XXVII

TRANSFORMATIONAL THEORY*

1. STYLES OF GRAMMAR AND PROPERTIES OF SENTENCES

It may be helpful to understand transformational analysis in the light of other styles of grammatical analysis. The establishment of descriptive linguistics as a successful research method, and the piling up of grammatical descriptions, have made possible the investigation of various types of grammatical relation. Different ways of analyzing sentence-structures have been found or proposed; these are characterized by different kinds of aspects in terms of which the sentences of a language are described. Traditional grammar established various distinguished segments of sentences which were hierarchically subdivided into smaller segments (in a manner made explicit by Leonard Bloomfield, as the method of immediate constituents), or were altered by a grammatical process (in a manner developed, for example, in the work of Edward Sapir). Another decomposition is given by string analysis, in which each sentence is segmented into one center string and a number of adjunct strings which are adjoined to the center or adjunct strings.

In describing sentence structure, string analysis differs from constituent analysis primarily in that it isolates a distinguished elementary sentence and elementary adjuncts within each sentence, whereas constituent analysis does not directly express the fact that the heads of the various constituents of a sentence or constituent X, at a given level of constituency, make up a sentence or adjunct string which can by itself appear in the linguistic environments in which X appears. That is, if a sentence or adjunct string X consists of constituents A (composed, in constituent terms, of head-of-A plus remainder-of-A) and B (composed of head-of-B plus remainder-of-B), then the environments in which the sequence head-of-A plus head-of-B can occur are closely related to the environments in which X can occur: they are the same (as in *I walked home briskly. The air was clear* and *I walked home. The air was clear*) or the same except for parallel remainders within connected sentences (as in *I walked slowly. But John walked briskly*), or the like.[1] Thus in the sentence

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However, a sample which a young naturalist can obtain directly is often of value

we have

(1) center string: *a sample is of value;*
(2) adjunct on 1: *however;*
(3) right-adjunct on subject of 1: *which a naturalist can obtain;*
(4) left-adjunct on subject of 3: *young;*
(5) (right)-adjunct on verb of 3: *directly;*
(6) adjunct on 1: *often.*[2]

If we compare the statements in string analysis with those in constituent analysis, we see that constituent analysis gives a hierarchical subdivision (in principle unbounded) of a sentence and its parts into parts, whereas string analysis gives a center and adjuncts, the adjoining of some adjuncts being in principle unboundedly repeatable. The fact that an adjunct may adjoin another adjunct is equivalent to part of the hierarchy in constituent description, but certain pseudo-hierarchical features of constituent description are replaced by the sequential composition of elementary strings and by the repeatability of certain adjunctions.[3]

Transformational analysis yields yet another decomposition of sentences: into sentences and operations on them, ultimately into elementary sentences K and elementary operations φ which operate on K and φ. The operations (transformations) thus decompose a sentence into sentences. In the above example we have (using here a rough formulation of transformations):

(1) elementary sentence: *a sample has value;*
(2) elementary sentence: *a naturalist obtains a sample;*
(3) elementary sentence: *a naturalist is young;*
(4) *however* (sentence-insert) operating on sentence 1, yielding a sentence;
(5) *often* (sentence-insert) operating on sentence 1, yielding a sentence;
(6) *has* $N \rightarrow$ *is of* N (for a certain subcategory of N);
(7) *wh-* connective on sentences 1, 2, yielding a sentence;
(8) *can* (verb-operator) on sentence 2;
(9) *directly* (adverbial insert) on sentence 2;
(10) *wh-* connective on sentences 2, 3, yielding a sentence;
(11) zeroing of *who is* in 10, with permutation of remainder of sentence 3.

Transformational analysis is relevant to linguistics because (1) it is possible to give formal and reasonable criteria for decomposing a sentence into sentences, and this by means of a reasonably small set of transformations; (2) the set of sentences of the language has an interesting structure, and one which has a semantic interpretation, under the transformational operations; (3) the set of transformations also has an interesting structure, and is not merely an arbitrary list of operations sufficient to decompose sentences into

sentences. Transformational analysis is of particular interest, first, because it can be described and investigated with algebraic tools, and second, because it provides exceptionally subtle analyses and distinctions for sentences.[4]

To interrelate these analyses, it is necessary to understand that these are not competing theories, but rather complement each other in the description of sentences.[5] It is not that grammar is one or another of these analyses, but that sentences exhibit simultaneously all of these properties. Indeed one can devise modifications of languages, say of English, which lack one property while retaining the others; but the result is not structurally the same as the original language. Thus English sentences, taken transformationally as they now are, would have no simple string structure if the words due to separate elementary sentences were intermixed irregularly in the transformational resultant; and the sentences would have no string structure at all if transformations combined morphemes from separate elementary sentences into novel product-morphemes (portmanteau blends).

Each of these properties can be used as the basis for a description of the whole language because the effects of the other properties can be brought in as restrictions on the chosen property. For example, the string restriction on transformations can be expressed as follows: Consider a string of 21 positions, which can be expanded by repeatable insertion of *s, l, r* on *s,l, r*:

$$s\,l\,N\,r\,s\,l\,V\,r\,s\,l\,\Omega_1\,r\,s\,l\,P\,r\,s\,l\,N_2\,r\,s$$

where the tense (and auxiliaries) is left out to be added after any transformations, and where

s: adjunct on sentence
l, r: left and right adjuncts of their neighboring category
N, V, P: noun, verb, preposition word-categories
Ω_1: first section of object; may be empty
$P\,N_2$: second section of object; empty except for some cases of $\Omega_1 = N, A$

(If Ω_1 or P or $P\,N_2$ is empty, their l, r, and following s positions are also empty.) We can say that each transformation takes the words which are in specified positions of one or of two such strings and sends them, with possibly some added constants (including primitive adjuncts and operators) and zeroings, into specified positions of such a string. This conforms with two facts: that sentences have a quite limited string structure, and that transformations operate on a sentence, or on two, to produce a sentence.[6] The string property of the resultant sentence can thus be stated as a restriction on the transformation which yields that resultant.

Conversely the effect of each transformation on a sentence can be stated as a restriction on the string structure of that sentence. This is seen as follows:

Consider the string structure of a subset of sentences which we will call elementary. Here all the *s, l, r* positions are empty, and the *N, V,* Ω_1, *P,* N_2 positions are filled by particular subcategories (largely of unimorphemic words). It can be shown that each transformation which operates on an elementary sentence brings into one or another of the positions a subcategory which had not occurred there in the string structure of the sentence on which the transformation had operated. By asking what subcategories occur in each string position of a sentence – which is a question in purely string terms – we obtain the same information about the sentence as we would by asking what transformations had operated to produce the sentence.

Comparable statements can be made for constituent analysis, and in this sense each of these major sentential properties can be formulated so as to include the relevant effects of the other properties and so as to describe in its own terms the whole set of sentences.[7] In organizing a language description around one or another of these properties, the main difference lies not in the sentences which can be described, but in the way in which the description relates each sentence to certain others, i.e. in the various subsets of sentences that the description creates. Constituent analysis groups all sentences having similar hierarchical complexities; string analysis groups sentences which have the same center, or the same types of adjunction; transformational analysis groups sentences which have the same kernel (elementary) sentences, or the same transformations – i.e. each transformation is a set of sentence pairs, and transformational theory creates or characterizes these pairs.

However, the greatest interest in each of these properties lies not in its utilization as an organizing scheme for grammatical analysis, but in the statements which can be made, uniquely in terms of the given property, about the structure of language. For example, in terms of the string property we can make the fundamental statement that if we define in a given language a small set of center strings and a few sets of adjunct strings – each set being characterized by its adjoining a particular type of string at a particular point in it – then (aside from grammatical ambiguity) each sentence can be decomposed in a mechanical way into one center sentence and certain adjunct strings.[8] There are, besides, additional interesting statements which can be made in terms of each property. For example, in terms of string analysis, we can say that the discontinuous elements of constituent analysis present no problem of noncontiguity (relation at a distance). Every relation (co-occurrence or selection, agreement, structural composition, etc.) holds within a string (among the symbols of a string) or else between a string (or its first member) and the string to which it is adjoined. Thus the 'movable' adjective in Latin, and the 'detached' relative clause of *My friend came, whom I had mentioned to you,* are indeed distant from their nouns, but they

are contiguous to the string containing that noun; they cannot be non-contiguous to that string or its adjuncts.

