inflection, the grammatical functions can be defined configurationally; in a language having free word order and richer inflection, the grammatical functions can be defined, at least partly, in terms of case. (The universality of grammatical functions is proposed by Perlmutter and Postal 1977; the configurational definition of grammatical functions in English is

Table 1.1 Grammatical functions



proposed by Chomsky 1965; a definition of grammatical functions of Walbiri by means of case is given in Hale, Jeanne, and Platiero 1977.)

With this notation, partial lexical representations can now be provided for the verbs *sleep*, *hit*, *eat*, *lie*, and *rely on*:

- | | | |
|---------------------|------------------------------|--|
| (33) <i>sleep</i> : | V, [____], | NP ₁ SLEEP |
| (34) <i>hit</i> : | V, [____ NP], | NP ₁ HIT NP ₂ |
| (35) <i>eat</i> : | V, [____ NP],
[____], | NP ₁ EAT NP ₂
($\exists y$) NP ₁ EAT y |
| (36) <i>lie</i> : | V, [____ PP], | NP ₁ LIE LOC |
| (37) <i>rely</i> : | V, [____ [PP on NP]], | NP ₁ RELY-ON NP _{on} |

The material in square brackets will be referred to as the *syntactic contexts*; they represent the immediate syntactic context for lexical insertion of the verbs. The formulas to the right will be called the *functional structures*; they combine the grammatical functions with the logical argument structures.

Observe that the syntactic contexts in (33)–(37) diverge from the functional structures in several respects. First, the syntactic context ignores material outside of the verb phrase, but the functional structure makes reference to NP₁, the subject. Next, the verb *eat* has two syntactic contexts; one is like that for *sleep*, but even with that context *eat* still has a logical object, unlike *sleep*. Finally, both *lie* and *rely* are inserted into their syntactic contexts before PPs, but their functional structures are different: *lie* is represented by a relation between an individual designated by the subject and a location designated by the locative; *rely on* is represented as a relation between individuals designated by the subject and the prepositional object of *on*.

Because *rely* is inserted before a PP rather than a NP, it is

syntactically intransitive; nevertheless, it is logically transitive in its functional representation. Let us briefly consider the evidence for this discrepancy.

The *on*-phrase following *rely* behaves syntactically like a PP: it can be preposed as a unit in the relative clause in (38).

- (38) [He is someone you can rely [_{PP} on whom]] \Rightarrow
 [He is someone [_{PP} on whom] you can rely]

This behavior is shared by the PP following *lie*:

- (39) [Here is something you can lie [_{PP} on which]] \Rightarrow
 [Here is something [_{PP} on which] you can lie]

The *on*-phrase following *rely* can undergo emphatic preposing:

- (40) On that, you can rely!

The same is true for *lie*:

- (41) On that, you can lie!

Of course, the PP following *lie*, being locative in the functional structure, differs in some ways from the PP associated with *rely*: for example, it can be used to answer a *where* question:

- (42) Where does the cat lie for comfort? — On the mat.

But this is not true of *rely*:

- (43) *Where does John rely for support? — On Mary.

Instead of (43), however, we can have (44):

- (44) On whom does John rely for support? — On Mary.

It is a pervasive generalization of transformational grammar that transformations do not move nonconstituent sequences of categories. For example, the sequence *on his clothes* is not a constituent sequence (that is, a phrase) in (45):

- (45) John put on his clothes.

And it cannot undergo movement as a unit:

- (46) *On which clothes did John put?
 Which clothes did John put on?

From these facts, therefore, it can be concluded that the sequence *on NP* following *rely* is indeed a prepositional phrase, as it is represented in (37).

At the same time, *rely on* has a functional representation that is logically transitive. Note that its prepositional object can be passivized:

- (47) All of us are relying on her for support.
She is being relied on for support by all of us.

In contrast, the object of *on* is not passivizable with *lie* (but compare footnote 3):

- (48) All of the cats are lying on the mat.
*The mat is being lain on by all the cats.

It should be noted that some verbs have two uses, one like *lie* in (36) and another like *rely* in (37). One example is *arrive*:

- (49) *arrive*: V, [____ PP], NP₁ ARRIVE LOC
(50) *arrive*: V, [____ [_{PP} at NP]], NP₁ ARRIVE-AT NP_{at}

Corresponding to the distinct functional structures are the following contrasts (noted by Quirk et al. 1972):

- (51) They arrived at the new Stadium.
*The new Stadium was arrived at.
(52) They arrived at the expected result.
The expected result was arrived at.

The two representations of *arrive* accord with other differences:

- (53) Where will they arrive? — At the new Stadium.
— *At the expected result.

But both *at*-phrases behave as syntactic units:

- (54) Here is the Stadium [_{PP} at which] they arrived.
Here is the result [_{PP} at which] we have just arrived.

Thus, the prepositions *on* and *at* in (37) and (50) function as transitivizers of their verbs. This is a well-developed semantic process in English.

If it should seem odd to associate a semantic unit (the logically transitive relation) with elements that do not form a structural unit,

notice that we do this anyway for discontinuous verbs like *bring . . . to*, *put . . . to shame*, *take . . . to task*. For example, to *bring someone to* means to “revive someone.”

However, in some cases the transitivizing process may result in the structural incorporation of the preposition into the verbal category V. An example might be *care for* in the sense of “tend” or “minister to”; *Mary is caring for the sick snakes*. Here *for* is apparently not separable from the verb: **For what is she caring? — For the sick snakes?* **For the snakes she is caring!* This verb *care for* appears to be the root of the deverbal adjective in *The snakes looked cared-for and complacent*. Negative *un-* may be prefixed: *the uncared-for snakes*.

Now observe that the notation developed for expressing the functional structures of active verbs can also be used to express functional structures for passive verbs. Consider (55) and (56):

- (55) The cat was eating.
- (56) The cat was eaten.

The passive verb (*be*) *eaten* is syntactically an intransitive verb, just as (*be*) *eating* is. The difference in the logical argument structures of (*be*) *eating* and (*be*) *eaten* is that in the former the logical object has been eliminated, but in the latter the logical subject has been eliminated:

- (57) $(\exists y) x \text{ EAT } y$
- (58) $(\exists x) x \text{ EAT } y$

Further, the grammatical subject, *the cat*, plays the role of the logical subject, *x*, in (57), but it plays the role of the logical object, *y*, in (58). This information is expressed in the functional structures:

- (59) $(\exists y) NP_1 \text{ EAT } y$
- (60) $(\exists x) x \text{ EAT } NP_1$

Accordingly, it is possible to provide lexical entries for the passive verbs (*be*) *eaten*, (*be*) *hit*, and (*be*) *relied on*, as in (61)–(63):

- (61) *eat+en*: V, [be ____], $(\exists x) x \text{ EAT } NP_1$
- (62) *hit+∅*: V, [be ____], $(\exists x) x \text{ HIT } NP_1$
- (63) *reli+ed*: V, [be ____ [on]], $(\exists x) x \text{ RELY-ON } NP_1$

As for the agentive *by*-phrase that optionally appears with passives, it can be analyzed simply as an optional prepositional phrase that

functions semantically to identify the logical subject of the passive verb. This is illustrated in (64).

- (64) *eat+en*: V, [be ____ [_{PP} by NP]],
 $(\exists x)(x \text{ EAT } \text{NP}_1 \& x = \text{NP}_{by})$

Let us now compare the passive lexical entries (61)–(63) with those for the corresponding active verbs in (34)–(37). We see that the syntactic contexts are related by the simple rule: [____ (P) NP . . .] → [be ____ (P) . . .]. And the passive functional structures are related to the active functional structures by the operations: “Eliminate NP₁” and either “Replace NP₂ by NP₁” or “Replace NP_p by NP₁. ” These operations will be referred to collectively as the active–passive relation. Since the syntactic contexts appear to be redundant—that is, predictable from the functional structures—there may be no need to state the contextual rule separately. (In a more detailed analysis we would take *be* to be a verb subcategorized for passives, as *get* is: compare Hasegawa 1968, Bresnan 1972, and Emonds 1976.)

The active–passive relation does not apply to the functional structures of the nonpassivizing verbs that have been discussed—which is as it should be. But given the lexical entry to *put* shown in (65), the active–passive relation will produce (66).

- (65) *put*: V, [____ NP PP], NP₁ PUT NP₂ LOC
 (Someone put your clothes into the closet.)
- (66) *put+Ø*: V, [be ____ PP], $(\exists x)x \text{ PUT } \text{NP}_1 \text{ LOC}$
 (Your clothes were put into the closet.)

It will not create **The closet was put your clothes into*, because there is no lexical relation between *the closet* and *put*. (There is, of course, nothing wrong with the phrase *put your clothes into* when the verb is not passivized: *The closet to put your clothes into is the one on the left.*) If there were a lexical relation in English for *put your clothes into*, the active–passive relation might apply to it, as it does for *make use of* in *The closet was made use of*. The set of lexical relations is not fixed: it can change to embody those concepts that become important for communication.³

³ For example, on encountering passives like **The mat is being lain on by the cats*, we find it relatively easy to imagine the mat as an object of some special activity of the cats; when we do this, we seem to be hypothesizing a new, logically transitive, relation of *lying on*.

We can see, then, that it is the lexical relation between the noun phrase and its verb that governs passivization, not the syntactic relation between them. A noun phrase that follows *lie on*, *rely on*, *arrive at*, bears the same syntactic relation to each verb, namely, V [_{PP} P NP]; but the ability of the NP to passivize depends upon its lexical relation to the verb, as expressed in the functional structure. Similarly, *make* is followed by a noun phrase in both (67a) and (67b).

- (67) a. The boys made good cakes.
b. The boys made good cooks.

Yet the lexical relation of this noun phrase to the verb is different in the two examples. In (67b) *good cooks* does not function as an object of the verb (as NP₂), but as what has been called a predicate nominative or a subjective complement (on which see Quirk et al. 1972). Unlike the object, the subjective complement plays a role in determining concord; in English a subjective complement NP agrees in number with the subject. Further, the syntactic NP that functions as a subjective complement never passivizes:

- (68) a. Good cakes were made by the boys.
b. *Good cooks were made by the boys.

