4

PHRASE STRUCTURE

4.1 Customarily, linguistic description on the syntactic level is formulated in terms of constituent analysis (parsing). We now ask what form of grammar is presupposed by description of this sort. We find that the new form of grammar is *essentially* more powerful than the finite state model rejected above, and that the associated concept of "linguistic level" is different in fundamental respects.

As a simple example of the new form for grammars associated with constituent analysis, consider the following:

(13) (i) $Sentence \rightarrow NP + VP$
(ii) $NP \rightarrow T + N$
(iii) $VP \rightarrow Verb + NP$
(iv) $T \rightarrow$ *the*
(v) $N \rightarrow$ *man*, *ball*, etc.
(vi) $Verb \rightarrow$ *hit*, *took*, etc.

Suppose that we interpret each rule $X \rightarrow Y$ of (13) as the instruction "rewrite X as Y". We shall call (14) a *derivation* of the sentence "the man hit the ball," where the numbers at the right of each line of the derivation refer to the rule of the "grammar" (13) used in constructing that line from the preceding line.[1]

[1] The numbered rules of English grammar to which reference will constantly be made in the following pages are collected and properly ordered in § 12, *Appendix II*. The notational conventions that we shall use throughout the discussion of English structure are stated in § 11, *Appendix I*.

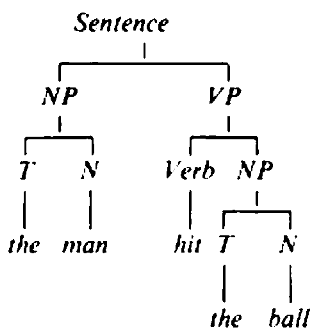
In his "Axiomatic syntax: the construction and evaluation of a syntactic calculus," *Language* 31.409–14 (1955), Harwood describes a system of word class analysis similar in form to the system developed below for phrase structure. The system he describes would be concerned only with the relation between $T + N + Verb + T + N$ and *the* + *man* + *hit* + *the* + *ball* in the example discussed

(14) *Sentence*

$NP + VP$	(i)
$T + N + VP$	(ii)
$T + N + Verb + NP$	(iii)
$the + N + Verb + NP$	(iv)
$the + man + Verb + NP$	(v)
$the + man + hit + NP$	(vi)
$the + man + hit + T + N$	(ii)
$the + man + hit + the + N$	(iv)
$the + man + hit + the + ball$	(v)

Thus the second line of (14) is formed from the first line by rewriting *Sentence* as $NP + VP$ in accordance with rule (i) of (13); the third line is formed from the second by rewriting NP as $T + N$ in accordance with rule (ii) of (13); etc. We can represent the derivation (14) in an obvious way by means of the following diagram:

(15)



The diagram (15) conveys less information than the derivation (14), since it does not tell us in what order the rules were applied in (14).

in (13)–(15); i.e., the grammar would contain the "initial string" $T + N + Verb + T + N$ and such rules as (13iv–vi). It would thus be a weaker system than the elementary theory discussed in § 3, since it could not generate an infinite language with a finite grammar. While Harwood's formal account (pp. 409–11) deals only with word class analysis, the linguistic application (p. 412) is a case of immediate constituent analysis, with the classes $C_{i..m}$ presumably taken to be classes of word sequences. This extended application is not quite compatible with the formal account, however. For example, none of the proposed measures of goodness of fit can stand without revision under this reinterpretation of the formalism.

Given (14), we can construct (15) uniquely, but not vice versa, since it is possible to construct a derivation that reduces to (15) with a different order of application of the rules. The diagram (15) retains just what is essential in (14) for the determination of the phrase structure (constituent analysis) of the derived sentence "the man hit the ball." A sequence of words of this sentence is a constituent of type Z if we can trace this sequence back to a single point of origin in (15), and this point of origin is labelled Z. Thus "hit the ball" can be traced back to VP in (15); hence "hit the ball" is a VP in the derived sentence. But "man hit" cannot be traced back to any single point of origin in (15); hence "man hit" is not a constituent at all.

We say that two derivations are *equivalent* if they reduce to the same diagram of the form (15). Occasionally, a grammar may permit us to construct nonequivalent derivations for a given sentence. Under these circumstances, we say that we have a case of "constructional homonymity",[2] and if our grammar is correct, this sentence of the language should be ambiguous. We return to the important notion of constructional homonymity below.

One generalization of (13) is clearly necessary. We must be able to limit application of a rule to a certain context. Thus T can be rewritten *a* if the following noun is singular, but not if it is plural; similarly, *Verb* can be rewritten "hits" if the preceding noun is *man*, but not if it is *men*. In general, if we wish to limit the rewriting of X as Y to the context $Z - W$, we can state in the grammar the rule

(16) $Z + X + W \rightarrow Z + Y + W.$

For example, in the case of singular and plural verbs, instead of having $Verb \rightarrow hits$ as an additional rule of (13), we should have

(17) $NP_{sing} + Verb \rightarrow NP_{sing} + hits$

indicating that *Verb* is rewritten *hits* only in the context $NP_{sing}-$.

[2] See § 8.1 for some examples of constructional homonymity. See my *The logical structure of linguistic theory* (mimeographed); "Three models for the description of language" (above, p. 22, fn. 3); C. F. Hockett, "Two models of grammatical description," *Linguistics Today*, *Word* 10.210–33 (1954); R. S. Wells, "Immediate constituents," *Language* 23.81–117 (1947) for more detailed discussion.

Correspondingly, (13ii) will have to be restated to include NP_{sing} and NP_{pl}.[3] This is a straightforward generalization of (13). One feature of (13) must be preserved, however, as it is in (17): only a single element can be rewritten in any single rule; i.e., in (16), X must be a single symbol such as T, *Verb*, and not a sequence such as $T + N$. If this condition is not met, we will not be able to recover properly the phrase structure of derived sentences from the associated diagrams of the form (15), as we did above.

We can now describe more generally the form of grammar associated with the theory of linguistic structure based upon constituent analysis. Each such grammar is defined by a finite set Σ of initial strings and a finite set F of 'instruction formulas' of the form $X \rightarrow Y$ interpreted: "rewrite X as Y." Though X need not be a single symbol, only a single symbol of X can be rewritten in forming Y. In the grammar (13), the only member of the set Σ of initial strings was the single symbol *Sentence*, and F consisted of the rules (i) - (vi); but we might want to extend Σ to include, for example, *Declarative Sentence*, *Interrogative Sentence*, as additional symbols. Given the grammar [Σ, F], we define a *derivation* as a finite sequence of strings, beginning with an initial string of Σ, and with each string in the sequence being derived from the preceding string by application of one of the instruction formulas of F. Thus (14) is a derivation, and the five-termed sequence of strings consisting of the first five lines of (14) is also a derivation. Certain derivations are *terminated* derivations, in the sense that their final string cannot be rewritten any further by the rules F. Thus (14) is a terminated derivation, but the sequence consisting of the first five