It should be mentioned that the investigation of the several basic properties of sentences, and the possibility of using each as the central method of sentence analysis, are different from the question of the logical forms of grammar as a theory of language. The properties, e.g. the transformational relation, can be studied empirically; and a particular form of grammar can use various of these properties.[9]

2. CRITERIA FOR TRANSFORMATION

Before considering the transformational structure of a language, it might be well to state under what conditions two sentences (or sets of sentences) are transforms of each other; here we offer this, rather than a definition of transformation. Take an n-place form, i.e. a sequence of n symbols for word-categories such as *N*, *V*, with possibly some individual morphemes which will be called constants of the form e.g. (1) N_1 *t V* N_2 *P* N_3 (*t*: tense morpheme; the subscripts are only for distinguishing the various occurrences of *N*).

We now take ordered n-tuples of words, each containing one member for each word-category in the sentence-form, e.g. (2):

man, give, book, to, boy.
man, give, book, to, girl.
man, give, boy, to, table.

The result of substituting the words of an n-tuple for the category-symbols of the sentence-form (allowing for morphophonemic and other requirements, such as the article) will be called a satisfier of the form, e.g. (3):

The man gave a book to the boy.
The man gave a book to the girl.
The man gave a boy to the table.

Among these satisfiers there are some differences in their acceptability as sentences, differences which make them partially ordered on a scale of naturalness, likelihood of occurrence in particular language use (e.g. scientific articles, fairy tales), type (including, presumably, timing) of response by particular hearers, or the like. Or the satisfiers are differentiated, not linearly, on several such scales.

Consider now another sentence form of the same n word-categories, say (4) N_2 *t be Ven by* N_1 *P* N_3. If we find a set of n-tuples whose satisfiers *X* of the first form have the same order on this scale as their satisfiers *Y* of the second

form, we say that the two forms can be taken as transforms of each other for that set of n-tuples (or: the two sets of sentences can be transforms of each other).[10] Whether they are indeed so taken will depend on whether the set of n-tuples is not ad hoc, i.e. whether it can be characterized in some useful way in respect to other sets of n-tuples: for example, whether the set appears again in transformations to yet other sentence-forms, whether the set is characterizable by some morphological or syntactic property (e.g. if it contains all *V* which can have – or lack – certain affixes, or certain types of object), whether the complement set of n-tuples participates in other transformations, and so on. This is much the same kind of consideration as is used in determining what categories of words are worth setting up in linguistic structure. As with all linguistic classifications, the chosen criteria suffice for the great bulk of the material; however, scattered residues will be found which do not satisfy all the requirements of the chosen criteria, but can be analyzed in such a way as to fit with the analysis of the bulk of the language. Thus after the main transformations have been set up, it will be convenient to define certain transformations for small sets of words which are not otherwise recognized as sets. Such treatments are unavoidable throughout linguistic analysis, because of the existence of aberrant detail in language.[11]

It should be clear that the interest here is not in the actual acceptances that a given n-tuple has in a given form (something which is often difficult to evaluate), but in the fact that the ordering of acceptability for a set of n-tuples is the same in several sentence forms (even if the actual acceptabilities, or the amount of difference in acceptability, may differ in the several forms). This suffices to relate the several forms in respect to the given set of n-tuples.

By this criterion, we can take forms (1) and (4) as transforms of each other (written (1)↔(4)) for a set of n-tuples including (2), since the acceptability-ordering of (2) in (3) is the same as in (5):

A book was given by the man to the boy.
A book was given by the man to the girl.
A boy was given by the man to the table.

Both in (3) and in (5) the first two n-tuples yield normal acceptance, while the third gives one pause. But when the same n-tuples are used as satisfiers of (6) $N_1\ t\ V\ N_3\ P\ N_2$, we get a different acceptability-ordering:

The man gave the boy to a book.
The man gave the girl to a book.
The man gave the table to a boy.

Hence (1)↔(6).

Furthermore, the transformation (1)↔(4) does not hold for such n-tuples as (7):

man, practise, hour, on, Tuesday
man, walk, mile, on, Tuesday

which are acceptable in (1), but have no or only special acceptance in (4); as in

$\sim\exists$ *An hour was practised by the man on Tuesday.*
$\sim\exists$ *A mile was walked by the man on Tuesday.*

Note, however, that (7) is acceptable in (8) N_1 *V for* N_2 *P* N_3 as in

The man practised for an hour on Tuesday.
The man walked for a mile on Tuesday.

so that for (7) we have (1)↔(8).

In the light of this criterion we can see, for example, that (9) N_1 *t V* N_2 is not a transform of (10) N_2 *t V* N_1. True, there are n-tuples whose acceptability-ordering is presented in the two forms, e.g. in *John saw Bill* and *Bill saw John*. But for each *V* there can be found nouns whose acceptability-ordering as objects of that *V* is not the same as their acceptability-ordering as subjects of it, as can be seen from *Can the deaf see the blind?* Even if the *N* are restricted to personal names we can find such cases, as in *Did John see Helen Keller?*[12] There is thus no independent property which would characterize the n-tuples whose acceptability-ordering is the same in (9) and (10) from those for which it is not.[13]

Similarly, (11) *A* N_1 *t V* N_2 is not a transform of (12) N_1 *t V A* N_2. For (11) is a transform of the pair of forms (13) N_1 *t V* N_2, N_1 *is A* (by the connective *wh* on N_1), while (12) is a transform of (14) N_1 *t V* N_2, N_2 *is A* (by the connective *wh* on N_2); and even if N_1 and N_2 are the same word, we can always find, for each *V*, some set of *A* such that the acceptability-ordering of n-tuples containing these *A* in (11) and in (13) is not preserved (in the manner of note 12) in (12) and in (14).

It is possible to define transformations, as a relation among sentences, in various ways.[14] All adequate formulations ultimately yield virtually the same transformations for a language.[15] The formulation sketched here in terms of acceptability-differences fits into the fact that there is no well-defined set of sentences in a language. Rather, some word sequences are clearly sentences, others are odd or even undecidable as to sentencehood in one or another way, and some are entirely impossible. In terms of transformational theory, we can say that all these differences and types of acceptability are to be found in the elementary sentence-forms, in respect to the satisfaction of these forms by various word n-tuples. The transformations preserve the acceptability-

ordering (and so the normalcy, jocularity, marginality, etc.) of these n-tuple satisfactions, from the elementary sentence-forms into all the other sentence-forms of the language. It is thus possible to find a precise set of transformations in a language without having to state a precise set of sentences for the language. Transformations simply tell us that the sense in which an n-tuple satisfies a particular complex sentence-form is the same as that in which it satisfies some other (and ultimately, some elementary) sentence-form. As happens so often in science, in order to describe a particular set of phenomena we have to start with a class of objects which is different from our initial interest but which is precisely definable and in respect to which we can describe our particular phenomena. In the present case, we set out to describe a relation among sentences, but we have to define a relation among sentence-forms in respect to certain n-tuples which satisfy them.[16]

3. THE TRANSFORMATIONS

The transformations of English fall into certain types which in gross character seem to be the case for many other languages too.[17]

3.1. *Unaries*

There are unary transformations between two sentence-forms. These include some in which word-categories are permuted (or, rarely, repeated or dropped), usually with the addition of some constant words or morphemes. In most or all of these there is no substantive change of meaning, e.g. between the active and the passive. In addition to the well-established transformations, there are transformations which are barely acceptable or are used only in particular linguistic environments: e.g. *He works at night→His work is at night, He prepared the experiment→The preparation of the experiment was by him.* Many of these latter transformations come in families, in which the individual transformations apply a particular change to various parts of the sentence-form; e.g. the important set of extraction transformations: *His story describes Sicily→His story is what describes Sicily, It is his story that describes Sicily, Sicily is what his story describes, It is Sicily that his story describes.* We could also find *He left it on the table→The table is what he left it on.* In several such families we find parts of the sentence for which the transformation is more complicated or difficult, e.g. the extraction of the verb in *Describing Sicily* (or: *To describe Sicily*) *is what his story does.* There may even be parts of the sentence such that we cannot say whether the family of transformations extends to them or not: *He wrote the story within one week→ (?) One week is what he wrote the story within, *Within one week is when he wrote the story.*

Many such cases of difficult or uncertain transformations would not even be noticed if it were not for having a family of transformations, which operate in comparable ways on various parts of a sentence, and which we then discover to be neither definitely acceptable or definitely unacceptable on certain other parts of the sentence, but rather partially acceptable in various ways.