An active-passive relation exists in many languages of the world, having highly different syntactic forms. The syntactic form of the relation seems to vary chaotically from language to language. But an examination of functional structures reveals a general organizing principle. Perlmutter and Postal (1977) have proposed that the active-passive relation can be universally identified as a set of operations on grammatical functions: "Eliminate the subject," "Make the object the subject."

A basic assumption is that human languages must be organized for communication, which requires both efficiency of expression and semantic stability. The functional structures outlined here for passive verbs are designed to provide a direct mapping between their logical argument structures and the syntactic contexts in which they can occur. As we will see, with these functional structures in the lexicon of our grammar, we can achieve efficiency in grammatical processing, immediately extracting the logical relation for a word we know from the syntactic form in which it appears (or vice versa). At the same time, the various syntactic forms in which a verb appears are

semantically stable: they are associated with the same underlying logical relation by operations like the active–passive relation.

Previous theories of transformational grammar have provided for semantic stability at the cost of grammatical efficiency: complex sentences can be related to semantically interpretable structures only through long chains of transformational operations on syntactic structures. In contrast, the lexical operations in the theory proposed here need not be involved in grammatical processing at all, although they may be involved in organizing the lexicon for communication (as in learning). Perhaps the active–passive relation belongs to a universal “logic of relations” by which the lexicon of a human language—the repository of meanings—can be organized.⁴

The Interpretation of Passives in Complex Sentences

The preceding section began with the question, How is the logical argument structure of a verb related to the various syntactic contexts in which it appears?

The familiar transformational response to this question is to hypothesize a syntactic deep structure in which logical subjects and objects of verbs correspond directly to their grammatical subjects and objects. Syntactic transformations then map this deep structure into the various surface structures in which the verb appears.

I have proposed an alternative solution, constructed by defining a set of lexical functional structures that provide a direct mapping from the logical argument structure of a verb into its various syntactic contexts. The relations between the functional structures of a given verb in different syntactic contexts can be expressed as operations on its logical argument structure. In this way, as we have seen, the active–passive relation can be expressed as a (universal) relation on lexical functional structures rather than as a transformational operation on syntactic structures.

I will now show how these lexical functional structures permit us to extract, directly from the surface structure of a sentence, information equivalent to that provided by the syntactic deep structures of previous transformational theory. This information will be referred to

⁴ The idea that lexical rules defined on grammatical functions may be universal was suggested to me by Moira Yip. See Yip (1977) for an illuminating study of such a rule in Chinese.

as “the interpretation,” or “the functional interpretation.” In the use of this term I am deliberately excluding the semantic interpretation of pronouns, articles, quantifiers, and other logical elements, which I assume to be provided by a separate inferential system.

In order to interpret a simple sentence it is necessary to find the functional structure of its verb, identify the grammatical functions of its phrases, and assign the phrases their functional interpretation with respect to the verb. These tasks might be performed by any of a number of different procedures, but the tasks themselves are logically separable.

The lexicon provides us with the functional structure of the verb in its immediate syntactic context, as illustrated in (69).

- (69) Mary was annoyed by John.

$$\begin{aligned} \text{annoy+ed: } & V, [be ___ [pp \text{ by NP}]], \\ & (\exists x) (x \text{ ANNOY NP}_1 \& x = \text{NP}_{by}) \end{aligned}$$

To identify the grammatical functions of *Mary* and *John* in sentence (69), we apply the grammatical functions defined in Table 1 to the syntactic structure in which the phrases appear. This is shown in Figure 1.3. We now have the information given in (70).

- (70) $(\exists x) (x \text{ ANNOY NP}_1 \& x = \text{NP}_{by})$

$$\begin{aligned} \text{NP}_1: & \text{Mary} \\ \text{NP}_{by}: & \text{John} \end{aligned}$$

To complete the interpretation of the sentence, it is necessary to assign the phrases their functional interpretation with respect to the verb. This is done by (i) assigning indices to the subject *Mary* and the prepositional object *John*, and (ii) substituting these indices into the

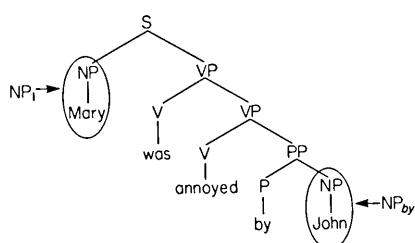


Figure 1.3 Identification of grammatical functions for interpretation of *Mary was annoyed by John*

appropriate argument positions in the lexical functional structure, as shown in (71).

- (71) (i) $(\exists x)(x \text{ ANNOY } NP_1 \ \& \ x = NP_{by})$
 $NP_1: Mary = i$
 $NP_{by}: John = j$
-
- (ii) $Mary = i, John = j$
 $(\exists x)(x \text{ ANNOY } i \ \& \ x = j)$

From (71 ii) it is possible to infer “John annoyed Mary” or, rather, “Someone named John annoyed someone named Mary.” (The notation harmlessly suppresses several logical niceties.)

Now let us turn to the interpretation of passives in complex sentences. In the sentences to be considered here, the main verb has, not an object (or noun phrase complement), but a verbal complement. As an illustration, Figure 1.4 shows the syntactic structure for the complex sentence *John tends to annoy Mary*.

In Figure 1.4 the verb *tend* is immediately followed by an infinitival verb phrase, denoted by \overline{VP} . In English the syntactic category \overline{VP} can have the grammatical function of verbal complement. Just as the syntactic category NP can be distinguished from its grammatical functions as subject (NP_1), object (NP_2), and so on, so must the syntactic verb phrase be distinguished from its grammatical function as verbal complement. The notation $()VP$ is introduced for this purpose and is defined (for English) as a \overline{VP} immediately dominated by VP. Not all infinitival verb phrases function as complements: in particular, those that are immediately dominated by NP do not; for example, in the sentence *To annoy Mary seems to be John's purpose in life*, diagrammed in Figure 1.5, *to annoy Mary* functions as the subject (NP_1) of *seems*. The different grammatical functions of

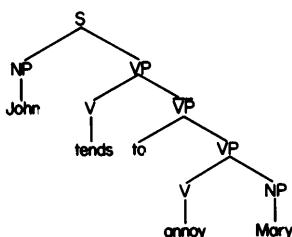


Figure 1.4 Syntactic structure of *John tends to annoy Mary*

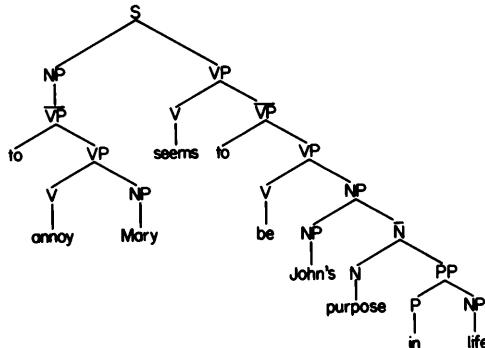


Figure 1.5 Syntactic structure of *To annoy Mary seems to be John's purpose in life*

infinitival verb phrases play an important role in interpreting their understood subjects, but we will be concerned only with verbal complements. (For a full discussion, see Bresnan, in preparation.)

The notation for the verbal complement function, ()VP, is designed to indicate that a verbal complement is functionally incomplete, in a sense to be explained directly. Any verb can be lexically inserted into a $\overline{\text{VP}}$, as *annoy* has been inserted in *John tends to annoy Mary* (Figure 1.4). The syntactic context for *annoy* is satisfied whether or not a subject NP precedes it:

- (72) *annoy*: V, [____ NP], NP₁ ANNOY NP₂

But the functional structure for *annoy* cannot be completely satisfied within the $\overline{\text{VP}}$, because verb phrases do not contain grammatical subjects, by definition. In this sense, a verbal complement is functionally incomplete: the lexical functional structure of its main verb should contain an unsatisfied NP₁.

To interpret such a complex sentence, it is necessary to complete its verbal complement, which means that the unfilled subject NP₁ within the verbal complement must be assigned the index of some phrase in the syntactic structure. The lexical functional structure of a complement-taking verb like *tend* will tell us which phrase provides the index we need:

- (73) *tend*: V, [____ $\overline{\text{VP}}$], TEND ((NP₁)VP)

In (73) the functional structure for *tend* indicates that its verbal complement, ()VP, is to be completed by the index of the grammati-

cal subject of *tend*, NP₁. Notice that this grammatical subject of *tend* does not function as a logical subject of *tend*. *Tend* has no logical subject; it functions semantically as an operator on its functionally closed complement. In this respect, *tend* resembles a modal verb.

Figure 1.6 shows the syntactic structure for *Mary tends to be annoyed by John*. An explicit procedure for providing this structure with its functional interpretation can easily be devised. (There are, of course, many other possible procedures.)

To interpret the structure of Figure 1.6, we use the lexical functional structure for *tend* in the context [____ VP], which is given in (73). Then we identify the grammatical functions of the phrases in the sentence, applying the definitions of NP₁ and ()VP, as shown in Figure 1.7. We now have the information given in (74).

- (74) TEND ((NP₁)VP)
 NP₁: *Mary*
 ()VP: *to be annoyed by John*

The next step in interpreting the sentence is to assign the phrases their functional interpretation with respect to the verb. To do this, we (i) assign indices to the subject *Mary* and to the verbal complement *to be annoyed by John*, and (ii) substitute these indices into the appropriate argument positions in the lexical functional structure. Step (i) is shown in (75).