[3] Thus in a more complete grammar, (13ii) might be replaced by a set of rules that includes the following:

$$NP \rightarrow \begin{Bmatrix} NP_{sing} \\ NP_{pl} \end{Bmatrix}$$
$$NP_{sing} \rightarrow T + N + \emptyset \;(+\; \textit{Prepositional Phrase})$$
$$NP_{pl} \rightarrow T + N + S \;(+\; \textit{Prepositional Phrase})$$

where S is the morpheme which is singular for verbs and plural for nouns ("comes," "boys"), and $\emptyset$ is the morpheme which is singular for nouns and plural for verbs ("boy," "come"). We shall omit all mention of first and second person throughout this discussion. Identification of the nominal and verbal number affix is actually of questionable validity.

lines of (14) is not. If a string is the last line of a terminated derivation, we say that it is a *terminal* string. Thus *the* + *man* + *hit* + *the* + *ball* is a terminal string from the grammar (13). Some grammars of the form [Σ, F] may have no terminal strings, but we are interested only in grammars that do have terminal strings, i.e., that describe some language. A set of strings is called a *terminal language* if it is the set of terminal strings for some grammar [Σ, F]. Thus each such grammar defines some terminal language (perhaps the 'empty' language containing no sentences), and each terminal language is produced by some grammar of the form [Σ, F]. Given a terminal language and its grammar, we can reconstruct the phrase structure of each sentence of the language (each terminal string of the grammar) by considering the associated diagrams of the form (15), as we saw above. We can also define the grammatical relations in these languages in a formal way in terms of the associated diagrams.

4.2 In § 3 we considered languages, called "finite state languages", which were generated by finite state Markov processes. Now we are considering terminal languages that are generated by systems of the form [Σ, F]. These two types of languages are related in the following way

Theorem: Every finite state language is a terminal language, but there are terminal languages which are not finite state languages.[4]

The import of this theorem is that description in terms of phrase structure is essentially more powerful than description in terms of the elementary theory presented above in § 3. As examples of terminal languages that are not finite state languages we have the languages (10i), (10ii) discussed in § 3. Thus the language (10i), consisting of all and only the strings *ab*, *aabb*, *aaabbb*, ... can be produced by the [Σ, F] grammar (18).

(18) Σ: Z

F: $Z \rightarrow ab$

$Z \rightarrow aZb$

[4] See my "Three models for the description of language" (above, p. 22, fn. 3) for proofs of this and related theorems about relative power of grammars.

This grammar has the initial string Z (as (13) has the initial string *Sentence*) and it has two rules. It can easily be seen that each terminated derivation constructed from (18) ends in a string of the language (10i), and that all such strings are produced in this way. Similarly, languages of the form (10ii) can be produced by [Σ, F] grammars (10iii), however, cannot be produced by a grammar of this type, unless the rules embody contextual restrictions.[5]

In § 3 we pointed out that the languages (10i) and (10ii) correspond to subparts of English, and that therefore the finite state Markov process model is not adequate for English. We now see that the phrase structure model does not fail in such cases. We have not proved the adequacy of the phrase structure model, but we have shown that large parts of English which literally cannot be described in terms of the finite-state process model can be described in terms of phrase structure.

Note that in the case of (18), we can say that in the string *aaabbb* of (10i), for example, *ab* is a *Z*, *aabb* is a *Z*, and *aaabbb* itself is a *Z*.[6] Thus this particular string contains three 'phrases,' each of which is a *Z*. This is, of course, a very trivial language. It is important to observe that in describing this language we have introduced a symbol *Z* which is not contained in the sentences of this language. This is the essential fact about phrase structure which gives it its 'abstract' character.

Observe also that in the case of both (13) and (18) (as in every system of phrase structure), each terminal string has many different representations. For example, in the case of (13), the terminal string "the man hit the ball" is represented by the strings *Sentence*, $NP + VP$, $T + N + VP$, and all the other lines of (14), as well as by such strings as $NP + Verb + NP$, $T + N + hit + NP$, which would occur in other derivations equivalent to (14) in the sense there defined. On the level of phrase structure, then, each sentence of the language is represented by a *set* of strings, not by a single string as it

[5] See my "On certain formal properties of grammars", *Information and Control* 2.133–167 (1959).

[6] Where "is a" is the relation defined in § 4.1 in terms of such diagrams as (15).

is on the level of phonemes, morphemes, or words. Thus phrase structure, taken as a linguistic level, has the fundamentally different and nontrivial character which, as we saw in the last paragraph of § 3, is required for some linguistic level. We cannot set up a hierarchy among the various representations of "the man hit the ball"; we cannot subdivide the system of phrase structure into a finite set of levels, ordered from higher to lower, with one representation for each sentence on each of these sublevels. For example, there is no way of ordering the elements *NP* and *VP* relative to one another. Noun phrases are contained within verb phrases, and verb phrases within noun phrases, in English. Phrase structure must be considered as a single level, with a set of representations for each sentence of the language. There is a one-one correspondence between the properly chosen sets of representations, and diagrams of the form (15).

4.3 Suppose that by a [Σ, F] grammar we can generate all of the grammatical sequences of morphemes of a language. In order to complete the grammar we must state the phonemic structure of these morphemes, so that the grammar will produce the grammatical phoneme sequences of the language. But this statement (which we would call the *morphophonemics* of the language) can also be given by a set of rules of the form "rewrite *X* as *Y*", e.g., for English,

(19) (i) *walk* → /wɔk/
(ii) *take* + *past* → /tuk/
(iii) *hit* + *past* → /hit/
(iv) /...D/ + *past* → /...D/ + /ɨd/ (where D = /t/ or /d/)
(v) /...C_{unv}/ + *past* → /...C_{unv}/ + /t/ (where C_{unv} is an unvoiced consonant)
(vi) *past* → /d/.
(vii) *take* → /teyk/
etc.

or something similar. Note, incidentally, that order must be defined among these rules — e.g., (ii) must precede (v) or (vii), or we will derive such forms as /teykt/ for the past tense of *take*. In these morphophonemic rules we need no longer require that only a single symbol be rewritten in each rule.

We can now extend the phras: structure derivations by applying (19), so that we have a unified process for generating phoneme sequence from the initial string *Sentence*. This makes it appear as though the break between the higher level of phrase structure and the lower levels is arbitrary. Actually, the distinction is not arbitrary. For one thing, as we have seen, the formal properties of the rules $X \rightarrow Y$ corresponding to phrase structure are different from those of the morphophonemic rules, since in the case of the former we must require that only a single symbol be rewritten. Second, the elements that figure in the rules (19) can be classified into a finite set of levels (e.g., phonemes and morphemes; or, perhaps, phonemes, morphophonemes, and morphemes) each of which is elementary in the sense that a single string of elements of this level is associated with each sentence as its representation on this level (except in cases of homonymity), and each such string represents a single sentence. But the elements that appear in the rules corresponding to phrase structure cannot be classified into higher and lower levels in this way. We shall see below that there is an even more fundamental reason for marking this subdivison into the higher level rules of phrase structure and the lower level rules that convert strings of morphemes into strings of phonemes.