As will be seen, the great majority of transformations listed below operate on all words of the major word-categories on which they act, or on all words which do or don't come from particular other transformations (e.g. the passive does not act on N_2 which have come from the *P*-zeroing transformation of § 3.4). A few, like the instrumental, act on a particular subcategory of *V*, *N*, etc. And a few, like the middle, act on small subcategories but are productive with weakened acceptability outside the subcategory.

The transformations of a language can be grouped in various ways. Here we will group the main unary transformations of English in a way that will be useful for the further decomposition of transformations in § 5 below.

One type of transformation is that which permutes parts of an elementary sentence (and, in some cases, an insert to it), without adding any constants, in such a way as to yield a form that differs from any elementary sentence-form of the language. Such are:

$N_1\ t\ V\ N_2 \rightarrow N_2\ N_1\ t\ V$: *I like this, This I like.*
$N_1\ t\ V\ N_2 \rightarrow N_2\ t\ V\ N_1$: *All the scientists say this, This say all the scientists.*

There is no change in the syntactic character of the parts (i.e. the subjection to major transformations and morphophonemics, as in plural agreement): e.g. *This* does not become the subject and does not agree in number with *say*. Hence we may call these the ASYNTACTIC transformations. They are uncomfortable except in cases where the permuted object is stressed and where ambiguity is not likely (e.g. *This say*... is not ambiguous because the number differs). All other transformations yield sentences which have elementary sentence-forms (though with new items satisfying some of the symbols) plus, possibly, adjuncts.

Another small type of transformation is the addition of PLEONASTIC material in a way that does not destroy elementary sentence-form (e.g. the addition being in the form of an insert):

$N_1\ t\ V\ N_2 \rightarrow N_1\ t\ V\ N_1$'*s* N_2: *He learned a lesson, He learned his lesson.*

(*his* is not independent here; $\sim\exists$ *He learned her lesson*, except in a different sense, with a different transformational analysis).

An important transformation is the replacement of words (chiefly nouns) by PROWORDS (pronouns): *The man came, He came.*

Another transformation is the substitution one for another of semantically weak verbs or VERBALIZING suffixes, which give various forms to sentences whose information is carried by two nouns, or by noun and adjective:

He lived in a room there, He stayed in a room there, He roomed there.
It has value, It is of value.
He was sick, He became sick, He sickened.

Yet another is the replacement of subject by object in what we may call the MIDDLE (between active and passive):

I attach this interpretation to your words, This interpretation attaches to your words.

Another is the transformation which MIRRORS a sentence in its verb *be*:

Mathematics is his forte, His forte is mathematics.

Then there is the large set of MODULATIONS noted above:

His work is at night; The preparation of the experiment was by him.

In these the nominalized verb appears as subject; but related to these are transformations in which the subject is replaced by the object or by an added indirect object peculiar to certain verbs:
e.g. the PASSIVE:

$N_1\ t\ V\ N_2 \rightarrow N_2\ t\ be\ Ven\ by\ N_1$: *He saw the man, The man was seen by him.*

and passive-like transformations:

$N_1\ t\ V\ N_2 \rightarrow N_2\ t\ be\ Ven\ P\ N_1$: *The plan involves him, He is involved in the plan.*

and the INSTRUMENTAL (on a subcategory of V):

$N_1\ t\ V\ N_2\ with\ N_3 \rightarrow N_3\ t\ V\ N_2$: *He cut the meat with a knife, The knife cut the meat.*

There is a set of quotation-forms and intonationally-marked moods:
Quotation: *Social means not individual* → *'Social' means not individual.*
Question: *He took the book* → *Did he take the book?, Who took the book?, What did he take?, What did he do?*
Imperative: *Take the book!*
Optative: *Would that he took the book!*

Finally, there is the family of EXTRACTIONS mentioned above (*Sicily is what his story describes*, etc.), and the ZEROING OF INDEFINITE PRONOUNS which is seen in deletion of the object:

He read all day ← *He read things all day,*

in adjective used as noun:

I prefer the larger ← *I prefer the larger one,*

and in such limited constructions as indefinite pronoun (or classifier-noun) plus preposition before noun of receptacle:

The whole room laughed ← *All those in the room laughed.*

3.2. *Nonsentential Increments*

The pure unaries listed above rearrange the words of a sentence, with some zeroings or the addition of constants or repetitions. There are other operations, which add to a sentence-form a whole category of words. These naturally alter the meaning of the sentence, but the added meanings are not like the concrete meanings of the words in the elementary sentence; rather, they are metasentential (in the sense of talking about the meanings in the sentence), or relational, or aspectual, or they refer to conditions of time, place, and manner, and so on. The addition of any of these increments to a sentence yields again a sentence, and the resultant (as also in all the pure unaries except the asyntactic) has an elementary sentence-form (with new items satisfying some of the symbols) plus, possibly, adjuncts. It is therefore possible to consider the addition of these increments to be unary transformations.

The main incremental unaries are the inserts, verb-operators, and sentence-operators.

All inserts are adjuncts (modifiers) on a sentence or on one of its parts. A sentence of the form $X_1 X_2 X_3$, with an insert J adjoined to X_i, is a sentence with center $X_1 X_2 X_3$ and adjunct J on X_i.

LOCAL INSERTS adjoin certain small subcategories, of vaguely quantitative meanings, e.g. *a* to the left of *N*, *very* to the left of *A*, *quite* to the left (or right) of *V* (or *A*), *almost* to the left of *V* or *P*.

TENSE INSERTS, which can perhaps be best considered as operating on *t* (tense), have particular transformations on them, e.g. *not* (to the right of *t* in the sentence-form), the auxiliaries (*can*, *may*, etc.) to the left of *t*.

SENTENCE-INSERTS occur in all positions, before or after any symbol of an elementary sentence-form, e.g. *however*, *in general*. Some of these have conjunctional force, others can be viewed as irregular residues of conjoined

sentences; but as they appear at present, they form a set of primitive inserts (not regularly derivable from second sentences).

ADVERBIAL INSERTS, *D* (mostly *Aly*) and *P N*, have some subcategories only to the right of *V* (e.g. *down, out*), others in all or most of the positions that sentence-inserts occupy.

All VERB-OPERATORS bring in a new *V* of certain special subcategories, change the original *V* into what might be called the object of the new *V* (*Vn, Va*, etc.); some also add or change a preposition before the N_2 object of the old *V*.[18] Thus:

$$N_1\ t\ V\ \Omega \rightarrow N_1\ t\ V_{\text{new}}\ Vx\ (P)\ \Omega.$$

A special set of verb-operators (symbolized by *Y*) includes *be-ing* and *have-en: He is writing a story, He has written a story.*

The other verb-operators (marked *U*) fall into several subcategories, of which the main ones are the following:

be Va (P): A complicated set of changes, acting on special subcategories of *V* e.g.

This destroys our trust → This is destructive of our trust.
He loves Italy → He is in love with Italy.
It irritated them → It was (very) irritating to them.
He is clever → He is being clever.
The door sticks → The door is stuck.

be Vn P: acting on most *V*, mostly with *-er*:

He studies eclipses → He is a student of eclipses.
He builds bridges → He is a builder of bridges.

U_g *Ving*, U_t *to V*: on every *V*:

He began building bridges, He began to build bridges.
He stopped building bridges. (But $\sim \exists$ *He stopped to build bridges*).

U_{hg} *Ving*, U_{ht} *to V*: only on sentences whose subject is taken in a human-like sense.

He tried building bridges, He tried to build bridges.
The electron tries to escape.

U_d (*the*) *Ving P*: on most or all *V*, but with varying acceptability.

He does the building of bridges,
He began the building of bridges.