- (75) TEND ((NP₁)VP)
 NP₁: *Mary* = *i*
 ()VP: *to be annoyed by John* = *f*

Notice that the verbal complement phrase is indexed by *f*, which

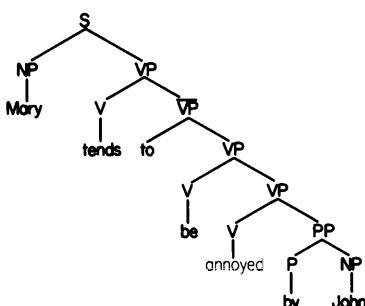


Figure 1.6 Syntactic structure of *Mary tends to be annoyed by John*

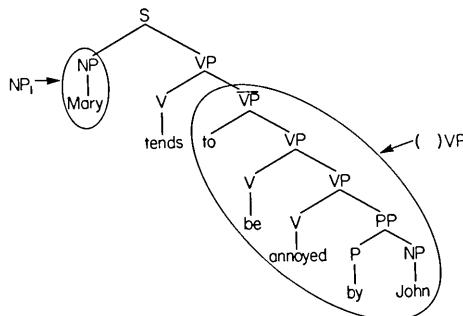


Figure 1.7 Identification of grammatical functions for interpretation of *Mary tends to be annoyed by John*

denotes a function. The index f is a function of subject and object indices; when f is applied to the index i , it tells us that the verbal complement that it indexes applies to i —to *Mary*, in this case. Making the appropriate substitutions, step (ii), we arrive at (76).

- (76) *Mary = i, to be annoyed by John = f*
 $\text{TEND } (f(i))$

Since *to be annoyed by John* has not yet been interpreted, all that (76) really tells us is that Mary tends to . . . To complete the interpretation of the sentence, we must now interpret *(to) be annoyed by John*. From (76), we already know one thing about the interpretation of this phrase: it “applies to” i . What that means, in turn, is that in the functional interpretation of f , $\text{NP}_1 = i$. Thus, we start anew with the information in (77).

- (77) $f = \text{to be annoyed by John}$
 $\text{NP}_1 = i$

Now, just as we did in the case of the simple sentence, we find the lexical functional structure of *annoyed* in the context [*be* ____ [_{PP} *by* *NP*]] and identify the grammatical functions of the phrases in the syntactic structure, which is the $\overline{\text{VP}}$ in Figure 1.7. We now have the information in (78).

- (78) $f = \text{to be annoyed by John}$
 $\text{NP}_1 = i$
 $(\exists x) (x \text{ ANNOY } \text{NP}_1 \& x = \text{NP}_{by})$
 $\text{NP}_{by}: \text{John}$

To complete the interpretation of f , we must (i) assign the prepositional object *John* an index, and (ii) substitute indices into their appropriate positions in the lexical functional structure. The result is called $f(i)$:

$$(79) \quad f(i): \text{John} = j, (\exists x) (x \text{ ANNOY } i \ \& \ x = j)$$

Taking (76) and (79) together, we have (80):

$$(80) \quad \text{Mary} = i, \text{TEND} (\text{John} = j, (\exists x) (x \text{ ANNOY } i \ \& \ x = j))$$

Notice that in (80) a comma loosely connects each of the formulas $\text{Mary} = i$ and $\text{John} = j$ to the formula following it. This comma connective can be construed to mean that the person designated by the index has the property described by the formula. Then from (80) we can infer that Mary has a complex tendency, which consists of being in an annoying relation with John, where Mary is the one annoyed (the logical object of *annoy*) and John is the annoyer (*Mary tends to be annoyed by John*).

If we apply the interpretive procedure outlined above to the sentence *John tends to annoy Mary*, we arrive at (81).

$$(81) \quad \text{John} = i, \text{TEND} (\text{Mary} = j, (i \text{ ANNOY } j))$$

From (81) we infer that John has a complex tendency, which consists of annoying Mary; again, John is the annoyer and Mary the annoyed.

The point to be emphasized is that all of the functional information that is relevant to the interpretation of these sentences — the fact that Mary is the logical object of *annoy*, and so on — has been extracted from the surface structure and the lexicon. There is no need to compute the grammatical relations of *John* and *Mary* in some deep structure tree in order to find their functional relations in the sentence. In fact, there is no need to compute the surface syntactic structure prior to determining the grammatical functions of its parts: the structural and functional relations can be determined by procedures operating simultaneously, in parallel.

The same interpretive procedure can be applied to sentence (82).

$$(82) \quad \text{John tries to annoy Mary.}$$

The syntactic form of (82) is identical to that for *John tends to annoy Mary*, shown in Figure 1.4. But the lexical functional structure of *try*

differs in one important respect from that of *tend*: the grammatical subject of *try* is also the logical subject of *try*, as shown in (83).

- (83) *try*: V, [____ $\overline{\text{VP}}$], $\text{NP}_1 \text{ TRY } ((\text{NP}_1) \text{VP})$

By following the interpretive procedure just outlined, we can derive the following interpretation of (82):

- (84) *John = i, i TRY (Mary = j, i ANNOY j)*

Similarly, sentence (85) has the same syntactic structure as that shown in Figure 1.6 for *Mary tends to be annoyed by John*, but its interpretation will be as in (86).

- (85) *Mary tries to be annoyed by John.*

- (86) *Mary = i, i TRY (John = j, ($\exists x$) (x ANNOY i & x = j))*

Observe that in both (84) and (86) *Mary* is the logical object of *annoy*; the interpretations differ in that *John* is the logical subject of *try* in (84) and *Mary* is the logical subject of *try* in (86).

Before proceeding further, it should be noted that some noun phrases are meaningless in themselves but derive an interpretation from restricted contexts. One example is the expletive *there*:

- (87) *There's a knack to it.*

There has an existential meaning in contexts of the form: [____ *be* NP . . .]. This special interpretation can be represented in the lexical entry for *be*, as indicated in part in (88). (See Jenkins 1975 for a study of the syntactic contexts of *be* in existentials; he gives evidence that the syntactic contexts must be base-generated.)

- (88) *be*: V, [____ NP], $\text{NP}_1 \text{ BE } \text{NP}_2$,
 $\text{THERE BE } \text{NP}_2 \equiv \text{NP}_2 \text{ EXISTS}$

The entry provided for *there* itself is shown in (89).

- (89) *there*: [_{NP} ____], THERE

Although (89) permits *there* to be inserted into a NP position, *there* will find an interpretation only in the appropriate contexts of *be*. To derive this interpretation, *there* will simply be treated as its own index (THERE) and substituted into an appropriate position in a lexical functional structure. It will follow that sentence (90) will have no

interpretation, but sentence (87) will be correctly interpreted, as in (91).

- (90) *There sang.
 - (91) There is a knack to it.
- THERE BE $i \equiv i$ EXISTS
 $i = a$ *knack to it*

For the complex sentence *There tends to be a knack to it*, there is lexically inserted in its position as grammatical subject of *tend*. The interpretive procedure automatically provides us with (92); then we obtain (93) from (88).

- (92) TEND (THERE BE i , $i = a$ *knack to it*)
- (93) TEND (i EXISTS, $i = a$ *knack to it*)

In other words, sentences like *There tends to be a knack to it* can simply be base-generated; if the meaningless index THERE cannot be eliminated by the rules of interpretation, the sentence is functionally ill-formed.

It is possible to use the same approach in dealing with fragments of idioms, like *the cat* in (94).

- (94) The cat tends to get his tongue.

The meaning of the idiom is simply listed in the lexicon and its meaningless parts are treated as their own indices and passed through the functional structures until they find their interpretation. The interesting aspect of this approach is that it requires that idioms — despite their abnormal meanings — have normal syntactic structure in order to be interpreted. This property of idioms is in fact general and well known.⁵

Just as some meaningless noun phrases — expletives and idiom fragments — must serve as their own indices, so certain noun phrases must derive their index from other phrases. An example is the reflexive pronoun:

- (95) John likes himself.

Reflexives have a very simple analysis in the present framework. The

⁵ This consequence was pointed out to me by Jane Grimshaw. See Katz (1973) for a recent discussion of the structural properties of English idioms.

general rule for their functional interpretation is given in (96). (For a more complete analysis, see Bresnan, in preparation.)

- (96) A reflexive pronoun is coindexed with the subject, NP_1 .

This rule applies automatically in the course of the functional interpretation of the sentence. That is, as soon as we arrive at the information “ NP_2 : reflexive pronoun,” we can assign NP_2 the index of the current NP_1 . In this way sentence (97) is automatically assigned the indicated interpretation.

- (97) John tries to like himself.

John = i, i TRY (i LIKE i)

One of the consequences of rule (96) is that the reflexive pronoun cannot function as subject: in that situation there would be no NP_1 to derive its index from. Thus both (98) and (99) must be ill-formed:

- (98) *Himself likes John.

- (99) *Himself is liked by John.

It is also possible to reformulate the Noncoreference Rule (20) as a condition on this indexing procedure: informally, a nonpronominal noun phrase cannot be coindexed with a noun phrase that precedes and commands it.

Let us now return to the question of the active–passive relation. In previous theories of transformational grammar, passive sentences are derived by syntactic transformations. The relation between active and passive sentences in English is expressed by assigning passive sentences activelike deep structures, then transformationally displacing the syntactic subject (the first NP to the left of the verb) into a *by*-phrase and moving the syntactic object (the first NP to the right of the verb) into the original position of the subject. These theories do not explain the dependence of the transformational relation on grammatical functions; indeed, the dependence is not even recognized, since transformations are defined as structure-dependent operations, and functional information is not expressed in the syntactic structures to which transformations apply. Additional principles have to be invoked to make sure that “the first NP to the right of the verb” is the correct one, namely, the grammatical object. For example, in a sentence like (100) the first NP to the right of the verb, *disapprove of*, can be *children*:

- (100) Doctors may disapprove of children smoking.

Yet *children* is the wrong NP for passivization:

- (101) *Children may be disapproved of smoking by doctors.

The correct NP is the one that functions as the object of *disapprove of*:

- (102) Children smoking may be disapproved of by doctors.

It has required some ingenuity to explain this fact in the transformational theory of passivization, yet it and many other facts equally difficult to explain are simple and obvious consequences of the alternative theory proposed here. (For one transformational account of (100)–(102), see Bresnan 1976a.)