The formal properties of the system of phrase structure make an interesting study, and it is easy to show that further elaboration of the form of grammar is both necessary and possible. Thus it can easily be seen that it would be quite advantageous to order the rules of the set F so that certain of the rules can apply only after others have applied. For example, we should certainly want all rules of the form (17) to apply before any rule which enables us to rewrite *NP* as *NP* + *Preposition* + *NP*, or the like; otherwise the grammar will produce such nonsentences as "the men near the truck begins work at eight." But this elaboration leads to problems that would carry us beyond the scope of this study.

5

LIMITATIONS OF PHRASE STRUCTURE DESCRIPTION

5.1 We have discussed two models for the structure of language, a communication theoretic model based on a conception of language as a Markov process and corresponding, in a sense, to the minimal linguistic theory, and a phrase structure model based on immediate constituent analysis. We have seen that the first is surely inadequate for the purposes of grammar, and that the second is more powerful than the first, and does not fail in the same way. Of course there are languages (in our general sense) that cannot be described in terms of phrase structure, but I do not know whether or not English is itself literally outside the range of such analysis. However, I think that there are other grounds for rejecting the theory of phrase structure as inadequate for the purpose of linguistic description.

The strongest possible proof of the inadequacy of a linguistic theory is to show that it literally cannot apply to some natural language. A weaker, but perfectly sufficient demonstration of inadequacy would be to show that the theory can apply only clumsily; that is, to show that any grammar that can be constructed in terms of this theory will be extremely complex, *ad hoc*, and 'unrevealing', that certain very simple ways of describing grammatical sentences cannot be accommodated within the associated forms of grammar, and that certain fundamental formal properties of natural language cannot be utilized to simplify grammars. We can gather a good deal of evidence of this sort in favor of the thesis that the form of grammar described above, and the conception of linguistic theory that underlies it, are fundamentally inadequate.

The only way to test the adequacy of our present apparatus is to attempt to apply it directly to the description of English sentences.

As soon as we consider any sentences beyond the simplest type, and in particular, when we attempt to define some order among the rules that produce these sentences, we find that we run into numerous difficulties and complications. To give substance to this claim would require a large expenditure of effort and space, and I can only assert here that this can be shown fairly convincingly.[1] Instead of undertaking this rather arduous and ambitious course here, I shall limit myself to sketching a few simple cases in which considerable improvement is possible over grammars of the form $[\Sigma, F]$. In § 8 I shall suggest an independent method of demonstrating the inadequacy of constituent analysis as a means of describing English sentence structure.

5.2 One of the most productive processes for forming new sentences is the process of conjunction. If we have two sentences $Z + X + W$ and $Z + Y + W$, and if X and Y are actually constituents of these sentences, we can generally form a new sentence $Z - X +$ *and* $+ Y - W$. For example, from the sentences (20a-b) we can form the new sentence (21).

(20) (a) the scene – of the movie – was in Chicago
(b) the scene – of the play – was in Chicago

(21) the scene – of the movie and of the play – was in Chicago.

If X and Y are, however, not constituents, we generally cannot do this.[2] For example we cannot form (23) from (22a-b).

[1] See my *The logical structure of linguistic theory* for detailed analysis of this problem.

[2] (21) and (23) are extreme cases in which there is no question about the possibility of conjunction. There are many less clear cases. For example, it is obvious that "John enjoyed the book and liked the play" (a string of the form $NP - VP +$ *and* $+ VP$) is a perfectly good sentence, but many would question the grammaticalness of, e.g., "John enjoyed and my friend liked the play" (a string of the form $NP + Verb +$ *and* $+ Verb - NP$). The latter sentence, in which conjunction crosses over constituent boundaries, is much less natural than the alternative "John enjoyed the play and my friend liked it", but there is no preferable alternative to the former. Such sentences with conjunction crossing constituent boundaries are also, in general, marked by special phonemic features such as extra long pauses (in our example, between "liked" and "the"), contrastive stress and intonation, failure to reduce vowels and drop final consonants in

(22) (a) the – liner sailed down the – river
(b) the – tugboat chugged up the – river

(23) the – liner sailed down the and tugboat chugged up the – river.

Similarly, if X and Y are both constituents, but are constituents of different kinds (i.e., if in the diagram of the form (15) they each have a single origin, but this origin is labelled differently), then we cannot in general form a new sentence by conjunction. For example, we cannot form (25) from (24a-b).

(24) (a) the scene – of the movie – was in Chicago
(b) the scene – that I wrote – was in Chicago

(25) the scene – of the movie and that I wrote – was in Chicago

In fact, the possibility of conjunction offers one of the best criteria for the initial determination of phrase structure. We can simplify the description of conjunction if we try to set up constituents in such a way that the following rule will hold:

(26) If S_1 and S_2 are grammatical sentences, and S_1 differs from S_2 only in that X appears in S_1 where Y appears in S_2 (i.e., $S_1 = ..X..$ and $S_2 = ..Y..$), and X and Y are constituents of the same type in S_1 and S_2, respectively, then S_3 is a sentence, where S_3 is the result of replacing X by $X + and + Y$ in S_1 (i.e., $S_3 = ..X + and + Y..$).

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rapid speech, etc. Such features normally mark the reading of non-grammatical strings. The most reasonable way to describe this situation would seem to be by a description of the following kind: to form fully grammatical sentences by conjunction, it is necessary to conjoin single constituents; if we conjoin pairs of constituents, and these are major constituents (i.e., 'high up' in the diagram (15)), the resulting sentences are semi-grammatical; the more completely we violate constituent structure by conjunction, the less grammatical is the resulting sentence. This description requires that we generalize the grammatical-ungrammatical dichotomy, developing a notion of degree of grammaticalness. It is immaterial to our discussion, however, whether we decide to exclude such sentences as "John enjoyed and my friend liked the play" as ungrammatical, whether we include them as semi-grammatical, or whether we include them as fully grammatical but with special phonemic features. In any event they form a class of utterances distinct from "John enjoyed the play and liked the book," etc., where constituent structure is preserved perfectly; and our conclusion that the rule for conjunction must make explicit reference to constituent structure therefore stands, since this distinction will have to be pointed out in the grammar.

Even though additional qualification is necessary here, the grammar is enormously simplified if we set up constituents in such a way that (26) holds even approximately. That is, it is easier to state the distribution of "and" by means of qualifications on this rule than to do so directly without such a rule. But we now face the following difficulty: we cannot incorporate the rule (26) or anything like it ir a grammar $[\Sigma, F]$ of phrase structure, because of certain fundamental limitations on such grammars. The essential property of rule (26) is that in order to apply it to sentences S_1 and S_2 to form the new sentence S_3 we must know not only the actual form of S_1 and S_2 but also their constituent structure — we must know not only the final shape of these sentences, but also their 'history of derivation.' But each rule $X \to Y$ of the grammar $[\Sigma, F]$ applies or fails to apply to a given string by virtue of the actual substance of this string. The question of how this string gradually assumed this form is irrelevant. If the string contains X as a substring, the rule $X \to Y$ can apply to it; if not, the rule cannot apply.