U_m *Vn P*: on many *V* which have *Vn* (with zero or real affix):

He does studies of eclipses.
He makes studies of eclipses.
He began the study of eclipses, He began a study of eclipses.
He thinks of a repeat → He has thoughts of a repeat.

U_n *a Vn P*: for each *U* just a few particular *V*, unextendable, with *n* usually zero.

He kicked the door → He gave a kick to the door.
He looked at it → He took a look at it, He gave a look at it.

U_{ap} *Vn P*: particular *U* 'appropriate' to particular *V*; the U_{ap} is often the same morpheme as the *V* or a classifier of it:

He slept quietly → He slept a quiet sleep.
He fears it → He feels fear of it.

Finally, there are the SENTENCE-OPERATORS (marked *W*), formed out of particular subcategories of *V, A, N*. These are *N V* whose object is a slightly deformed sentence, or they are *V* Ω (including *is A, is N, is P N*) whose subject is a similarly deformed sentence.[19] The deformations are[20]:

N t V Ω: (*that*) *N t V* Ω, (*that*) *N V* Ω, *if N t V* Ω } marked Sn^0
N's Ving Ω, marked *Sn'*
N's Vn of Ω, marked *Sn*

Examples:

I know (that) he came.
I prefer (that) he come, I prefer for him to come.
I wonder if he came or not, I wonder whether he came or not.
She appreciated his having signed the letter.
They imitated his signing of the letter.
That he came surprised me, ... is a fact, ... is the trouble.
That he came is important, For him to come is important.
Whether he will come or not is the question.
His leaving school occurred two years ago.
His leaving of school was secretive.

There are additional forms which occur only as objects of particular *N V* and *N is A*. These include:[21]

(*P*) N_i *that* N_j *t V* Ω
(*P*) N_i *if* N_j *t V* Ω
(*P*) N_i *that* N_i *V* Ω, variant N_i *to V* Ω

(*P*) N_i *P* N_i'*s Ving* Ω, with (*P*) N_i'*s* zeroed (for some *W*, necessarily)
P Sn'
P Sn
N V Ω, with *N* accusative if pronoun.

Examples:

I told him that she came.
I reported to him that she came.
I asked (of) him if she came or not.
I ordered them that they be present, I ordered them to be present.
I required of them that they be present, I required of them to be present.
I restrained him from going, I got him to thinking.
I refrained from buying paper-backs.[22]
I am aware of his having come.
I made him come.[23]

There is also a zero (and affix) causative in which the *W* contains no new verb, but the *N* and *V* of the operand sentence are permuted:

The children sat → *He seated the children.*
The patient walked → *The nurse walked the patient.*

Just as in the pure unaries we had a pairing of sets of sentences with and without certain structural changes, so in the incremental unaries we have a pairing of sets of sentences with and without certain increments; the increments either are adjuncts or contain new verbs, and the new verb has either the old *V* Ω as its object or else the whole old sentence as its subject or object. In each case the paired sentence-forms are satisfied by the same n-tuples with acceptability-ordering preserved, so that they are transforms of each other for the given n-tuple sets. The structural difference in each pair can be considered an operation which operates on the simpler member of the pair, as operand, to yield the other member as resultant.

3.3. *Binaries*

There are also binary transformations operating on two sentences to yield a resultant sentence. No conjunctional transformations operate on three sentences at a time; but this may not apply to the connective verbs mentioned below. All the conjunctional transformations except the connective verbs leave the first sentence unchanged (at least initially, before any further transformation operates) and add a connective *C* or a deformation or both to the second sentence, the modified second sentence having then (precisely

or partially) the position of an adjunct in respect to the first. Thus, the connective *and* on the pair *The man talked, The man drove* yields

The man talked and the man drove; The man talked and drove.

The connective *after* yields:

The man talked after he drove; After he drove the man talked; The man talked after driving; etc.

The *wh*-connective yields:

The man who drove talked.

Furthermore, most of the connectives require particular similarities and particular minimal differences between the two sentences on which they act. Thus, in the coordinate conjunctions, *and* requires no differences, *or* requires at least one difference, *but* requires at least one difference in the predicate[24]:

Years passed and years passed.
He will go or she will go.
He bought books but she bought flowers.

In the pure comparative conjunctions, the two participant sentences can always be transformed into (or from) a canonical *N is A* form (below). In the *wh* (relative clause) connective, the two sentences must have a noun in common (i.e. the same member of the *N* category, as enlarged by any transformations, must appear in both), and in the second sentence the common noun must be in a position from which it can be permuted to the head of its sentence by an existing transformation. Thus:

wh [*The man talked about it, The man drove*]
= *The man who drove talked about it.*
wh [*His friend talked about it, His friend I saw*←*I saw his friend*]
= *His friend whom I saw talked about it.*

In the subordinate conjunctions and the secondary comparatives (e.g. *enough for*), the specification of differences is more involved and requires investigation.

The connectives of English fall into a few subcategories which are differentiated by the transformations that can operate upon them (§ 3.4):

Coordinate conjunctions: *and, or, but* (and secondarily comma, semicolon, period). These permit particular zeroings and permutations; e.g. ∼∃ *and he came, I went.*

Subordinate conjunctions, C_s, in various subcategories:

because, etc. before *S*: *I came because he arrived.*
while before *S*, *Ving* Ω: *I came while he arrived, I talked while driving.*
after before *S*, *Sn'*: *I came after he left, I came after his having left.*
during before *Sn*: *I came during his signing of the letter.*

These permit different zeroings and permutations; e.g. ∃ *Because he came, I went.*

Comparative conjunctions: *-er* (or: *less*) *than, as much as* between two sentences (not necessarily elementary) of *N is A* form. Existing transformations relate this form to other sentence-forms, in the course of which the first ('adverbial') part of the connective (*-er, less, as*) is moved into various positions of the first sentence as a marker of what is being compared. As an example of a comparative sentence: *A larger frame arrived than we had ordered.* Its canonical transform: *The frame which arrived is large | er than | the frame which we had ordered (is large).* Weakened conditions on this yield the properties of secondary comparatives, e.g. *The frame is too large to order.*

The *wh*-connective takes a sentence containing a particular N_i and a second sentence beginning (after suitable transformations) with the same N_i, replaces N_i by a pronoun of it attached to *wh*; and inserts the thus deformed second sentence as a right adjunct on the N_i in the first sentence: as above. *wh* also operates on the ordered pair (S_i, $S_i n$ *V* Ω): *He left, which surprised me←wh (He left, His leaving surprised me).*

To the binaries must be added the subcategories of *V* which have two deformed *S*, one as subject and one as object:

That he felt responsible indicates that he knew everything.
That he knew everything follows from his having felt responsible.
The change of temperature caused a change of plans.
The size of the frame which arrived exceeded the size which we had ordered.

Although these have the combined features of *W* with object *S* and *W* with subject *S*, they are not operators on a single sentence, as are the *W*, but on two. Some of them can be related to subordinate and comparative conjunctions. In any case, they are connectives which do not leave the first sentence unchanged, so that some of the string properties of conjunctions do not apply to these connective *V*.[25]

3.4. *Unaries on Increments and Binaries*

To complete the transformational analysis of English sentences, we

recognize transformations which operate on the resultants of increments and binaries somewhat as the pure unaries (§ 3.1) operate on elementary sentences: they permute, repeat, and zero various parts (symbols) of the resultant sentence form, and add constants.

In the first place, various of the pure unaries are extended to operate on some of these resultants. This requires the extension of the argument of the unary; so that if for example the passive has been defined on certain N_1 *t* V N_2, the domain of V and N_2 is now extended to include U and *Ving* Ω respectively (but not U and *to* V Ω):

Europeans soon began printing → *Printing was soon begun by Europeans*

(but no passive of *Europeans soon began to print*), and also to include verbs of W and Sn° or Sn' or Sn:

They recognize that he came → *That he came is recognized by them.*

Of greater interest are the new, nonelementary, unaries which appear specifically on incremental and connected sentences. A simple example of these is the permutation of t and N in the presence of certain D (adverbs)[26]:

He would little care to see her → *Little would he care to see her.*

Another permutation related to increments is the preference, in a sequence of syntactically parallel items, to have the longer ones come later; this is especially strong after the V, among the objects and verb-adjuncts. Thus:

Ω_1 Ω_2 in the elementary S: *He referred a man to the office.*
short D[27], and Ω: *He broke up the game.*
Ω shortened by pronouning: *He broke it up.*
Ω_1 lengthened by adjunction: *He referred to the office a man who had been making persistent inquiries.*

The adverbial increments D, primarily P N and those containing *-ly*, are transformable into the position of A and V members of W with sentential subject:

$SD_t \rightarrow Sn'$ *occurs* D_t, Sn' *is* A_t
$SD_m \rightarrow Sn$ *is* A_m

Here D_t indicates P N or *Aly* of time and place, and A_t the corresponding P N or A; *occur* stands for a set of synonymous verbs (*take place*, etc.); and the tense of *occur* or *be* is the tense of the S (lost in Sn'). Similarly for D_m of manner.