Likewise, “the first NP to the left of the verb,” required by the passive transformation, has to be the grammatical subject of the verb. Yet passive verbs appear in constructions where there is no subject, such as the verbal complement constructions already discussed. For example, to account for sentences like (103) —

- (103) Mary tends to be annoyed by John.

— it was proposed (in Bresnan 1972) that the verb *tend* takes a sentential complement in deep structure, as shown in (104).

- (104) [s[_{NP}Δ] [v_P tend [_S John annoy Mary]]]

The dummy subject, Δ, was designed to account for the fact that *tend* is logically subjectless. The passive transformation could apply to the sentential complement of *tend*, and then a raising transformation would move the passivized subject into the subject position for *tend*, replacing Δ. The raising transformation had to be made obligatory in some way, because the fact is that *tend* never appears with sentential complements:

- (105) *It tends that John annoys Mary.

*It tends for John to annoy Mary.

In English there are quite a few verbs like *tend*, which simply take infinitival complements. (See Kajita 1968 for a study of these verbs in a transformational framework.)

In the case of verbs like *try*, the transformational analysis requires even more ingenuity. Perlmutter (1968) showed that such verbs are subject to a "like-subject constraint" that requires their deep structure complement subjects to be identical to the main verb subjects:

- (106) *John tried for a doctor to examine him.
- (107) John tried to see a doctor.

Janet Fodor (1974) demonstrated that this constraint has to be applied, not in deep structure, but after the passive transformation has applied in the complement:

- (108) John tried to be examined by a doctor.
- (109) *John tried for a doctor to be seen by him.

She showed, moreover, that the constraint itself is not enough to get the correct results; the subject in the complement, however it arrived in subject position, has to be deleted, obligatorily:

- (110) *John tried for him(self) to see a doctor.
- (111) *John tried for him(self) to be examined by a doctor.

And in some cases the correct complement subject might never "arrive." For example, unless both passive and raising transformations apply to the deep structure (112), it is impossible to derive (113).

- (112) [_s Mary tried [_s it not to seem [_s John annoy her(self)]]]
- (113) Mary tried not to seem to be annoyed by John.

Recently, Chomsky and Lasnik (1977) have proposed that a special "rule of control," a lexical property of *try*, applies to the surface structures of sentences containing *try*, and rules out all of the bad sentences that are derived from (112):

- (114) *Mary tried for it not to seem that John annoys her.
- *Mary tried for it not to seem that she is annoyed by John.
- *Mary tried for John not to seem to annoy her.
- *Mary tried for her not to seem to be annoyed by John.

They go on to suggest that lexical insertion might apply, not to deep structures, but to structures that have undergone all the requisite transformations. These "surface structures" would contain a record of all the movements in their transformational derivations.

The simple and obvious solution to all these problems was pro-

posed by Brame (1976): the verb *try* does not take a sentential complement at all; it is simply subcategorized to take an infinitival verb phrase complement — or \overline{VP} , in the terms used here; the fact that passivized verbs appear in the complement to *try* simply indicates that there is no passive transformation. This, of course, is the solution adopted in the present theory.⁶

A question that must be asked is why the passive transformation has been perceived as a structure-dependent operation. The answer seems to be that certain noun phrases can be passivized (that is, they can be preposed by the passive transformation) even though they bear no logical relation to the passivizing verb. An example:

- (115) The hot dog is believed to be dangerous to our health.

In (115) *the hot dog* is not the logical object of *believe* but the logical subject of *to be dangerous to our health*. In other words, we can't "believe the hot dog." The logical object of *believe* is the proposition that the hot dog is dangerous to our health. From this it has been concluded that the passive transformation is blind to grammatical functions — that it is purely structure-dependent. (This reasoning appears in Bresnan 1972, Wasow 1977, Anderson 1977, and elsewhere.)

As can now be seen, this reasoning confuses grammatical functions with logical functions: it is based on the assumption that if *the hot dog* is not a logical object of *believe*, it cannot have been a grammatical object of *believe*. But the assumption is not necessary.

Once grammatical functions are distinguished from logical functions, it is easy to account for sentences like (115). The active verb *believe* is assigned the lexical representation in (116).

- (116) *believe*: V, [____ NP \overline{VP}], $NP_1 \text{ BELIEVE } ((NP_2)VP)$

The active–passive relation provides the representation in (117).

- (117) *believe+d*: V, [*be* ____ \overline{VP}], $(\exists x) (x \text{ BELIEVE } ((NP_1)VP))$

Observe that the lexical functional structure in (117) is almost identical to that for *tend*, repeated here:

- (73) *tend*: V, [____ \overline{VP}], $TEND ((NP_1)VP)$

⁶ Brame (1976) argues on independent grounds for base-generation of structures that have previously been derived through passive, equi-NP deletion, and other transformations.

Therefore, the interpretive procedure already outlined will automatically provide the desired interpretation for sentence (115).

In short, we simply analyze *believe* as having a grammatical object that serves as the logical subject of its verbal complement. However, for other verbs, such as *compel*, the lexical representation (and therefore the functional interpretation) is different: their grammatical objects serve also as their logical objects:

- (118) We must compel John to see a doctor.

compel: V, [____ NP $\overline{\text{VP}}$], $\text{NP}_1 \text{ COMPEL } \text{NP}_2 ((\text{NP}_2)\text{VP})$

But — as expected — the grammatical objects of both types of verbs can be reflexive pronouns:

- (119) We compel ourselves to be honest.

- (120) We believe ourselves to be honest.

Thus the difference between *compel* and *believe* parallels the difference between *try* and *tend*.

The Need for Transformations

The analysis of the active–passive relation that has been described in the preceding sections permits a great simplification of the syntactic component of grammar; all of the sentences discussed there have “deep structures” that are identical to their surface structures. This immediately raises the question: Is there any need at all for a level of deep structure distinct from surface structure? Or — to put it slightly differently — is there any need for syntactic transformations that map syntactic structures into syntactic structures?

In answer to this question, let me first point out that the active–passive relation is *function-dependent*, in the sense that it relates (lexical) functional structures. And the active–passive relation is not unique; it can be shown that the transformations that interact with the passive can themselves be expressed as function-dependent relations (see Bresnan, in preparation). Moreover, the interpretive procedure that has been constructed is also function-dependent, in that it combines lexical functional structures. Syntactic transformations, on the other hand, are *structure-dependent*: they are assumed to map syntactic structures into syntactic structures. Therefore, let me reformulate the question. Is there any need for structure-dependent rules of grammar?

Recall that some of the earliest work in transformational grammar was devoted to demonstrating the empirical inadequacies of phrase structure grammars for natural languages. (See Levelt 1974, vol. 2, for a recent survey.) Although phrase structure grammars can naturally represent the fact that words are grouped hierarchically into phrases, many cross-phrasal regularities in natural languages cannot be adequately described within these grammars. To give just one illustration, a verb in English normally shows number agreement with its subject noun phrase, immediately to its left:

- (121) a. The problem *was/*were* unsolvable.
 b. The problems *were/*was* unsolvable.

Here the choice of plural *were* or singular *was* must depend on agreement with the number of *the problem(s)*. This type of local regularity could be described within a phrase structure grammar by means of context-sensitive rules, as could the inverted forms in (122), although there would be a certain redundancy of description.

- (122) a. *Was/*were* the problem unsolvable?
 b. *Were/*was* the problems unsolvable?

However, in many cases the number of a verb agrees with that of a noun phrase at some distance from it:

- (123) a. **Which problem* did your professor say she thought *were* unsolvable?
 b. *Which problem* did your professor say she thought *was* unsolvable?
 (124) a. *Which problems* did your professor say she thought *were* unsolvable?
 b. **Which problems* did your professor say she thought *was* unsolvable?

In (123) and (124) the number of *was/were* agrees with *which problem(s)*. Furthermore, this type of syntactic dependency can extend as far as memory or patience permits:

- (125) a. Can you tell me which problem your professor is likely to have said she thought *was* unsolvable?
 b. Can you tell me which problem your professor is likely to have said she thought everyone knew *was* unsolvable?

In contrast to the local type of number agreement in (121) and (122), the distant type of agreement in (123)–(125) cannot be adequately described even by context-sensitive phrase structure rules, for the possible context is not correctly describable as a finite string of phrases.

The transformational solution to this problem is to state number agreement as a local regularity and to formulate a transformation of Question Movement, which can displace a phrase to an interrogative position. To illustrate, (123b) would be formed from the structure shown in Figure 1.8.

The Question Movement transformation provides a solution to many other syntactic problems unrelated to number agreement. For example, some verbs of English, like *put*, *dart*, *glance*, require a prepositional phrase complement in simple sentences. *Put* requires both a direct object noun phrase and a locative prepositional phrase:

- (126) a. You put the diamonds into a sack. V NP PP
 b. *You put the diamonds. *V NP
 c. *You put into a sack. *V PP
 d. *You put the diamonds a sack. *V NP NP
 e. *You put the diamonds stealthily. *V NP Adv

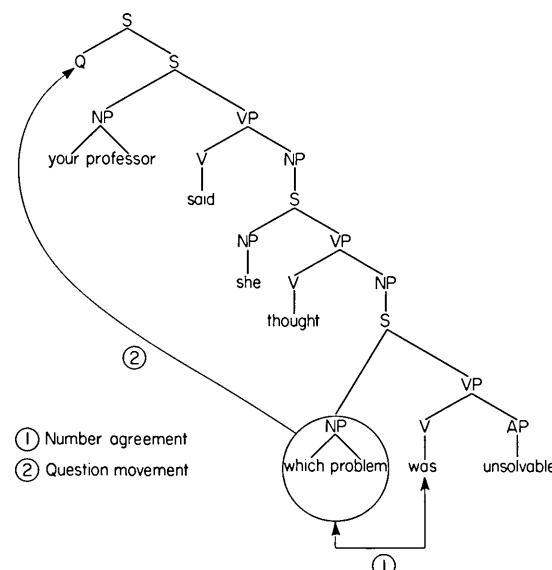


Figure 1.8 Transformational derivation of example (123b), *Which problem did your professor say she thought was unsolvable?*

(We distinguish this *put* from the athletic *put* in *put the shot*.) Yet in certain complex interrogative constructions, (126b,c,e) can occur as subsentences. For example, (126b) so occurs in (127).