We can put this somewhat differently. The grammar $[\Sigma, F]$ can also be regarded as a very elementary process that generates sentences not from "left to right" but from "top to bottom". Suppose that we have the following grammar of phrase structure:

(27) Σ: *Sentence*

$$\begin{aligned} F:\ & X_1 \to Y_1 \\ & \quad \vdots \\ & X_n \to Y_n\,. \end{aligned}$$

Then we can represent this grammar as a machine with a finite number of internal states, including an initial and a final state. In its initial state it can produce only the element *Sentence*, thereby moving into a new state. It can then produce any string Y_i such that *Sentence* $\to Y_i$ is one of the rules of F in (27), again moving into a new state. Suppose that Y_i is the string $\ldots X_j \ldots$ Then the machine can produce the string $\ldots Y_j \ldots$ by "applying" the rule $X_j \to Y_j$. The machine proceeds in this way from state to state until it finally produces a terminal string; it is now in the final state. The machine thus produces derivations, in the sense of §4. The important point is that the state of the machine is completely determined by the string it has just produced (i.e., by the last step of the derivation); more specifically, the state is determined by the subset of 'left-hand' elements X_i of F which are contained in this last-produced string. But rule (26) requires a more powerful machine, which can "look back" to earlier strings in the derivation in order to determine how to produce the next step in the derivation.

Rule (26) is also fundamentally new in a different sense. It makes essential reference to two distinct sentences S_1 and S_2, but in grammars of the [Σ, F] type, there is no way to incorporate such double reference. The fact that rule (26) cannot be incorporated into the grammar of phrase structure indicates that even if this form for grammar is not literally inapplicable to English, it is certainly inadequate in the weaker but sufficient sense considered above. This rule leads to a considerable simplification of the grammar; in fact, it provides one of the best criteria for determining how to set up constituents. We shall see that there are many other rules of the same general type as (26) which play the same dual role.

5.3 In the grammar (13) we gave only one way of analyzing the element *Verb*, namely, as *hit* (cf. (13vi)). But even with the verbal root fixed (let us say, as *take*), there are many other forms that this element can assume, e.g., *takes*, *has + taken*, *will + take*, *has + been + taken*, *is + being + taken*, etc. The study of these "auxiliary verbs" turns out to be quite crucial in the development of English grammar. We shall see that their behavior is very regular and simply describable when observed from a point of view that is quite different from that developed above. though it appears to be quite complex if we attempt to incorporate these phrases directly into a [Σ, F] grammar.

Consider first the auxiliaries that appear unstressed; for example, "has" in "John has read the book" but not "does" in "John *does* read books."[3] We can state the occurrence of these auxiliaries in declarative sentences by adding to the grammar (13) the following rules:

[3] We return to the stressed auxiliary "do" below, in § 7.1 (45)–(47).

(28) (i) $Verb \rightarrow Aux + V$

(ii) $V \rightarrow$ *hit, take, walk, read,* etc.

(iii) $Aux \rightarrow C(M)$ (*have* + *en*) (*be* + *ing*) (*be* + *en*)

(iv) $M \rightarrow$ *will, can, may, shall, must*

(29) (i) $C \rightarrow \left\{ \begin{array}{l} S \text{ in the context } NP_{sing}\text{–} \\ \emptyset \text{ in the context } NP_{pl}\text{–} \\ past \end{array} \right\}$[4]

(ii) Let Af stand for any of the affixes *past*, S, $\emptyset$, *en*, *ing*. Let v stand for any M or V, or *have* or *be* (i.e., for any non-affix in the phrase *Verb*). Then:

$Af + v \rightarrow v + Af\,\#$,

where # is interpreted as word boundary.[5]

(iii) Replace + by # except in the context $v - Af$. Insert # initially and finally.

The interpretation of the notations in (28iii) is as follows: we must choose the element C, and we may choose zero or more of the parenthesized elements in the given order. In (29i) we may develop C into any of three morphemes, observing the contextual restrictions given. As an example of the application of these rules, we construct a derivation in the style of (14), omitting the initial steps.

(30) *the + man + Verb + the + book* from (13i-v)

the + man + Aux + V + the + book (28i)

the + man + Aux + read + the + book (28ii)

the + man + C + have + en + be + ing + read + the + book
(28iii) – we select the elements C, *have + en* and *be + ing*.

the + man + S + have + en + be + ing + read + the + book
(29i)

[4] We assume here that (13ii) has been extended in the manner of fn. 3, above, p. 29, or something similar.

[5] If we were formulating the theory of grammar more carefully, we would interpret # as the concatenation operator on the level of words, while + is the concatention operator on the level of phrase structure. (29) would then be part of the definition of a mapping which carries certain objects on the level of phrase structure (essentially, diagrams of the form (15)) into strings of words. See my *The logical structure of linguistic theory* for a more careful formulation.

the + man + have + S # be + en # read + ing # the + book
(29 ii) – three times.
 # the # man # have + S # be + en # read + ing # the # book #
(29 iii)

The morphophonemic rules (19), etc., will convert the last line of this derivation into:

(31) the man has been reading the book

in phonemic transcription. Similarly, every other auxiliary verb phrase can be generated. We return later to the question of further restrictions that must be placed on these rules so that only grammatical sequences can be generated. Note, incidentally, that the morphophonemic rules will have to include such rules as: *will + S →* *will, will + past → would.* These rules can be dropped if we rewrite (28 iii) so that either *C* or *M*, but not both, can be selected. But now the forms *would, could, might, should* must be added to (28 iv), and certain 'sequence of tense' statements become more complex. It is immateral to our further discussion which of these alternative analysescsis iadopted. Several other minor revisions are possible.

Notice that in order to apply (29 i) in (30) we had to use the fact that *the + man* is a singular noun phrase NP_{sing}. That is, we had to refer back to some earlier step in the derivation in order to determine the constituent structure of *the + man.* (The alternative of ordering (29 i) and the rule that develops NP_{sing} into *the + man* in such a way that (29 i) must precede the latter is not possible, for a variety of reasons, some of which appear below). Hence, (29 i), just like (26), goes beyond the elementary Markovian character of grammars of phrase structure, and cannot be incorporated within the [Σ, F] grammar.

Rule (29 ii) violates the requirements of [Σ, F] grammars even more severely. It also requires reference to constituent structure (i.e., past history of derivation) and in addition, we have no way to express the required inversion within the terms of phrase structure. Note that this rule is useful elsewhere in the grammar, at least in the case where *Af* is *ing*. Thus the morphemes *to* and *ing* play a very similar role within the noun phrase in that they convert verb phrases into noun phrases, giving, e.g.,

(32) $\left\{\begin{array}{l}\text{to prove that theorem}\\ \text{proving that theorem}\end{array}\right\}$ was difficult.

etc. We can exploit this parallel by adding to the grammar (13) the rule

(33) $NP \rightarrow \left\{\begin{array}{l} ing \\ to \end{array}\right\} VP$

The rule (29 ii) will then convert *ing + prove + that + theorem* into *proving # that + theorem*. A more detailed analysis of the *VP* shows that this parallel extends much further than this, in fact.