He spoke there on Tuesday. His speaking there occurred on Tuesday. His speaking there was on Tuesday.
He may break the toys frequently. His breaking the toys may occur frequently.
His breaking the toys may be frequent.
He broke the toys vindictively. His breaking of the toys was vindictive.

In addition, the A_m of manner take a transformation like certain A members of *W: N's Ving* Ω *is* $A \rightarrow$ *N is A in Ving* Ω.

He was vindictive in breaking the toys.
He was vindictive in his (or: *the*) *breaking of the toys.*

Similarly, in *W*:

For him to do this is helpful; He is helpful to do this.

Among the transformations which involve only small subcategories of words are these:

The zeroing of *P* in *P N* of measure: *He ran for two hours* $\rightarrow$ *He ran two hours.*

The repeating of the subject after certain *U*: *He took a walk* $\rightarrow$ *He took his walk.*

On *W*, there are the variants within the deformation of *S* as noted above. Furthermore, every subcategory of *W* that occurs with *Sn*° has a transformation $\rightarrow$*Sn'*, and every *W* that occurs with *Sn'* has a transformation $\rightarrow$ *Sn*:

I know that he signed the letter $\rightarrow$ *I know of his having signed the letter* $\rightarrow$ *I know of his signing of the letter.*

Also, every sentence of the form *Sn*° *V* $\Omega \rightarrow$ *It V* Ω *Sn*°:

That he came is odd $\rightarrow$ *It is odd that he came.*

The various *W* on *S* are also transformable into the positions of *D* as adjuncts on that *S*; e.g.

I know that he came $\rightarrow$ *He came, to my knowledge.*
He came, as I know.
He came, I know.
That he came is clear $\rightarrow$ *He came, clearly.*

Given an *S* which is the object of a *W*, if the subject of the *S* is the same (in referent) as the subject of the *W* (or as the Ω_1 of the *W* if the given *W* has such an Ω_1), the subject of the operand *S* is zeroed (with various special conditions):

I asked that I might come → *I asked to come.*
I asked him that he should come → *I asked him to come.*

The transformations on connectives are of three main kinds: interchanges among the connectives; zeroing of repeated or otherwise redundant material; permuting of the second sentence.

The main interchange among connectives is that certain subordinate conjunctions C_s become conjunctional preposition P_s and in some cases finally adverbs:

$$C_s\ N\ t\ V\ \Omega \rightarrow \left\{ \begin{matrix} C_s\ Ving\ \Omega \\ P_s\ (N's)\ Ving\ \Omega \end{matrix} \right\} \rightarrow Vingly$$

while he smiled, while smiling, smilingly

There are also transformations between conjunctions and the binary verbs.

The zeroing occurs under different conditions for different conjunctions. In C_s, $V\ \Omega$ is zeroed if identical with the $V\ \Omega$ of the first sentence; but it may be zeroed in the first sentence if the second S with C_s precedes:

I will go if you will.
If you will go, I will.

In C_s and P_s forms with *-ing* in the second sentence, the subject must or may be zeroed (depending on the conjunction) if identical in referent with subject or object of the first sentence:

I returned, after driving all night.

In coordinate conjunctions, words in the second sentence (under the conjunction) are zeroed if they are identical with the words in the corresponding string position in the first sentence; but there are certain restrictions, and even certain references to the position of the words in the underlying elementary sentences.

He bought books and she bought flowers → *He bought books and she flowers.*
He bought books and she too bought books → *He bought books and she too.*

In comparative conjunctions, the zeroing is much like that of the coordinate conjunctions, with some interesting differences.

In addition, there is zeroing of words in the second sentence which can be determined (up to synonymity) from other words in it. This appears in the zeroing of *is* (with zeroing of referent repeating subject) in

If he is free, he will go → *If free, he will go.*

It appears in the zeroing of *wh*-word plus *is* in

The mountain which is very angular is the Matterhorn → The very angular mountain is the Matterhorn.

It appears in more complicated ways in the zeroing of 'appropriate' V in certain compound nouns, and in the zeroing of *each other* after reciprocal verbs.

C_s S, in any of its transformations, can be permuted into any sentence-insert position in the first sentence. Second sentences headed by coordinate or comparative conjunctions can be permuted to a particular point in the first sentence: the coordinate to immediately after the word which corresponds to the last non-zeroed word under the conjunction (*He and she too bought books*); the comparative to immediately after the word in the first sentence which carried the comparative marker (*A larger frame than we ordered has arrived*).

3.5. *How the Transformations Operate*

The pure unaries, the increments, and the binaries have been defined as operations from elementary sentences to a resultant sentence. The non-elementary unaries (§ 3.4) were defined on specific resultants, yielding a new resultant. All of these can also operate on particular other sentence-structures which have resulted from the prior operation of other transformations. To see why this is possible, we note certain restrictions on the set of elementary sentences and on the set of transformations, restrictions which will become more apparent in the discussion of elementary transformations below. (1) All elementary sentence-forms are similar to each other in certain features: all consist of a subcategory of N plus t plus a subcategory of V plus an Ω structure determined by the V subcategory. (2) All transformations are defined initially on one or some of the elementary sentence forms, or else on the resultants of transformations which have been defined on elementary sentence forms. (3) The resultant of a transformation differs from its operand (and therefore from some elementary sentence form) by only certain limited differences: either there has only been an insertion to the right or left of one of the symbols of the form, or the subcategories which are the domains of the symbols have been changed[28], or the order of symbols is no longer the same as in one of the elementary sentence forms.

For an operation φ_j, defined on elementary sentence forms, to operate also on the resultant of an operation φ_i, it is necessary only to extend the domain of the argument of φ_j so as to include the effects due to φ_i. Thus, since the passive operates on *He began the smoking of cigars*, i.e. on the resultant of U_{gr}, we extend the definition of the passive to apply not only to the domains of V and N_2 in the elementary sentence forms, but also to the new V sub-

category which includes *begin* and to *the Vn* (for all the elementary subcategories of V) as satisfying the N_2 symbol. But since the passive does not operate on *He began to smoke cigars*, i.e. on the resultant of U_t, we do not extend the domain of N_2, as argument of the passive, to include *to V*; we need not then specify here whether *to V* is or is not the Ω of *begin*, since we are not defining the symbols absolutely, but only in respect to the various transformations for which their domain has to be specified. And, since the passive defined on $N_1\ t\ V\ N_2$ fails to operate on the resultant of P-zeroing before N of measure (see note 28), we say: N of measure is not included in the elementary domain of N_2 for V other than measure-verbs, so that the passive does not operate on sentences containing such N of measure as elementary sentences; and when we extend the definition of the passive, we do not extend it to N of measure after nonmeasure V.

Transformations can therefore be defined as operations on elementary sentences and on the resultants of transformations. This in turn is equivalent to defining transformations as operations on elementary sentences and on transformations. When we extend the argument of a transformation to include the effects of particular transformations, we are specifying which transformations can follow upon which transformations, and so giving their partial ordering. With their arguments defined in this way, the transformations need not be further ordered in respect to each other; although when we give a transformational characterization of a particular sentence we may have to specify a partial ordering among the transformations for that particular resultant. Thus *Smoking of cigars was begun by them* is Passive of U_g of *They smoked cigars*, while *Cigars began to be smoked by them* is U_g of Passive of *They smoked cigars*. The question of which transformations can repeat is also included in this specification of arguments.