- (127) Into which sack do you think you put the diamonds?

Question Movement transforms the structure shown in Figure 1.9 into that for (127) by displacing the prepositional phrase to the interrogative position. Note that in the structure of Figure 1.9 *put* has a prepositional phrase complement.

Now observe that, as in Figure 1.8, the noun phrase *which sack* can itself be displaced to interrogative position, leaving the preposition *into* behind:

- (128) Which sack do you think you put the diamonds into?

The subsentence *you put the diamonds into* is not well-formed as an independent sentence, but its occurrence in (128) follows from the application of Question Movement. Conversely, the subsentence *you put the diamonds into the box*, which is well-formed, creates ungrammaticality when it occurs in (129):

- (129) *Which sack do you think you put the diamonds into the box?

The reason is that (129) is not a well-formed source for Question Movement:

- (130) *[Q you think [you put the diamonds into the box which sack]]

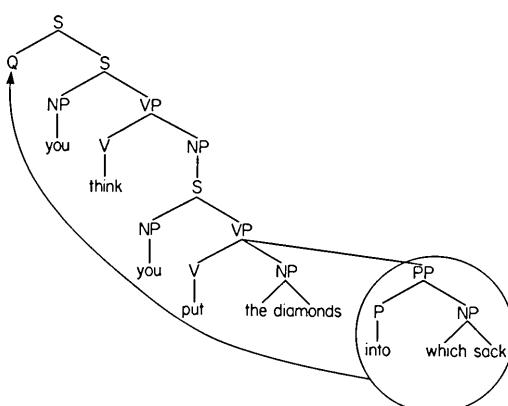


Figure 1.9 Transformational derivation of example (127), *Into which sack do you think you put the diamonds?*

Once again, Question Movement permits a simple and natural statement of a local regularity that cannot be adequately described by means of phrase structure rules alone.

Now let us view Question Movement in reverse. When a sentence begins as *What . . .*, it is not clear exactly where *what* will fit into the functional interpretation. This can be true even over extended fragments of the sentence, as examples like (128) showed. Viewed in reverse, Question Movement relates a phrase that is in a displaced position, outside of its clause, to some position within the clause where a grammatical function can be assigned. Since the interrogative phrase has no assigned grammatical function in its displaced position, (inverse) Question Movement is not a function-dependent rule of English.

Consequences

Let us now consider some of the consequences of reorganizing transformational grammar by eliminating from the syntactic component all rules that are function-dependent, in the sense explained in the preceding section. The grammar will contain a set of phrase structure rules, which define the basic, or canonical, sentence patterns of the language. The lexicon will contain a set of lexical functional structures, which provide a direct mapping between the logical argument structures of words and the syntactic patterns in which they appear. Rules of functional interpretation will combine functional structures to associate composite meanings with complex sentences. A restricted class of structure-dependent transformations will deform or (if they apply inversely) restore the basic sentence patterns, associating displaced phrases with their functional positions.

As outlined, this theory of grammar has interesting consequences for linguistics and psychology. A major consequence — the emergence of the English active-passive relation as an instance of a linguistic universal — has already been discussed (pp. 20–23). In what follows we can only glance at other consequences.

Rule ordering In the discussion of the interpretation of passives, a simple procedure was defined for combining functional structures — a procedure that is recursive, or iterative. This recursiveness is necessary simply because one functional structure can be embedded in

another, and each is interpreted by the same procedure. The choice of lexical items is quite free, up to their ability to receive a combined interpretation, and this depends only on their intrinsic structure. As a result, sentences like (131) are directly generated and automatically provided with the correct functional interpretations:

- (131) a. John wants to appear to be loved by Mary.
- b. John appears to want to be loved by Mary.
- c. Mary is expected to be elected.

By contrast, in the transformational analysis of these sentences, passive, raising, and equi-NP deletion transformations are assumed to apply cyclically to each other's outputs, resulting in different orders of application in two derivations (131a,b) or in multiple applications in the same derivation (131c). It has often been noted that such transformations do not appear to be extrinsically ordered with respect to each other (see Koutsoudas 1972, 1973, and the references cited there; also Chomsky and Lasnik 1977). This property is explained by the theory proposed here: there is no extrinsic ordering among lexical representations.⁷

In previous transformational theory, the passive transformation has another unexplained ordering property: it never applies to a noun phrase that has already been moved by Question Movement (QM):

- (132) a. The boys asked Q they should talk to *which girls* ⇒ (by QM)
- b. The boys asked *which girls* they should talk to. ⇒ (by passive)
- c. **Which girls* were asked they should talk to by the boys.

If there were a structure-dependent passive transformation, there would be no reason why it should not apply to *which girls* in (132b), for that is the first NP to the right of the verb. As a function-dependent rule, however, passivization can affect only the grammatical object of the passivizing verb, and in (132b) the displaced interrogative NP (*which girls*) is not the grammatical object of *ask*. This explanation is confirmed by the observation that passivization can apply to an interrogative NP that has *not* been moved by

⁷ This consequence is pointed out by Schmerling (1977). She proposes a new analysis of English imperatives that provides some evidence for a nontransformational approach to passivization like the one advanced here.

Question Movement, so long as that NP is the object of the verb:

- (133) a. Q the boys asked *which girls* question \Rightarrow (by passive)
- b. Q *which girls* were asked questions by the boys \Rightarrow (by QM)
- c. *Which girls* were asked questions by the boys?

One attempt to explain such observations in previous transformational theory was to propose that Question Movement belongs to a class of so-called postcyclic transformations that apply after the cyclic transformations like the passive. But the fact that Question Movement applies to structures that are already passive — as in (134b) — is an immediate consequence of the present theory.

- (134) a. Q which boys asked the girls questions
 (active form) \Rightarrow (by QM)
 Which boys asked the girls questions?
- b. Q the girls were asked questions by *which boys*
 (passive form) \Rightarrow (by QM)
 Which boys were the girls asked questions by?

Phonological effects of transformations It has been recognized for some time that transformations that move or delete material can produce phonological perturbations in sentences. A very well known type of example was pointed out by L. Horn, who observed that a sentence like (135), pronounced without contracting *want to* to *wanna*, is ambiguous between (a) and (b), whereas (136) is not.

- (135) Teddy is the man I want to succeed.
 - a. Teddy is the man (whom) I want to to succeed.
 “I want Teddy to succeed”
 - b. Teddy is the man (whom) I want to succeed_.
 “I want to succeed Teddy”
- (136) Teddy is the man I wanna succeed.
 = Teddy is the man (whom) I want to succeed_.
 “I want to succeed Teddy”

When the relative pronoun derives from an underlying position

between *want* and *to*, contraction to *wanna* is blocked, as in (135a). Question Movement can be shown to produce the same effects.

Yet certain transformations that have been assumed to move or delete material do not behave as expected: they produce no phonological perturbations at all; their structural effects are “invisible” to the contraction rules. For example, the equi-NP deletion transformation, though it is supposed to delete a pronoun from between *want* and *to*, fails to block contraction, as we see in (137).

- (137) a. I wanna succeed Teddy.
 b. I want [pro (= I) to succeed Teddy]

(This fact and its implications were observed by Baker and Brame 1972 and Brame 1976.)

Similarly, the subject raising transformation does not affect the contraction of *going to* to *gonna* in (138).

- (138) a. There's gonna be a movie made about us.
 b. There is going [to be a movie made about us]

In the transformational theory, *there* would first be inserted into the complement of *be going* on a lower transformational cycle as the subject of *to be . . . made*; it would then be moved into position as subject of *be going* on a higher transformational cycle — that is, it would be moved from a position between *going* and *to be . . . made*, in which case contraction of *going to* should be blocked. If *there* were inserted directly as subject of the higher cycle, (139) would be produced.

- (139) There's a movie gonna be made about us.

The unexpected behavior of these transformations is an immediate consequence of the present theory. Infinitival complements are not derived by equi-NP deletion and subject raising transformations; they are generated directly by the phrase structure rules. The verbs *want* and *be going* simply have infinitival verb phrase complements. In this respect they are very much like modal verbs. Unlike modals, however, they do not invert:

- (140) a. Will you see him?
 b. *Wanna you see him? vs. Do you wanna see him?
 c. *Are gonna you see him? vs. Are you gonna see him?

(On the verbal nature of the English modals, see Pullum and Wilson 1977.)

Language acquisition In his major study of the early stages of language acquisition, Brown (1973) has observed that the use of *wanna* in sentences like *I wanna go* is acquired by children before the use of *want* with a full sentential complement, as in *I want John to go*. This order of acquisition can be considered something of a puzzle, given a transformational analysis of such sentences, in which the infinitive is derived by deletion from an underlying full sentential complement containing a pronominal subject. How can the derived structure be mastered before the basic structure? But in the present theory, the verb + infinitive construction is a basic structure, like the modal + infinitive construction. (See Chapter 7 for further discussion of the acquisition of VP complements.)

Again, in the usual transformational analysis of passivization (for example, that of Chomsky 1965), a short passive, *John was killed*, is transformationally derived from a long passive, similar to *John was killed by someone*, by deletion of the *by*-phrase. In contrast, in the theory proposed here both short and long passives are basic structures; the long passive, however, requires semantic interpretation of the *by*-phrase, because the agent is present in this prepositional phrase from the beginning. As Maratsos reports in Chapter 7, there is no known evidence that long passives are acquired by children before short passives; in fact, short passives are spontaneously produced before long ones (Brown 1973).