The reader can easily determine that to duplicate the effect of (28 iii) and (29) without going beyond the bounds of a system [Σ, F] of phrase structure, it would be necessary to give a fairly complex statement. Once again, as in the case of conjunction, we see that significant simplification of the grammar is possible if we are permitted to formulate rules of a more complex type than those that correspond to a system of immediate constituent analysis. By allowing ourselves the freedom of (29 ii) we have been able to state the constituency of the auxiliary phrase in (28 iii) without regard to the interdependence of its elements, and it is always easier to describe a sequence of independent elements than a sequence of mutually dependent ones. To put the same thing differently, in the auxiliary verb phrase we really have discontinuous elements – e.g., in (30), the elements *have..en* and *be..ing*. But discontinuities cannot be handled within [Σ, F] grammars.[6] In (28 iii) we treated these

[6] We might attempt to extend the notions of phrase structure to account for discontinuities. It has been pointed out several times that fairly serious difficulties arise in any systematic attempt to pursue this course. Cf. my "System of syntactic analysis," *Journal of Symbolic Logic* 18.242–56 (1953); C. F. Hockett, "A formal statement of morphemic analysis," *Studies in Linguistics* 10.27–39 (1952); idem, "Two models of grammatical description," *Linguistics Today*, *Word* 10.210–33 (1954). Similarly, one might seek to remedy some of the other deficiencies of [Σ, F] grammars by a more complex account of phrase structure. I think that such an approach is ill-advised, and that it can only lead to the development of *ad hoc* and fruitless elaborations. It appears to be the case that the notions of phrase structure are quite adequate for a small

elements as continuous, and we introduced the discontinuity by the very simple additional rule (29 ii). We shall see below, in § 7, that this analysis of the element *Verb* serves as the basis for a far-reaching and extremely simple analysis of several important features of English syntax.

5.4 As a third example of the inadequacy of the conceptions of phrase structure, consider the case of the active-passive relation. Passive sentences are formed by selecting the element *be* + *en* in rule (28 iii). But there are heavy restrictions on this element that make it unique among the elements of the auxiliary phrase. For one thing, *be* + *en* can be selected only if the following *V* is transitive (e.g., *was* + *eaten* is permitted, but not *was* + *occurred*); but with a few exceptions the other elements of the auxiliary phrase can occur freely with verbs. Furthermore, *be* + *en* cannot be selected if the verb *V* is followed by a noun phrase, as in (30) (e.g., we cannot in general have *NP* + *is* + *V* + *en* + *NP*, even when *V* is transitive – we cannot have "lunch is eaten John"). Furthermore, if *V* is transitive and is followed by the prepositional phrase *by* + *NP*, then we *must* select *be* + *en* (we can have "lunch is eaten by John" but not "John is eating by lunch," etc.). Finally, note that in elaborating (13) into a full-fledged grammar we will have to place many restrictions on the choice of *V* in terms of subject and object in order to permit such sentences as: "John admires sincerity," "sincerity frightens John," "John plays golf," "John drinks wine," while excluding the 'inverse' non-sentences[7] "sincerity admires John," "John frightens sincerity,"

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part of the language and that the rest of the language can be derived by repeated application of a rather simple set of transformations to the strings given by the phrase structure grammar. If we were to attempt to extend phrase structure grammar to cover the entire language directly, we would lose the simplicity of the limited phrase structure grammar and of the transformational development. This approach would miss the main point of level construction (cf. first paragraph of § 3.1), namely, to rebuild the vast complexity of the actual language more elegantly and systematically by extracting the contribution to this complexity of several linguistic levels, each of which is simple in itself.

[7] Here too we might make use of a notion of levels of grammaticalness as suggested in footnote 2, p. 35. Thus "sincerity admires John," though clearly less grammatical than "John admires sincerity," is certainly more grammatical

"golf plays John," "wine drinks John". But this whole network of restrictions fails completely when we choose *be* + *en* as part of the auxiliary verb. In fact, in this case the same selectional dependencies hold, but in the opposite order. That is, for every sentence $NP_1 - V - NP_2$ we can have a corresponding sentence $NP_2 - is + Ven - by + NP_1$. If we try to include passives directly in the grammar (13), we shall have to restate all of these restrictions in the opposite order for the case in which *be* + *en* is chosen as part of the auxiliary verb. This inelegant duplication, as well as the special restrictions involving the element *be* + *en*, can be avoided only if we deliberately exclude passives from the grammar of phrase structure, and reintroduce them by a rule such as:

(34) If S_1 is a grammatical sentence of the form

$$NP_1 - Aux - V - NP_2,$$

then the corresponding string of the form

$$NP_2 - Aux + be + en - V - by + NP_1$$

is also a grammatical sentence.

For example, if *John* – *C* – *admire* – *sincerity* is a sentence, then *sincerity* – *C* + *be* + *en* – *admire* – *by* + *John* (which by (29) and (19) becomes "sincerity is admired by John") is also a sentence.

We can now drop the element *be* + *en*, and all of the special restrictions associated with it, from (28 iii). The fact that *be* + *en* requires a transitive verb, that it cannot occur before $V + NP$, that it must occur before $V + by + NP$ (where V is transitive), that it inverts the order of the surrounding noun phrases, is in each case an automatic consequence of rule (34). This rule thus leads to a considerable simplification of the grammar. But (34) is well beyond the limits of [Σ, F] grammars. Like (29 ii), it requires reference to the constituent structure of the string to which it applies and it carries out an inversion on this string in a structurally determined manner.

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than "of admires John," I believe that a workable notion of degree of grammaticalness can be developed in purely formal terms (cf. my *The logical structure of linguistic theory*), but this goes beyond the bounds of the present discussion. See § 7.5 for an even stronger demonstration that inversion is necessary in the passive.

5.5 We have discussed three rules ((26), (29), (34)) which materially simplify the description of English but which cannot be incorporated into a [Σ, F] grammar. There are a great many other rules of this type, a few of which we shall discuss below. By further study of the limitations of phrase structure grammars with respect to English we can show quite conclusively that these grammars will be so hopelessly complex that they will be without interest unless we incorporate such rules.

If we examine carefully the implications of these supplementary rules, however, we see that they lead to an entirely new conception of linguistic structure. Let us call each such rule a "grammatical transformation." A grammatical transformation T operates on a given string (or, as in the case of (26), on a set of strings) with a given constituent structure and converts it into a new string with a new derived constituent structure. To show exactly *how* this operation is performed requires a rather elaborate study which would go far beyond the scope of these remarks, but we can in fact develop a certain fairly complex but reasonably natural algebra of transformations having the properties that we apparently require for grammatical description.[8]

From these few examples we can already detect some of the essential properties of a transformational grammar. For one thing, it is clear that we must define an order of application on these transformations. The passive transformation (34), for example, must apply *before* (29). It must precede (29i), in particular, so that the verbal element in the resulting sentence will have the same number as the new grammatical subject of the passive sentence. And it must precede (29ii) so that the latter rule will apply properly to the new inserted element *be + en*. (In discussing the question of whether or not (29i) can be fitted into a [Σ, F] grammar, we mentioned that this rule could not be required to apply before the rule

[8] See my "Three models for the description of language" (above, p. 22, fn. 3) for a brief account of transformations, and *The logical structure of linguistic theory* and *Transformational Analysis* for a detailed development of transformational algebra and transformational grammars. See Z. S. Harris, "Cooccurrence and Transformations in linguistic structure," *Language* 33.283-340 (1957), for a somewhat different approach to transformational analysis.

analyzing NP_{sing} into *the* + *man*, etc. One reason for this is now obvious -- (29 i) must apply after (34), but (34) must apply after the analysis of NP_{sing}, or we will not have the proper selectional relations between the subject and verb and the verb and 'agent' in the passive.)