When so specified, the transformations can be said to be able to occur whenever the conditions of their argument (including the availability of any necessary affixes for the particular words selected) are met. That is, every sentence that can be formed by the defined transformations should be a possible sentence, with an acceptability determined by the n-tuples and the transformations.[29]

The brief sketch above of the transformations of English and of their mode of operation is thus a sketch of a transformational grammar of English. Many problems remain concerning the precise domain of certain transformations, and whether certain relations among sentences satisfy the criteria of being a transformation; and there are problems in the boundaries between transformational structure and other features of language. However, a transformation once established is not normally falsifiable by further research; and the existence of the transformational relation and the general

properties discussed below of the set of sentences under this relation, and of the set of transformations, are not shaken by individual problems concerning transformations.

4. THE SET OF SENTENCES UNDER TRANSFORMATIONS

When we describe the set of sentences in terms of the transformational relation, we have the following.

There is a family of elementary (axiomatic) sentence forms, the kernel of the set of sentence forms under mapping onto the set of transformations. The sequence of symbols $N\ t\ V\ \Omega$ (Ω=zero, N, $N\ P\ N$, etc. according to the subtype of V) is the well-formedness requirement for the sentences of the kernel. The well-formedness requirement for the other sentences, transformationally related to the kernel sentences, is the same, except that:

(1) Stated local inserts may appear to the left or right of stated symbols; transformed sentences headed by *wh*, and by coordinate and comparative conjunctions, may appear to the right of stated symbols (with zeroed *wh- is*; also to the left); and sentence inserts, including sentences headed by subordinate conjunctions, may appear before or after any symbol of the kernel sentence.

(2) The domain of V is extended to include the verbs of (a) Y, U and (b) W[30], with the domain (a) of Ω being correspondingly extended to include V with various affixes (including *to*), and (b) of the subject N or the Ω (or, for the binary verbs, both) being extended to include Sn° or Sn' or Sn.

(3) A sentence headed by a conjunction (or, more rarely, subject or object of W) may have to have certain similarities or differences with respect to the sentence to which it is being conjoined (or to the W under which it is), and may (or in some cases must) have certain of its symbols satisfied by zero. In a very few situations symbols of a sentence are satisfiable by zero when a second sentence is conjoined to it in a particular way.

(4) Almost any word X of the elementary sentence, or else an adverbial insert X on it, can appear as the value of the subject N (or object of the verb *be*) when *wh* plus pronoun of X plus the rest of the elementary sentence appears as the object of *be* (or the subject N): *Nice is what he is, How he speaks is quietly.*

(5) A few permutations occur: of $N\ t$ after certain D and under question intonation; of Ω to the head of the sentence under question and contrastive intonations.

(6) Satisfiers of N positions can be replaced by pronouns (including *wh*-pronouns under question intonation).

We thus have, for nonkernel sentences, a secondary well-formedness

requirement derived from kernel well-formedness, and one which could as well be expressed in string or other terms as in transformational terms. A stronger composition rule specifies the nonkernel sentences transformationally in respect to the kernel sentences: Given a number of sentences in a kernel form, which have among them a particular acceptability-ordering or differentiation (not necessarily linear), all successions of transformations which are permitted, by the definition of their argument, will produce sentences preserving the same acceptability-ordering or differentiation. These transformations therefore specify a decomposition of each derived sentence into a kernel sentence, or if some of the transformations were binary, into more than one kernel sentence. This decomposition can be used to give each sentence of the language a normal form, which represents that sentence as a set of kernel sentences with partially-ordered transformations operating upon them (each transformation operating on one or on two kernel sentences, or else on a transformation). Sentences which are grammatically ambiguous (i.e. homonymous) will have more than one normal representation.[31]

If a sequence of words (or of refined word subcategories) is not decomposable by transformations into one or more kernel sentences (or refined kernel sentence forms), then that sequence is ungrammatical. If it is so decomposable, then it has a certain kind and degree of acceptability as a sentence, which is some kind of reasonable sum of the acceptabilities of the component kernel sentences and the acceptability effects of the transformations which figure in the decomposition.

This decomposition, or normal form, is of special interest because of various correlations with vocabulary, information-content, etc. The kernel sentences are not only short and of simple form, but are also composed of a restricted and simple vocabulary: mostly concrete nouns and verbs and adjectives, and mostly unimorphemic words. Most morphologically derived words are not in the kernel, because in almost all cases it is not that a word takes on an affix of its own accord, in order to modify its meaning or change its category; but rather a sentence changes its form by a transformation and as part of the constants of this transformation some of the words take on affixes. Thus *boy→boyhood* appears in transformationally related sentences like *He was yet a boy, He was yet in his boyhood; theory→theorize* in such transformationally related sentences as *He made a theory about this, He theorized about this.* The kernel words are mostly concrete, because action nouns, nouns of result, and many abstract nouns are in general nominalizations of sentences under *W* and *U* operators (*This item covered him adequately, This item gave him adequate coverage*), because many intellectual and relational words are themselves *W* operators on a sentence (*–is a fact,*

–is obvious, believe that–), because various words of aspect or mode of action are *U* operators (*try to–, begin to–*), and so on. It can even be shown that pronouns, numbers, most plurals, most occurrences of *the*[32], etc. can be brought into the sentences by existing types of transformations, and need not be taken as occurring in the kernel sentences.

In addition, there is a correlation of different parts of the normal form with different kinds of selection (co-occurrence restrictions). The usual kind of word-selection occurs in kernel n-tuples and between *V* and *D* (adverbial inserts on verb). Between *U* operators and the operand kernel *V* there is in some cases a weak selection; there is a dependence between certain *W* or C_s and the *t* of the kernel under them; and there is a restriction on the amount and kind of difference between the two sentences joined by a connective.

In view of all this, it is clear that transformations provide not only a possible grammatical analysis, but also one that is particularly subtle and has various semantic correlations.

5. THE SET OF TRANSFORMATIONS

The interest of transformations for a theory of language structure would be greater if the transformations of a language are not just a set of differences or operations between sentences, but a set that has some coherent structure of its own. The possibility of finding such a structure is heightened by the fact that certain constants appear in various transformations (something which itself would have to be explained): e.g. *-ing* in *Y, U (He is buying books, He began buying books, He began the buying of books)* and *W (His buying of the books surprised me)* and C_s (*He left without buying the books*). What is more, in their various occurrences the constants are placed in similar ways in respect to the kernel symbols and the other constants: e.g. *by* precedes the original subject *N* and follows a nominalization or adjectivization of the original *V* both in the Passive, *The books were bought by him*, and also under *W, The buying of the books by him surprised me.* This suggests that these constants are not merely local morphological affixes, but parts of a syntactic (i.e. sentence-wide) activity with interrelated affixes over specified parts of the kernel, which gives the kernel sentence a particular deformation as operand of some operator or connective: e.g. the forms under *Y, U, W,* C_s.

Furthermore, when we see that the same constants appear in different kinds of syntactic situation, e.g. *by* in the deformation under *W* and in the unary Passive, we can ask if one of these forms is the result of a transformation on the other, so that the constant appears in the later form simply because it was carried over from the earlier. Such an analysis would require that many transformations which seem to be single, e.g. the Passive, are really the

resultants of some smaller transformation *B* operating on the resultant of another, *A* – smaller, in the sense that only part of the passive form would be due to *B*, the rest being due to the *A* on which *B* had operated. Since we have thus entered upon the situation of successions of transformations, discussed in § 3.5, it becomes relevant that the resultants of many transformations are of only a few string forms (e.g. the resultant of some transformations is like a kernel form; the resultant of the *Sn* deformations *N's Ving of N, Ving of N by N*, under *W* and P_s is like *N* with right and left adjuncts); this makes it easier for other transformations to operate on the resultants of the first.

We have thus reached the possibility of decomposing transformations into component (divisor) transformations which we may call ELEMENTARY OPERATIONS. We try to carry this out in such a way that (if possible) every constant is introduced by only one transformation (which must then be a divisor of every resultant containing that constant), and in a way that yields a reasonable set of elementary operations and a derivation rule to obtain all transformations out of them. This turns out to be not entirely attainable for English. The situation for English is as follows. Transformations have two properties. One, they distribute certain changes over specified parts of a sentence form *A*. Two, the result is a sentence form *B*, and the acceptability-ordering for the n-tuples of *A* is preserved in *B*. The optimal divisors into which we can break up the transformations of English fall just short of these properties in the following way.