Although the present theory does not predict that short passives must be acquired before long passives, it does suggest that what is crucial to the acquisition of long passives is the ability to integrate the postverbal prepositional phrase semantically. And Maratsos and Abramovitch (1975) do in fact present evidence that the comprehension of long passives by children crucially involves the semantic integration of an appropriate prepositional phrase. They report that nonsentences like **The cat is licked the dog* and **The cat is licked po the dog* (*po* being a nonsense syllable) are neither imitated nor interpreted as passive sentences by children, whereas *The cat is licked by the dog* and **The cat is licked of the dog* are interpreted as passives; furthermore, *from* is sometimes substituted for both *of* and *by* in imitations. They remark: "Apparently *of* was able to mediate

the passive schema because of the common membership of *of* and *by* in the class of prepositions; the fact that in imitations *from*, another preposition, was the only other morpheme commonly substituted (once even for *po*) where *by* should appear further indicates that children code the *by* of passives not as a unique morpheme but as one belonging to the general class of prepositions.”

Derivational complexity The theory proposed here will yield a very different assessment of derivational complexity from those associated with previous theories of transformational grammar. Although further research is required in this area, I will make two suggestions that may be of interest.

The first suggestion arises from the proposed treatment of the verbal complement system. Recall that infinitival complements to verbs like *tend* and *try* are generated directly in the base, by means of a phrase structure rule $VP \rightarrow V \overline{VP}$. Lexical functional structures have been constructed for the verbs *tend* and *try* in these syntactic contexts, and an explicit procedure has been designed for interpreting the construction by indexing the grammatical subject and the verbal complement. The verbal complement is indexed by a function f , which is then itself interpreted by reapplying the procedure. As a result, *Mary tends to . . .* can be partially interpreted before proceeding to the interpretation of the complement (*to*) *be annoyed by John*.

A point that is of interest here is that fragments of sentences, like *Mary tends to* or *Mary tries to*, frequently occur in discourses:

- (141) A: Does Sally still get silly at staff parties?
 B: She tends to.

It is natural to suppose that in comprehending A’s question, B has already interpreted $f = \text{get silly at staff parties}$; so in replying, B can simply retrieve the index, apply it to the current subject, and insert both into the lexical functional structure for *tends*. Thus, this theory suggests that sentences involving ellipsis (141B) are derivationally less complex than sentences without ellipsis (141A).

Fodor, Bever, and Garrett (1974) refer to psychological research that bears on this suggestion:

In an unpublished experiment by Jenkins, Fodor, and Saporta (1965), similar kinds of structural differences were evaluated for their

effects on complexity: for example, such variants of the comparative construction as "John swims faster than Bob swims," "John swims faster than Bob," "John swims faster than Bob does." If DTC [the derivational theory of complexity] is true, relative complexity should increase from the first to the third sentence, since the first sentence is fewer transformational steps from its base structure than either of the others, and the third sentence requires one step more than the second for its derivation. . . . When tachistoscopic thresholds were measured for such sentences, however, the first type turned out to be most difficult, whereas the other two types were indistinguishable. (p. 324)

Verb phrase ellipsis has proved to be a very recalcitrant problem in previous transformational theories, because ellipsis can occur in what have been considered transformed structures. For example, in (142) both *there*-insertion and raising would have to have applied in the syntactic formation of B's answer.

- (142) A: Is there a chance that she will succeed?
 B: There seems to be.

Recall that in the theory proposed here, the expletive *there* is base-generated as the subject of verbs like *seem* and *tend*, and is interpreted by normal procedures (see pp. 30–31). Thus, the existence of such fragments as (142B) poses no problem in this theory; no complication of the theory is required to explain it along the lines proposed here.

In the transformational theory, however, *there*-insertion structurally displaces an underlying subject NP, which is shifted to the right of *be*. Thus (142B) would have to be derived from a structural source containing the displaced NP. The NP would then have to be either deleted under identity to part of the preceding discourse (Sag 1976) or interpreted as identical to part of the preceding discourse (Wasow 1976, Williams 1977). Only in that way would it be possible to account for the contrast between (142) and (143).

- (143) A: Do you like succotash?
 B: *There seems to be.

In the present theory this contrast follows from the fact that *f = like succotash* is uninterpretable when applied to *there*.

What is unexplained in the transformational theory is why verb

phrase ellipsis is subject to the same conditions as pronominalization:

- (144) a. John will want to go if Mary wants to.
- b. John will want to if Mary wants to go.

In (144a) *Mary wants to* can be interpreted as “Mary wants to go.” But in (144b) *John will want to* is interpreted as meaning something other than “John will want to go.” Note that in (144b) *John will want to* precedes and commands *Mary wants to go*. (Recall the discussion of this notion of precedes and commands in connection with Rule (20).) When this structural relation is changed, cointerpretation is possible:

- (145) If John wants to, Mary will (also) want to go.

In (145) *John wants to* precedes but does not command *Mary will (also) want to go*, because the former is contained in a subordinate clause that excludes the latter. It should also be noted that the insertion of a heavy pause before *if* in (144b) may “break” the subordination of the *if*-clause, making cointerpretation possible.

These facts have an explanation in the present theory. Verbal complement anaphors can be generated in the base by means of phrase structure rules such as $\overline{VP} \rightarrow to (VP)$. Since the Noncoreference Rule (20) has been reformulated as a condition on the indexing procedure (p. 32), it can be applied to verbal complement indexing as well as to noun phrase indexing. This will mean that an anaphor — pronoun or elliptical VP (*to Ø*) — cannot be coindexed with a full, nonanaphoric phrase that the anaphor precedes and commands. Consequently, (146) will be parallel to (147).

- (146) *She_i* will try to go if *Mary_j* wants to go. $i \neq j$
- (147) John will want *to_f* if Mary wants *to go_g*. $f \neq g$

In both of these examples the anaphors (*she* and *to*) precede and command the full, nonanaphoric phrases (*Mary* and *to go*). But when the anaphors precede and command other *anaphors*, nothing prevents their coindexing.

- (148) *She* will try to go if *she* wants to go.
- (149) John will want *to* if Mary wants *to*.

As predicted by the hypothesis that such anaphors are freely cointerpreted except where prohibited by rules of the sentence grammar,

both types of anaphors can be understood as referring to the same things in these examples.

The unification of pronominal and elliptical anaphora achieved in this theory is itself a major consequence, having many interesting implications for linguistics. (See Bresnan, in preparation.)

The second suggestion regarding derivational complexity concerns the relative complexity of passives and actives. If the comprehension of a sentence involves the extraction of its functional interpretation from its surface form, the present theory suggests that the main task in the comprehension of simple sentences is to associate nouns with the functional structures of verbs. Thus in this theory the same task is involved in comprehending an active sentence like (150) as in comprehending a passive sentence like (151).

- (150) The girl hit the boy.
- (151) The boy was hit by the girl.

Specifically, the noun phrases must be assigned their functional interpretation with respect to the verb. In the procedure outlined for the interpretation of passives, indices are assigned to the noun phrases and then substituted into the lexical functional structure in their appropriate positions. In this procedure, we begin with the information displayed in (152) for the active and (153) for the passive.

- (152) $NP_1 \text{ HIT } NP_2$
 $NP_1: \text{the girl}$
 $NP_2: \text{the boy}$
- (153) $(\exists x) (x \text{ HIT } NP_1 \& x = NP_{by})$
 $NP_1: \text{the boy}$
 $NP_{by}: \text{the girl}$

Note that the lexical functional structure for the passive (153) is not identical to that for the active (152). In (153) *the girl* is indirectly associated with the logical subject of *hit*. Therefore, recognizing that *the girl* indeed is the logical subject of *hit* might take longer in (151) than in (150).

However, it is plausible to suppose that this recognition could be facilitated by additional information about the logical subject of a verb (the *x* argument) or the logical object (the *y* argument). For example, if we know that the logical subject of *eat* must be animate, that hot dogs are inanimate, and that girls are animate, we might more rapidly

recognize that *the girl* is the logical subject of *eat* in (154); consider (155):

- (154) The hot dog was eaten by the girl.

- (155) $(\exists x)(x \text{ EAT NP}_1 \& x = \text{NP}_{by})$

|
ANIMATE

NP₁: *the hot dog*

NP_{by}: *the girl*

These remarks may contribute to an understanding of experimental results like those of Slobin (1966b). Using a picture-verification test with six- to seven-year-old children, Slobin found a complexity difference between passives and actives, but only when the passives were "reversible." A reversible passive is one whose noun phrases can be sensibly interchanged (*The girl was hit by the boy*, *The boy was hit by the girl*); an example of a nonreversible passive would be *The kite was flown by the girl*. Nonreversible passives were found *not* to be more complex than their corresponding actives.

But more recently, Forster and Olbrei (1973) have found significant differences between responses to actives and passives by measuring decision latencies (how quickly subjects decided whether the example was "an intelligible grammatical sentence") and by measuring the mean number of lexical items correctly identified during their "rapid serial visual presentation" procedure. The actives were faster or less difficult than the passives. Moreover, Forster and Olbrei found only weak or insignificant reversibility effects in their experiments, and the reversibility effect was independent of the syntactic effect (passive vs. active). Forster (1976) comments on Slobin (1966b) as follows: "From my point of view, the problem with this experiment is that it used a picture verification technique. That is, after seeing the sentence, the subject is shown a picture, and must say whether the sentence is a true description of the picture. Apparently there are some grounds for doubting that this procedure taps on-line sentence processing."

If Forster's experimental procedures do tap "on-line sentence processing," then they show that the automatic grammatical processing of passives must be more complex than that of actives. It is this automatic grammatical processing that provides us with the information in (152) and (153): this includes finding the lexical functional

structure of the verb in its syntactic context and identifying the grammatical functions of the phrases in the sentence. For a simple active transitive sentence of the form NP V NP, the first NP will be NP₁ and the second NP will be NP₂. For a passive sentence of the form NP *be* V-ed by NP, the first NP will be NP₁ and the second NP may or may not be NP_{by}: *The boy was hit by the fence, The books were put by the magazines.* The identification of the grammatical function of the *by*-phrase in passives is inherently complicated by the fact that the *by*-phrase is a prepositional phrase. But once this automatic grammatical processing has done its work, knowledge can enter into the process of comprehension, in the way suggested here.