Secondly, note that certain transformations are *obligatory*, whereas others are only *optional*. For example, (29) must be applied to every derivation, or the result will simply not be a sentence.[9] But (34), the passive transformation, may or may not be applied in any particular case. Either way the result is a sentence. Hence (29) is an obligatory transformation and (34) is an optional transformation.

This distinction between obligatory and optional transformations leads us to set up a fundamental distinction among the sentences of the language. Suppose that we have a grammar G with a [Σ, F] part and a transformational part, and suppose that the transformational part has certain obligatory transformations and certain optional ones. Then we define the *kernel* of the language (in terms of the grammar G) as the set of sentences that are produced when we apply obligatory transformations to the terminal strings of the [Σ, F] grammar. The transformational part of the grammar will be set up in such a way that transformations can apply to kernel sentences (more correctly, to the forms that underlie kernel sentences—i.e., to terminal strings of the [Σ, F] part of the grammar) or to prior transforms. Thus every sentence of the language will either belong to the kernel or will be derived from the strings underlying one or more kernel sentences by a sequence of one or more transformations.

From these considerations we are led to a picture of grammars as possessing a natural tripartite arrangement. Corresponding to the level of phrase structure, a grammar has a sequence of rules of the form $X \rightarrow Y$, and corresponding to lower levels it has a sequence of

[9] But of the three parts of (29 i), only the third is obligatory. That is, *past* may occur after NP_{sing} or NP_{pl}. Whenever we have an element such as C in (29 i) which must be developed, but perhaps in several alternative ways, we can order the alternatives and make each one but the last optional, and the last, obligatory.

morphophonemic rules of the same basic form. Linking these two sequences, it has a sequence of transformational rules. Thus the grammar will look something like this:

(35) Σ: *Sentence*:

$$\left.\begin{array}{l} F: X_1 \rightarrow Y_1 \\ \quad \vdots \\ \quad X_n \rightarrow Y_n \end{array}\right\} \text{Phrase structure}$$

$$\left.\begin{array}{l} T_1 \\ \vdots \\ T_j \end{array}\right\} \text{Transformational structure}$$

$$\left.\begin{array}{l} Z_1 \rightarrow W_1 \\ \qquad \vdots \\ Z_m \rightarrow W_m \end{array}\right\} \text{Morphophonemics}$$

To produce a sentence from such a grammar we construct an extended derivation beginning with *Sentence*. Running through the rules of F we construct a terminal string that will be a sequence of morphemes, though not necessarily in the correct order. We then run through the sequence of transformations T_1, ... T_j, applying each obligatory one and perhaps certain optional ones. These transformations may rearrange strings or may add or delete morphemes. As a result they yield a string of words. We then run through the morphophonemic rules, thereby converting this string of words into a string of phonemes. The phrase structure segment of the grammar will include such rules as those of (13), (17) and (28). The transformational part will include such rules as (26), (29) and (34), formulated properly in the terms that must be developed in a full-scale theory of transformations. The morphophonemic part will include such rules as (19). This sketch of the process of generation of sentences must (and easily can) be generalized to allow for proper functioning of such rules as (26) which operate on a set of sentences, and to allow transformations to reapply to transforms so that more and more complex sentences can be produced.

When we apply only obligatory transformations in the generation of a given sentence, we call the resulting sentence a kernel sentence. Further investigation would show that in the phrase structure and morphophonemic parts of the grammar we can also extract a skeleton of obligatory rules that *must* be applied whenever we reach them in the process of generating a sentence. In the last few paragraphs of § 4 we pointed out that the phrase structure rules lead to a conception of linguistic structure and "level of representation" that is fundamentally different from that provided by the morphophonemic rules. On each of the lower levels corresponding to the lower third of the grammar an utterance is, in general, represented by a single sequence of elements. But phrase structure cannot be broken down into sublevels: on the level of phrase structure an utterance is represented by a set of strings that cannot be ordered into higher or lower levels. This set of representing strings is equivalent to a diagram of the form (15). On the transformational level, an utterance is represented even more abstractly in terms of a sequence of transformations by which it is derived, ultimately from kernel sentences (more correctly, from the strings which underlie kernel sentences). There is a very natural general definition of "linguistic level" that includes all of these cases,[10] and as we shall see later, there is good reason to consider each of these structures to be a linguistic level.

When transformational analysis is properly formulated we find that it is essentially more powerful than description in terms of phrase structure, just as the latter is essentially more powerfull than description in terms of finite state Markov processes that generate sentences from left to right. In particular, such languages as (10iii) which lie beyond the bounds of phrase structure description with context-free rules can be derived transformationally.[11] It is important to observe that the grammar is materially simplified when we add a transformational level, since it is now necessary to provide phrase structure directly only for kernel sentences — the terminal strings of the [Σ, F] grammar are just those which underlie kernel

[10] Cf. *The logical structure of linguistic theory* and *Transformational Analysis*.

[11] Let G be a [Σ, F] grammar with the initial string *Sentence* and with the set of all finite strings of *a*'s and *b*'s as its terminal output. There is such a grammar. Let G′ be the grammar which contains G as its phrase structure part, supplemented by the transformation T that operates on any string *K* which is a *Sentence*, converting it into $K + K$. Then the output of G′ is (10iii). Cf. p. 31.

sentences. We choose the kernel sentences in such a way that the terminal strings underlying the kernel are easily derived by means of a [Σ, F] description, while all other sentences can be derived from these terminal strings by simply statable transformations. We have seen, and shall see again below, several examples of simplifications resulting from transformational analysis. Full-scale syntactic investigation of English provides a great many more cases.

One further point about grammars of the form (35) deserves mention, since it has apparently led to some misunderstanding. We have described these grammars as devices for generating sentences. This formulation has occasionally led to the idea that there is a certain asymmetry in grammatical theory in the sense that grammar is taking the point of view of the speaker rather than the hearer; that it is concerned with the process of producing utterances rather than the 'inverse' process of analyzing and reconstructing the structure of given utterances. Actually, grammars of the form that we have been discussing are quite neutral as between speaker and hearer, between synthesis and analysis of utterances. A grammar does not tell us how to synthesize a specific utterance; it does not tell us how to analyze a particular given utterance. In fact, these two tasks which the speaker and hearer must perform are essentially the same, and are both outside the scope of grammars of the form (35). Each such grammar is simply a description of a certain set of utterances, namely, those which it generates. From this grammar we can reconstruct the formal relations that hold among these utterances in terms of the notions of phrase structure, transformational structure, etc. Perhaps the issue can be clarified by an analogy to a part of chemical theory concerned with the structurally possible compounds. This theory might be said to generate all physically possible compounds just as a grammar generates all grammatically 'possible' utterances. It would serve as a theoretical basis for techniques of qualitative analysis and synthesis of specific compounds, just as one might rely on a grammar in the investigation of such special problems as analysis and synthesis of particular utterances.