There are a few divisors whose resultant or operand is not quite acceptable as a sentence, or is a deformation of a sentence (type 3 below), but such that the next divisor operating on it yields an acceptable sentence. Thus the question-answer pair *What does he do? He draws cartoons* can be analyzed in the same way as *What does he draw? He draws cartoons* and *Who draws cartoons? He draws cartoons* only by relating *What does he do?* to *He does drawing of cartoons* and then the latter to *He draws cartoons.* In this way we can reach a set of elementary transformational divisors which have the following property: every transformation of the language is either one of these divisors or else a particular succession of them. Except for divisors of type 3 below, those resultants of a divisor which, for many n-tuples, are not acceptable as sentences are nevertheless acceptable for certain n-tuples or in the presence of certain kinds of adjuncts. Thus *He does drawing of cartoons* may be barely acceptable; *He did smoking of cigars* (between *What did he do?* and *He smoked cigars*) is rather unacceptable; but *He does teaching* is acceptable.

5.1. *The Elementary Transformations*

The elementary (axiomatic) operations (in a few cases, nonindependent

divisors) into which the transformations of English can be decomposed turn out to be a rather reasonable set:

(1) Local and sentential inserts and adverbial inserts, which do not affect the syntactic status (i.e. the subjectability to transformations) of the sentence parts to which they are adjoined.

(2) Operators *Y, U, W* on verb and on sentence, which introduce a new verb, with the original *V* or sentence being deformed as object or subject of it.

(3) Connectives, which head a sentence and may require a deformation of it, after which the connective-headed sentence is inserted into another sentence by the first operation above.[33]

(4) The zeroing of redundant material. Whereas the three transformational divisors listed above were all increments, this fourth one drops words from a sentence, but only words whose presence can be reconstructed from the environment. Hence we can say that the material is still morphemically present, that only its phonemes become zero, and that the language therefore has no dropping of morphemes. Nevertheless, this zeroing is real enough to be a transformational divisor in the derivation rule for transformations (§ 5.3).

5.2. *Zeroing of Redundant Material*

Since this operation is not easy to observe, a more detailed study of it will be given here.

Zeroing eliminates, from (usually) secondary members of a sequence of *K* and *W*, such words *Z* as can be determined (up to local synonymity[34]) from the particular words which occupy certain positions in the sequence distinguished relative to *Z*. *Z* therefore carries no information in the given sentence.

In all cases, what is removed is a redundancy that has arisen out of the juxtaposing of a kernel sentence *K* with an operator or insert, or with another *K* (or a disjunction or conjunction of *K*). Removal of redundancy is carried out in a way that leaves the resultant similar to some *K* form. The sentences which lack a word, because of a redundancy removal, have structures of the same kind as sentences without redundancy removal: e.g. *He denied his having slept, He denied having slept* (where the Ω loses a word, but remains Ω). This is so because most redundancy removal is in those parts of a sentence which have the form of an insert (e.g. the *his* above, which is like an insert in the Ω), or in a limited way in the Ω of the sentence.

The material that is zeroed in English is mainly 'appropriate' words (§ 5.21), repetitive words (§ 5.22), and indefinite pronouns (resulting from disjunctions or conjunctions of sentences, § 5.23).

5.21. *Appropriate Words*

The first type of redundancy removal operates in an insert or a secondary K, i.e. a $C\,K$, or a K that is under an operator. To consider the actual forms, it will be helpful first to define 'appropriate X', X_{ap}; X here ranges over the relation-expressing categories V, P, the operator W, and perhaps classifier-nouns N_{c1}. The X_{ap} of a particular word in a structure is the member (or members) of X which is the main co-occurrent of that word in that structure, for the given subject matter. That is, X_{ap}, in a K or insert or operator, is a particular member of category X which in the given culture or subject matter (e.g. conversation or science) is accepted (understood) as the main word to occur with the particular other words of that K or insert or operator, or with the particular word to which the K or insert is adjoined. In a form $A_i\,X_{ap}\,B_i$, the X_{ap} means not its full dictionary meaning but that which primarily carries out the X-relation (e.g. verb-relation) of A_i to B_i (in the present discourse).[35] Several words of category X may equally satisfy $A_i\,X_{ap}\,B_i$; they are then locally synonymous in respect to $A_i \ldots B_i$.

In many circumstances, specified below, the X_{ap} can be eliminated; other members of X cannot. There is no loss of information, for the absence of the X which is required in the $A\,X\,B$ structure (whose presence is evidenced by the remaining $A\,B$), points to the X_{ap} which is determined (up to local synonymity) by the individual words of the $A_i\,B_i$. Thus from *violin-prodigy* we generally reconstruct *violin-playing prodigy*, and from *violin-merchant* we generally reconstruct *violin-selling merchant*. In any case, the grammatical reality of X_{ap} lies in the fact that it and not other X can be zeroed in this way (or that X_{ap} is the only X that occurs in the given position). This treatment enables us to relate in a simple and reasonable way such aberrant forms $A\,B$ (e.g. compound nouns N-N) with grammatically regular form $A\,X\,B$.[36]

5.211. *Conditions for dropping* V_{ap}. The chief environmentally determined redundancy is in V_{ap} and the related *is* P_{ap}, which may be dropped when it occurs in an insert, or in the subject or Ω of the operator. Thus many compound nouns of the form N_2-N_1 are derived as follows:

$$N_2\text{-}N_1 \leftarrow N_2\text{-}V_{ap}ing\ N_1 \leftarrow N_1\ V_{ap}\ N_2$$

e.g.

the milkman

← **the milk-delivering man*

← *The man delivers milk* connected by *wh* to *man* in some other S.

Similarly, when N_1 *is* P_{ap} N_2 is connected by *wh* to N_1, we obtain N_2-N_1: *He painted the clothes-closet*←*wh* [*He painted the closet. The closet is for clothes*] (or *The closet contains clothes*, or the like).

Under an operator, when the K or its V is deformed, with $N\ V \rightarrow Ving\ of\ N$

(*Brecht wrote*→*writings of Brecht*) and *V N*→*to V N* (*to study French*), the *Ving* and *to V* can be dropped if *V* is V_{ap}.[37]

The writings of Brecht make good reading → *Brecht makes good reading.*
I began to study French → *I began French.*

To hear would not drop in *I began to hear French.*

I began to read the book → *I began the book.*
I began to write the book → *I began the book.*

But *to buy* does not drop in *I began to buy the book.* The appropriateness may also be determined by the operator, as in *The storm* (*crash, noise*, etc.) *caused the damage* (←*the occurrence of the storm*... etc.). In contrast, in *The ending of the storm caused the damage, The brevity of the storm caused the damage*, the words *the ending of, the brevity of* would not drop.[38]

Similarly, *When do you expect him to come?* (or *to arrive* etc.)→*When do you expect him?*; but in *When do you expect him to speak?* (or *to leave*), the *to V*, not being *to* V_{ap} for the operator *expect*, does not drop.[39]

Much investigation is still needed in the question of X_{ap}, since careful justification is necessary before absent words are reconstructed. Evidence of a dropped V_{ap} is particularly clear when a plural subject has a singular verb: *Too many cooks spoils the broth*←*Having* (or *The action of*) *too many cooks spoils the broth* (the common form *Too many cooks spoil the broth* is not understandable literally); *Two apparently opposed parties is the answer*←*Having*... As another example, consider a word which must be followed (when in category *P*) by a N_t of time, or (when in category P_s) by *Sn*, but which appears followed by *N* not of time: *It's the best bargain since Manhattan*←*... since the purchase of Manhattan.*[40]

A case of Ω_{ap} is *each other* as Ω of reciprocal *V*. The reciprocal *V* (for which N_1 *V* N_2↔N_2 *V* N_1: *She met him, He met her*) do not occur without Ω except as a result of a dropped Ω=*each other: He and she met*←*He and she met each other*; while *Tom and Jim argued*←*Tom and Jim argued with each other*, or←*Tom argued and Jim argued.* But in nonreciprocal *V*, the *each other* does not drop: *He and she dislike each other.*