Forster's work thus supports the assumption that there is a psychological analogue to the rules of grammar that provide the structural and functional information needed for semantic interpretation. The same is shown by the experiments reported in Chapter 3. It must be assumed that this "mental parser" operates extremely rapidly, providing the minimal information that is needed in the larger tasks of understanding and using language.

The realization problem The theory of grammar outlined in this chapter can be explicitly realized in various psychologically interesting models of language production and comprehension. I will informally illustrate here just one possible realization mapping, to make good my claim to have a realizable transformational grammar. The general psychological model I will use is one like that described in Chapter 3.

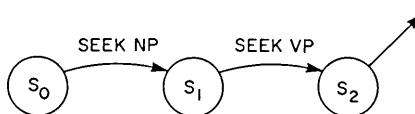
The phrase structure rules of the grammar, which define the basic structural patterns of a language, can be realized in a syntactic pattern-recognition system known as a transition network system, illustrated in Figure 1.10. As described in Chapter 3, a transition network system accepts a sentence by scanning the words in the sentence one by one and making appropriate transitions which define a path through the network. Such systems employ a memory (a pushdown store) which keeps track of the states left and returned to. Any sentence that can be generated by the phrase structure rules can be recognized by a transition network system.

Corresponding to each phrase structure rule in Figure 1.10 is an equivalent transition network diagram, consisting of a set of states connected by arcs. Four types of arc are shown. The CAT arcs permit a transition to be made if the word scanned belongs to the

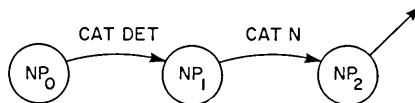
PHRASE STRUCTURE RULES

$$S \longrightarrow NP\ VP$$

TRANSITION NETWORKS



$$NP \longrightarrow DET\ N$$



$$VP \longrightarrow V\ (NP)$$

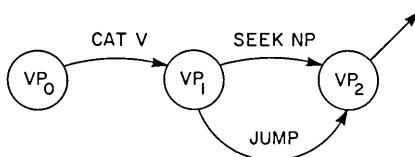


Figure 1.10

lexical category specified on the arc; if it does, the input string is advanced one word. The JUMP arcs permit a transition to be made without advancing the input string; they allow partially similar networks to be merged, just as partially similar phrase structure rules can be collapsed with the parenthesis notation. The unlabeled arcs leaving one state but not entering another designate the “accepting states.” The SEEK arcs permit a transition to be made if a phrase of the type sought has been accepted; if one has, the input string is advanced to the next word after that phrase. In effect, a SEEK arc calls for a subcomputation involving another network.

The sentence *The girl hit the boy* can be accepted by the transition network system represented in Figure 1.10 by starting in state S_0 , switching to state NP_0 , and testing the first word *the* to see whether it belongs to the category Det(erminer). Next, since *the* is a Det, a transition is made to state NP_1 , and the second word *girl* is scanned and tested. Then, since *girl* is a N(oun), a transition is made to state NP_2 , which is an accepting state for a noun phrase. Since a noun phrase *the girl* has been found, the transition can be made from state S_0 to state S_1 , the scanner advances to the next word in the sentence, and the process continues in the obvious way.

The sequence of transitions made in accepting a sentence determines a well-formed labeled bracketing of the sentence. The initial

states of each network — state S_0 , state NP_0 , state VP_0 — correspond to left brackets $[_S$, $[_{NP}$, $[_{VP}$, and the accepting states — state S_2 , state NP_2 , state VP_2 — correspond to right brackets $]_S$, $]_{NP}$, $]_{VP}$. A CAT transition corresponds to the labeling of lexical categories; for example, when *girl* satisfies CAT N, it can be bracketed $[_N \text{ girl } N]$. Since each well-formed labeled bracketing is equivalent to a surface structure (or surface phrase-marker (Peters and Ritchie 1973)), we can speak of the transition network system as “accepting surface structures.” This means that a sentence that has a certain labeled bracketing is accepted by a sequence of transitions that corresponds to that bracketing.

The transition network system just described can be augmented with a set of operations that assign grammatical functions to the phrases being parsed. This is illustrated (partially) in Figure 1.11. The ASSIGN and ASSEMBLE operations of Figure 1.11 identify and combine the functional structure of a verb with its subjects, objects, and complements in the sentence. The function assignments and operations make use of a working memory for functional information.

In recognizing the sentence *The girl hit the boy*, as the transition is made from state S_0 to state S_1 the information that *the girl* is the grammatical subject, NP_1 ; *the girl*, is placed in the working memory. Next, as the transition is made from state VP_0 to state VP_1 in

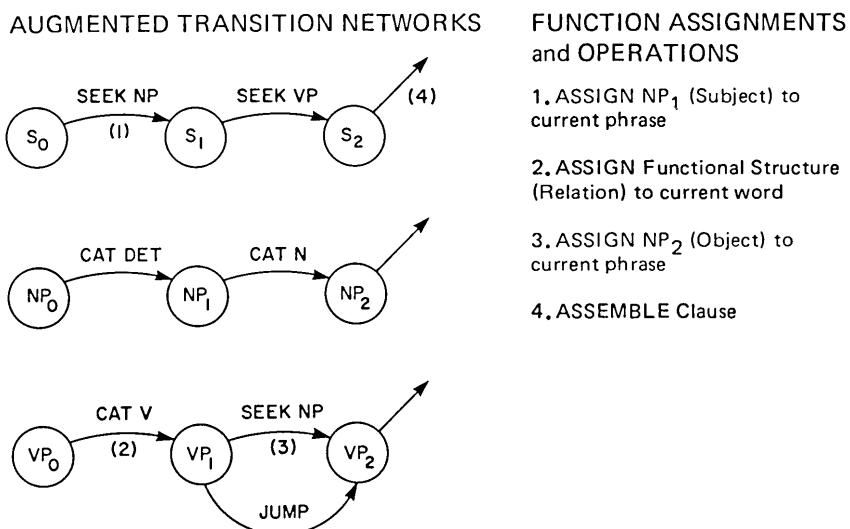
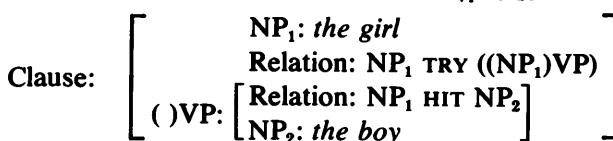


Figure 1.11

recognizing *hit*, the information $NP_1 \text{ HIT } NP_2$ is added to the working memory. (This information is derived from the lexicon.) Then, when the transition is made from state VP_1 to state VP_2 in recognizing *the boy*, the information that *the boy* is the grammatical object, NP_2 : *the boy*, comes in. When the entire sentence is accepted in state S_2 , the stored functional information can be assembled, or combined. Thus, as the transitions are made through the networks, a functional analysis is built up in the working memory. The functional analysis need not resemble the surface structure accepted, even in the order of constituents.

The augmented transition network (ATN) just described is easily extendible to complex sentences with verbal complements. Figure 1.12 shows the additions that correspond to the phrase structure rules, $VP \rightarrow V (NP)$ (\overline{VP}) and $\overline{VP} \rightarrow to VP$. The new arc-label, WORD *to*, connecting state \overline{VP}_0 to state \overline{VP}_1 , recognizes the infinitival marker *to*. The ATN shown in Figure 1.12 recognizes sentences like *The girl tried to hit the boy*, automatically extracting the structural and functional information needed for their interpretation, as represented in (156).

- (156) [s[NP[Det the Det][N girl N][NP][VP[v tried v][\overline{VP} to
[vp[v hit v][NP[Det the Det][N boy N][NP]vp] \overline{VP}]vp]s]]



In these simplified illustrations, I have not applied the indexing procedure given on pages 24–30, but have merely shown how an ATN can extract the minimal functional information needed for the interpretation of the sentence.

Having seen how the phrase-structural, lexical, and functional components of the grammar can correspond to separate components of an ATN system, let us now consider the transformational component of the grammar, represented by Question Movement. Since the grammar is being realized within a model of sentence comprehension, the assumption is that Question Movement applies in reverse to surface structures in which the interrogative phrase occurs in its displaced position outside of the clause, as in (157).

- (157) Which boy did the girl try to hit ?

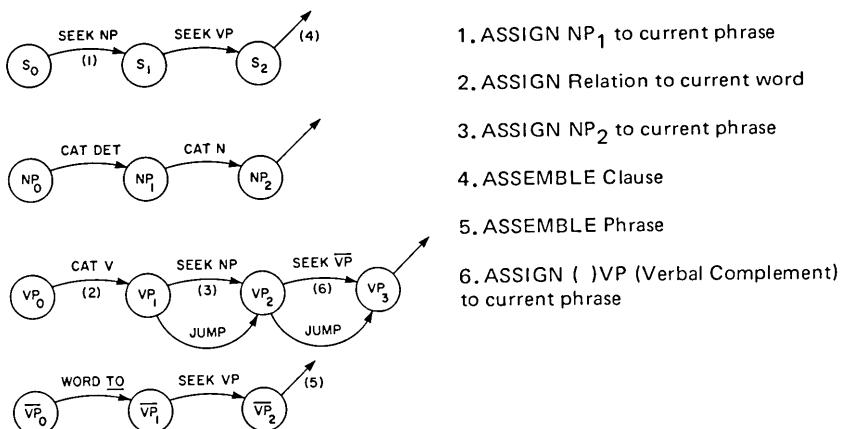


Figure 1.12 Augmented Transition Network system incorporating verbal complement networks

In order to generate surface structures like (157), phrase structure rules must be provided for the displaced phrase and for the empty position in the clause from which it is displaced. One set of rules for doing this is (158). (*Aux*, here and in Figure 1.13, stands for any inverted auxiliary. A detailed analysis of the English auxiliary verbs is not required for the purposes of this illustration.)