6

ON THE GOALS OF LINGUISTIC THEORY

6.1 In §§ 3, 4 two models of linguistic structure were developed: a simple communication theoretic model and a formalized version of immediate constituent analysis. Each was found to be inadequate, and in § 5 I suggested a more powerful model combining phrase structure and grammatical transformations that might remedy these inadequacies. Before going on to explore this possiblity, I would like to clarify certain points of view that underlie the whole approach of his study.

Our fundamental concern throughout this discussion of linguistic structure is the problem of justification of grammars. A grammar of the language L is essentially a theory of L. Any scientific theory is based on a finite number of observations, and it seeks to relate the observed phenomena and to predict new phenomena by constructing general laws in terms of hypothetical constructs such as (in physics, for example) "mass" and "electron." Similarly, a grammar of English is based on a finite corpus of utterances (observations), and it will contain certain grammatical rules (laws) stated in terms of the particular phonemes, phrases, etc., of English (hypothetical constructs). These rules express structural relations among the sentences of the corpus and the indefinite number of sentences generated by the grammar beyond the corpus (predictions). Our problem is to develop and clarify the criteria for selecting the correct grammar for each language, that is, the correct theory of this language.

Two types of criteria were mentioned in § 2.1. Clearly, every grammar will have to meet certain *external conditions of adequacy*; e.g., the sentences generated will have to be acceptable to the native speaker. In § 8 we shall consider several other external conditions of this sort. In addition, we pose a *condition of generality* on grammars; we require that the grammar of a given language be constructed in accordance with a specific theory of linguistic structure in which such terms as "phoneme" and "phrase" are defined independently of any particular language.[1] If we drop either the external conditions or the generality requirement, there will be no way to choose among a vast number of totally different 'grammars,' each compatible with a given corpus. But, as we observed in § 2.1, these requirements jointly give us a very strong test of adequacy for a general theory of linguistic structure and the set of grammars that it provides for particular languages.

Notice that neither the general theory nor the particular grammars are fixed for all time, in this view. Progress and revision may come from the discovery of new facts about particular languages, or from purely theoretical insights about organization of linguistic data — that is, new models for linguistic structure. But there is also no circularity in this conception. At any given time we can attempt to formulate as precisely as possible both the general theory and the set of associated grammars that must meet the empirical, external conditions of adequacy.

We have not yet considered the following very crucial question: What is the relation between the general theory and the particular grammars that follow from it? In other words, what sense can we give to the notion "follow from," in this context? It is at this point that our approach will diverge sharply from many theories of linguistic structure.

The strongest requirement that could be placed on the relation between a theory of linguistic structure and particular grammars is that the theory must provide a practical and mechanical method for

[1] I presume that these two conditions are similar to what Hjelmslev has in mind when he speaks of the *appropriateness* and *arbitrariness* of linguistic theory. Cf. L. Hjelmslev, *Prolegomena to a theory of language = Memoir 7, Indiana University Publications Antropology and Linguistics* (Baltimore, 1953), p. 8. See also Hockett's discussion of "metacriteria" for linguistics ("Two models of grammatical description," *Linguistics Today, Word* 10.232–3) in this connection.

actually constructing the grammar, given a corpus of utterances. Let us say that such a theory provides us with a *discovery procedure* for grammars.

A weaker requirement would be that the theory must provide a practical and mechanical method for determining whether or not a grammar proposed for a given corpus is, in fact, the best grammar of the language from which this corpus is drawn. Such a theory, which is not concerned with the question of *how* this grammar was constructed, might be said to provide a *decision procedure* for grammars.

An even weaker requirement would be that given a corpus and given two proposed grammars G_1 and G_2, the theory must tell us which is the better grammar of the language from which the corpus is drawn. In this case we might say that the theory provides an *evaluation procedure* for grammars.

These theories can be represented graphically in the following manner.

(36) (i) (ii) (iii)

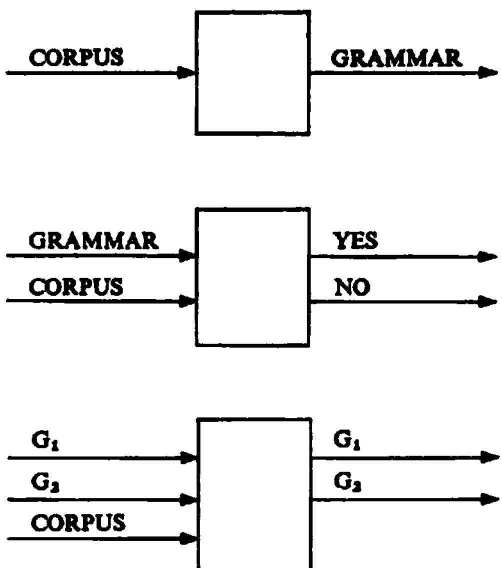

Figure (36i) represents a theory conceived as a machine with a corpus as its input and a grammar as its output; hence, a theory that provides a discovery procedure. (36ii) is a device with a grammar and a corpus as its inputs, and the answers "yes" or "no" as its outputs, as the grammar is or is not the correct one; hence, it represents a theory that provides a decision procedure for grammars. (36iii) represents a theory with grammars G_1 and G_2 and a corpus as inputs, and the more preferable of G_1 and G_2 as output; hence a theory that provides an evaluation procedure for grammars.[2]

The point of view adopted here is that it is unreasonable to demand of linguistic theory that it provide anything more than a practical evaluation procedure for grammars. That is, we adopt the weakest of the three positions described above. As I interpret most of the more careful proposals for the development of linguistic theory,[3] they attempt to meet the strongest of these three requirements. That is, they attempt to state methods of analysis that an investigator might actually use, if he had the time, to construct a grammar of a language directly from the raw data. I think that it is very questionable that this goal is attainable in any interesting way,

[2] The basic question at issue is not changed if we are willing to accept a small set of correct grammars instead of a single one.

[3] For example, B. Bloch, "A set of postulates for phonemic analysis," *Language* 24.3–46 (1948); N. Chomsky, "Systems of syntactic analysis," *Journal of Symbolic Logic* 18.242–56 (1953); Z. S. Harris, "From phoneme to morpheme," *Language* 31.190–222 (1955); idem, *Methods in structural linguistics* (Chicago, 1951); C. F. Hockett, "A formal statement of morphemic analysis," *Studies in Linguistics* 10.27–39 (1952); idem, "Problems of morphemic analysis," *Language* 23.321–43 (1947); R. S. Wells, "Immediate constituents," *Language* 23.81–117 (1947); and many other works. Although discovery procedures are the explicit goal of these works, we often find on careful examination that the theory that has actually been constructed furnishes no more than an evaluation procedure for grammars. For example, Hockett states his aim in "A formal statement of morphemic analysis" as the development of "formal procedures by which one can work from scratch to a complete description of the pattern of a language" (p. 27); but what he actually does is describe some of the formal properties of a morphological analysis and then propose a "criterion whereby the relative efficiency of two possible morphic solutions can be determined; with that, we can choose the maximally efficient possibility, or, arbitrarily, any one of those which are equally efficient but more efficient than all others" (p. 29).

and I suspect that any attempt to meet it will lead into a maze of more and more elaborate and complex analytic procedures that will fail to provide answers for many important questions about the nature of linguistic structure. I believe that by lowering our sights to the more modest goal of developing an evaluation procedure for grammars we can focus attention more clearly on really crucial problems of linguistic structure and we can arrive at more satisfying answers to them. The correctness of this judgment can only be determined by the actual development and comparison of theories of these various sorts. Notice, however, that the weakest of these three requirements is still strong enough to guarentee significance for a theory that meets it. There are few areas of science in which one would seriously consider the possibility of developing a general, practical, mechanical method for choosing among several theories, each compatible with the available data.

In the case of each of these conceptions of linguistic theory we have qualified the characterization of the type of procedure by the word "practical". This vague qualification is crucial for an empirical science. Suppose, for example, that we were to evaluate grammars by measuring some such simple property as length. Then it would be correct to say that we have a practical evaluation procedure for grammars, since we could count the number of symbols they contain; and it would also be literally correct to say that we have a discovery procedure, since we can order all sequences of the finite number of symbols from which grammars are constructed in terms of length, and we can test each of these sequences to see if it is a grammar, being sure that after some finite amount of time we shall find the shortest sequence that qualifies. But this is not the type of discovery procedure that is contemplated by those who are attempting to meet the strong requirement discussed above.

Suppose that we use the word "simplicity" to refer to the set of formal properties of grammars that we shall consider in choosing among them. Then there are three main tasks in the kind of program for linguistic theory that we have suggested. First, it is necessary to state precisely (if possible, with operational, behavioral tests) the external criteria of adequacy for grammars. Second, we must characterize the form of grammars in a general and explicit way so that we can actually propose grammars of this form for particular languages. Third, we must analyze and define the notion of simplicity that we intend to use in choosing among grammars all of which are of the proper form. Completion of the latter two tasks will enable us to formulate a general theory of linguistic structure in which such notions as "phoneme in L", "phrase in L", "transformation in L" are defined for an arbitrary language L in terms of physical and distributional properties of utterances of L and formal properties of grammars of L.[4] For example, we shall define the set of phonemes of L as a set of elements which have certain physical and distributional properties, and which appear in the simplest grammar for L. Given such a theory, we can attempt to construct grammars for actual languages, and we can determine whether or not the simplest grammars that we can find (i.e., the grammars that the general theory compels us to choose) meet the external conditions of adequacy. We shall continue to revise our notions of simplicity and out characterization of the form of grammars until the grammars selected by the theory do meet the external conditions.[5] Notice that this theory may not tell us, in any practical way, how to actually go about constructing the grammar of a given language from a corpus. But it must tell us how to evaluate such a grammar; it must thus enable us to choose between two proposed grammars.

In the preceding sections of this study we have been concerned with the second of these three tasks. We have assumed that the set of grammatical sentences of English is given and that we have some notion of simplicity, and we have tried to determine what sort of grammar will generate exactly the grammatical sentences in some simple way. To formulate this goal in somewhat different terms,

[4] Linguistic theory will thus be formulated in a metalanguage to the language in which grammars are written — a metametalanguage to any language for which a grammar is constructed.

[5] We may in fact revise the criteria of adequacy, too, in the course of research. That is, we may decide that certain of these tests do not apply to grammatical phenomena. The subject matter of a theory is not completely determined in advance of investigation. It is partially determined by the possibility of giving an organized and systematic account of some range of phenomena.

we remarked above that one of the notions that must be defined in general linguistic theory is "sentence in L." Entering into the definitions will be such terms as "observed utterance in L", "simplicity of the grammar of L," etc. This general theory is accordingly concerned with clarifying the relation between the set of grammatical sentence and the set of observed sentences. Our investigation of the structure of the former set is a preparatory study, proceeding from the assumption that before we can characterize this relation clearly, we will have to know a great deal more about the formal properties of each of these sets.

In § 7 below, we shall continue to investigate the relative complexity of various ways of describing English structure. In particular, we shall be concerned with the question of whether the whole grammar is simplified if we consider a certain class of sentences to be kernel sentences or if we consider them to be derived by transformation. We thus arrive at certain decisions about the structure of English. In § 8 we shall argue that there is independent evidence in favor of our method for selecting grammars. That is, we shall try to show that the simpler grammars meet certain external conditions of adequacy while the more complex grammars that embody different decisions about assignment of sentences to the kernel, etc., fail these conditions. These results can be no more than suggestive, however, until we give a rigorous account of the notion of simplicity employed. I think that such an account can be given, but this would go beyond the scope of the present monograph. Nevertheless, it should be fairly clear that under any reasonable definition of "simplicity of grammar", most of the decisions about relative complexity that we reach below will stand.[6]

Notice that simplicity is a *systematic* measure; the only ultimate

[6] See my *The logical structure of linguistic theory* for discussion of methods for evaluating grammars in terms of formal properties of simplicity.

We are not, incidentally, denying the usefullness of even partially adequate discovery procedures. They may provide valuable hints to the practicing linguist or they may lead to a small set of grammars that can then be evaluated. Our main point is that a linguistic theory should not be identified with a manual of useful procedures, nor should it be expected to provide mechanical procedures for the discovery of grammars.

criterion in evaluation is the simplicity of the whole system. In discussing particular cases, we can only indicate how one or another decision will affect the over-all complexity. Such validation can only be tentative, since by simplifying one part of the grammar we may complicate other parts. It is when we find that simplification of one part of the grammar leads to corresponding simplification of other parts that we feel that we are really on the right track. Below, we shall try to show that the simplest transformational analysis of one class of sentences does quite frequently clear the way to a simpler analysis of other classes.

In short, we shall never consider the question of how one might have arrived at the grammar whose simplicity is being determined; e.g., how one might have discovered the analysis of the verb phrase presented in § 5.3. Question of this sort are not relevant to the program of research that we have outlined above. One may arrive at a grammar by intuition, guess-work, all sorts of partial methodological hints, reliance on past experience, etc. It is no doubt possible to give an organized account of many useful procedures of analysis, but it is questionable whether these can be formulated rigorously, exhaustively and simply enough to qualify as a practical and mechanical discovery procedure. At any rate, this problem is not within the scope of our investigations here. Our ultimate aim is to provide an objective, non-intuitive way to evaluate a grammar once presented, and to compare it with other proposed grammars. We are thus interested in describing the form of grammars (equivalently, the nature of linguistic structure) and investigating the empirical consequences of adopting a certain model for linguistic structure, rather than in showing how, in principe, one might have arrived at the grammar of a language.

6.2 Once we have disclaimed any intention of finding a practical discovery procedure for grammars, certain problems that have been the subject of intense methodological controversy simply do not arise. Consider the problem of interdependence of levels. It has been correctly pointed out that if morphemes are defined in terms of phonemes, and, simultaneously, morphological considerations are