- (158) $\bar{S} \rightarrow (NP \text{ Aux}) S$ (phase structure rule for the displaced noun phrase)
 $NP \rightarrow \emptyset$ (phrase structure rule for the empty noun phrase position)

The rule $NP \rightarrow \emptyset$ indicates that the nonterminal symbol, NP , may be left dominating no terminal string. (Alternatively, the rule could be formulated with a designated terminal symbol such as Δ : $NP \rightarrow \Delta$.)

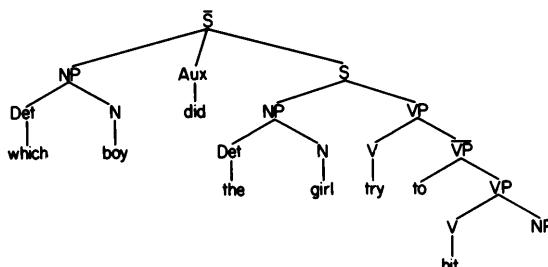


Figure 1.13 Surface structure of *Which boy did the girl try to hit?*

By adding the rules in (158) to the other phrase structure rules, the surface structures shown in Figures 1.13 and 1.14 can be generated.

By themselves, these phrase structure rules will overgenerate, producing many ill-formed strings in which too many or too few empty positions occur. If there are too few empty positions, as in (159) —

- (159) *Which boy did the girl try to hit the table?

— the inverse Question Movement transformation will not be able to apply, and the displaced interrogative phrase *which boy* will not receive a functional interpretation. If there are too many empty positions, as in (160) —

- (160) *Which girl hit [Ø]

— the transitive verb *hit* will not receive the necessary functional interpretation. Such cases can be accounted for simply by assuming that every sentence must have a complete and coherent functional interpretation assigned by the rules of the grammar.

As already observed (p. 40), the inverse rule of Question Movement is a structure-dependent operation, for in the displaced position the interrogative phrase has no grammatical function assigned to it. This suggests that in comprehending a sentence we need to remember the displaced phrase so that we can refer to it when we come to the empty position in the sentence from which it is displaced. ATN parsing systems, as described in Woods (1973) and in Chapter 3, have a special HOLD facility which does just this. A displaced phrase is held, without an assigned grammatical function, in a temporary memory cell until an empty position is encountered and the phrase

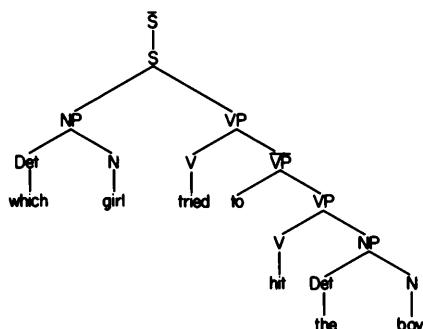


Figure 1.14 Surface structure of *Which girl tried to hit the boy?*

can be retrieved, permitting a transition to be made. Thus, corresponding to the phrase structure rules (158) are the transition networks diagrammed in Figure 1.15. The HOLD and RETRIEVE HOLD operations correspond to the Question Movement transformation. Like Question Movement, they are structure-dependent operations which make no reference to functional information. Apart from the surface structure and the functional interpretation, an ATN system does not distinguish a level of deep syntactic structure in the usual sense — but it does make use of a level of “remembered” syntactic structure in the HOLD facility. The fundamental structure-dependent property of transformations corresponds to this capability to remember syntactic structure.

With these additions, an ATN will accept the sentence *Which boy did the girl try to hit?* assigning to it the structural and functional information shown in (161), as the reader can easily verify.

- (161) [S[NP[Det which Det][N boy N]NP][Aux did Aux][S[NP[Det the Det][N girl N]NP][VP[V try V][VP[V hit V][NP NP]VP] VP] VP] S]S]

Clause:
$$\begin{array}{c} \text{NP}_1: \text{the girl} \\ \text{Relation: NP}_1 \text{ TRY } ((\text{NP}_1) \text{VP}) \\ () \text{VP:} \left[\begin{array}{l} \text{Relation: NP}_1 \text{ HIT NP}_2 \\ \text{NP}_2: \text{which boy} \end{array} \right] \end{array}$$

Notice that after the verb *hit* is recognized, an NP is sought. There is no NP following *hit* in the sentence *Which boy did the girl try to hit?* Nevertheless, a transition through the NP network diagrammed in Figure 1.15 can be made by retrieving the stored NP *which boy* from the HOLD cell; the transition goes directly from state NP_0 to state

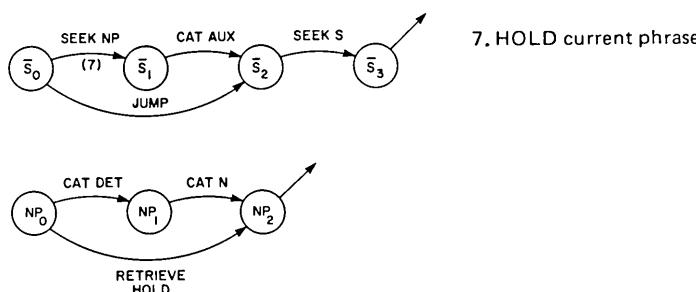


Figure 1.15 Augmented Transition Networks corresponding to phrase structure rule (158) and illustrating HOLD facility

NP₂. This is why the accepted surface structure in (161) contains the labeled brackets [NP NP] after *hit*.

Labeled brackets that surround no terminal string correspond to what Chomsky (1977) calls a "trace" and Bresnan (1976b, p. 389) calls a "structural residue." (Chomsky's conception of traces is far broader than that adopted here because he assumes that syntactic transformations that leave traces are involved in the derivation of passives and other constructions that are derived nontransformationally in the present theory.) The same labeled brackets provide precisely the structural information needed to explain the phonological perturbations produced by Question Movement and similar transformations (Selkirk, forthcoming). The same labeled brackets correspond to what Wanner and Maratsos refer to as "the gap" in Chapter 3. Thus the computational, syntactic, phonological, and psychological analyses converge at this point.

The experiments reported by Wanner and Maratsos indicate an increase in memory load or processing load during the comprehension of sentences containing gaps. The increase is quite specifically located in what they call the "critical region" of a sentence, the region lying between a "displaced" relative pronoun and the gap. When clauses interrupted by a memory task in the critical region are compared with clauses interrupted outside of the critical region, a significant difference in error scores emerges. The development of more refined measures of processing load will surely contribute to a more exact understanding of how grammatical information is employed in sentence processing.

In closing this discussion, I wish to reemphasize that the correspondences I have informally outlined are intended to be only illustrative of the possibilities for research on the grammatical realization problem. The conception of transformational grammar presented in this chapter is realizable in many different models of language use. In itself, it is intended to be neutral with respect to "top-down" or "bottom-up" parsing systems, and to production or perception models. Indeed, the realization outlined here suggests one respect in which ATN systems may model linguistic comprehension inadequately: in recognizing sentences, transition network systems appear to make insufficient use of lexical information.⁸

⁸ This possible inadequacy of ATN systems as psychological models of language processing was pointed out by George Miller in discussions of the MIT Workshop on Language and Cognition.

Referring to Figure 1.12, we can see that the path that will be taken through the verb networks is completely independent of the lexical information about verbs that is extracted along the way. Thus, the verb categorized between state VP_0 and state VP_1 could be *sleep*, *hit*, *tend*, or *compel*. Each verb can appear in specific syntactic contexts of which the language user surely has knowledge; yet the syntactic parser continues, blind to this information, making transitions that are determined only by the state it is in and the category of the word it is scanning. The result is that in recognizing complex sentences many unnecessary blind alleys can be taken, requiring extensive backtracking, as described in Chapter 3. Conceivably this could be the way we actually recognize sentences: but perhaps it is not.

One way to reduce syntactic nondeterminacy within an ATN system would be to build the relevant lexical information directly into the syntax. For example, a separate verb network diagram could be provided for each possible type of syntactic context. This technique is employed in Chapter 3, Figure 3.4, where separate states have been provided for intransitive verbs (V_I), simple verbs (V_S), and transitive verbs taking infinitival complements (V_T). The approach is equivalent grammatically to the use of phrase structure rules to describe verbal subcategorization, as in Chomsky (1957); in *Aspects* (1965, pp. 79–127) Chomsky criticized and abandoned this use of phrase structure rules in transformational grammar. A different solution to this problem has been developed by Ronald Kaplan (Kaplan 1977), and of course other solutions are possible outside of the ATN framework (for example, that of Marcus 1976).

I will leave the discussion of the realization problem at this point. It is clearly a problem on which joint research in theoretical linguistics, artificial intelligence, and experimental psychology should be very fruitful.

Conclusion

A realistic grammar should be psychologically real in the broad sense: it should contribute to the explanation of linguistic behavior and to our larger understanding of the human faculty of language. These broadly psychological and philosophical aims have inspired all work in transformational grammar since Chomsky first articulated his “realist” conception of linguistic theory. Yet the field of transforma-

tional grammar has undergone many changes and divisions, proliferating in divergent theories of grammar. How can we choose among these various theories? From a broad philosophical perspective, it is not necessary to do so, any more than it is necessary to choose among various theories of geometry, all of which contribute to our understanding of space and form and perhaps, in some way, even to the explanation of human behavior. But from a scientific perspective — if our goal is to explain human spatial perception, for example — we must find or construct the best theory.

The difficulty in linguistics is that we can characterize our knowledge of language in too many ways. What has been called the grammatical characterization problem — the problem of representing the language user's knowledge of language — is not very well defined. Therefore, it does not seem reasonable to argue that the grammatical characterization problem should be solved in advance of what has been called the grammatical realization problem: it is not clear that we will ever come to a solution to the grammatical characterization problem as it has been defined in the past.

But the grammatical realization problem can clarify and delimit the grammatical characterization problem. We can narrow the class of possible theoretical solutions by subjecting them to experimental psychological investigation as well as to linguistic investigation. Within the program of research proposed here, joint work by linguists, computer scientists, and psychologists could lead to a deeper scientific understanding of the role of language in cognition.