5.212. *Dropping of constants.* The dropping of words which are constants of certain forms can be taken as a grammatical parallel to the dropping of X_{ap}: the constants are X_{ap} of the forms. In certain insert and object forms of those *K* whose *V* is *be* (or has been reduced to *be*), the *be* is dropped. In *the people here*←*the people who are here* we have the *wh* word plus tense plus *be* dropped from the insert *who are here*, whereas another *V* in this position would not be dropped: *the people who ate here*↔*the people here.* When a *K* whose *V*

is *be* becomes the object of certain *W* operators or of certain P_s, the *be, to be*, or *being* may be dropped: *They left him angry* but *They left him feeling ill*[41]; *While ill, he thought of it*, but *While delivering milk, he thought of it.*

The dropping of a constant in a particular form gives rise to one of the most common transformations, namely the sharing transformation which takes two *K* that contain identical N_i and makes the residue of the second *K* into an adjective or other insert to the N_i in the first *K*. We start with K_1 *wh* K_2, in which K_2 necessarily contains an N_i which also occurs in K_1. K_2 is permuted so that N_i is its first part. The N_i at the head of the K_2 is replaced by a pronoun which becomes the second part of the *wh*-word: *I picked up the book which fell.* The *wh*-word (i.e. *wh* plus pronoun) may be replaced by *that*, which carries less information than *who* or *which*, since it does not specify the subcategory of N_i (something which however can be discovered from the N_i itself immediately preceding). Furthermore, in all cases where the constant, whether *wh*-word or *that*, is not followed by the verb K_2, the *wh*-word or *that* may be dropped: *I picked up the book which you dropped, I picked up the book you dropped.*

Here an additional use of the redundancy-removal operation comes into play: If the verb following the *wh*-word is the constant *be* (or certain U_d operators like *do* in *He does writing*), or V_{ap}, then both the *wh*-word and the *V*-constant or V_{ap} of K_2 may be dropped:

I described the tree which was nearby →
I described the tree nearby.

We thus obtain the very frequent and important situation of *wh*-less K_2 inserts on *N*, including the one-word left (and right) adjuncts of *N: I saw the people present* from *I saw the people who (that) were present, I saw the new book* from *I saw the book which (that) was new, I saw the milkman* from *I saw the man who (that) delivers milk* (or *brings* or *sells milk*).[42]

5.213. *Dropping of performative operators.* Related to the dropping of predictable material is the dropping of certain sentence-operators which have performative force (so that no information loss results from dropping them) and whose existence is indicated by characteristic intonations in the *K* on which they had operated. This is the case in English for the question and the imperative. As can be shown, all questions (both yes-no and *wh*-) are obtainable in a simple way, and without appeal to special transformations, from a particular *W* operator on a disjunction of *S*:

I ask if S_1 *or* $S_2 \ldots$ *or* S_n

where the *or* $S_2 \ldots$ *or* S_n can be promorphemed into a droppable *or not*, with *if* → *whether:*

I ask whether S_1 *(or not)*

e.g. *I ask whether he will go (or not)* → *I ask: Will he go (or not)?* → *Will he go?* If in the disjunction only one word, say the object, varies, we have:

I ask if he will take the pen or he will take the pencil... or he will take the brush.
→ *I ask whether he will take the pen or the pencil... or the brush.*
→ *I ask what he will take.*
→ *I ask: What will he take?*[43] → *What will he take?*

Similarly, we obtain the imperative from:

I request (order, etc.*) you that you (please) take it.*
→ *I request (order,* etc.*) you: (Please) take it.*
→ *(Please) take it!*

In each case, the deformed operand with its intonation is unique to the particular *W*; therefore the *W* is zeroable.

Similar considerations apply to quoted material. Thus we can derive:

'Long' contains four letters.
← *The word 'long' contains four letters.*
← *wh* [*The word contains four letters, The word is 'long'*]

with

The word is 'long'.
← *'Long' is a word.*
← *Long is a word.*

where the quotes are a unique transformation for the subjects of the kernel sentences *X is a word, X is a term,* etc.

In such ways we can eliminate the moods, quotes, etc. from the kernel, and show that they are not independent meaning-carrying operations but simply variants occurring under unique operators or kernel-words (such as *word*). Furthermore, *Will he go?* is then directly transformed not from *He will go* but from *I ask whether he will go*; and *'Long' contains four letters* is not transformed from *Long contains four letters* but from *The word 'long' contains four letters* (with source noted above).

It is possible also to say that any sentence *S* may be derived from its occurrence under droppable operators which leave it unchanged. Thus in

Someone says that S. → *Someone says: S.*

the conditions of § 5.213 would permit the dropping of the operator, leaving *S*. Similarly, since an informationless operator which can occur on all *S*

would be droppable by § 5.213, we could say that any *S* occurrence may be derived from its occurrence under such an operator. In particular, we could think of cycles consisting of the adding of such an operator and its zeroing:

He returned.
plus operator: → *His returning occurred.*
zeroing: → *He returned.*

As was noted near the beginning of § 3.4, in these forms the tense (and auxiliaries) moves to the operator when the tenseless *Sn'* is formed. This situation enables us to explain the difference between *He may return* in the sense of his volition and *He may return* in the sense of likelihood. The first is:

He returns.
plus *may*: → *He may return.*

The second is:

He returns.
plus operator: → *His returning occurs.*
plus *may*: → *His returning may occur.*
zeroing of operator: → *He may return.*

The difference between the two meanings is then due not to the meaning range of *may* but to a difference in transformations.

5.22. *Repetitive Material*

The second type of redundancy removal also operates only in secondary *K*, and permits or requires the dropping of a word (with certain appended constants, if they are present) if the same word precedes (rarely, follows) it, as antecedent, in a distinguished position of its primary K_1 or of the operator on the *K*.

The simplest case is in K_1 *wh* K_2, where the common *N* immediately following the *wh* is pronounced and becomes the second part of the *wh*-word.

A repetitive subject (if it has been transformed into the form of an insert) or adverbial *P N* (but not normally Ω) is zeroed under *W*, P_s. Thus when certain *W* with N_i subject (or Ω_1) operate on a *K* whose subject is N_i, the second N_i drops if it is in insert-form: in *I prefer that I should go first* there is no zeroing, but in the transform of this *I prefer for me to go first→I prefer to go first*. Similarly *I insist that I should go, I insist on my going→I insist on going*. Similarly, *I told him to go←I told him that he should go*; but there is no zeroing in *I told him that she should go, I told him that he was wrong*. There are other operators (e.g. *oppose*) after which the zero before *Ving* (e.g. *I oppose smoking*) is of type § 5.23 below.

Several conditions for zeroing a referent-repeating subject are found in S_2n after certain P_s. Thus: *He stopped after entering*←*He stopped after his entering* (or: *entry*); since *after* is also C_s, we also have *He stopped after he entered.* After *while*, we have (as C_s) *He stopped while he spoke* and (as P_s) *He stopped while speaking*, but the intermediate is lacking: $\sim\exists$ *He stopped while his speaking.* Zeroing of the subject of S_2n is the same whether the antecedent is the subject of S_1, as above, or the Ω of S_1, as in *He stopped her after (her) entering.* In many situations, therefore, the zeroed subject is ambiguous as to antecedent: *He caught them while leaving the hall.*

A different kind of zeroing of repeated words is found after the coordinate and comparative connectives and C_s, as was seen in § 3.4.

The answer after a question, and the question after an assertion, may zero the $V\,\Omega$, or the whole sentence except for the answering or questioning word: *I will go. You will?, What will he get? A book.*[44]

5.23. *Zeroing of Indefinite Pronouns*

The third type of redundancy operation permits the pronouning (or, in certain cases, dropping) of disjunctions (more rarely, conjunctions) of all the words in a category or subcategory. These disjunctions of words come from disjunctions of elementary sentences. If n is the number of words in subcategory N, we have:

N_1 *or* $N_2 \ldots$ *or* N_n $V_i\,\Omega_i$
←N_1 $V_i\,\Omega_i$ *or* $N_2 \ldots$ *or* N_n
←N_1 $V_i\,\Omega_i$ *or* N_2 $V_i\,\Omega_i \ldots$ *or* N_n $V_i\,\Omega_i$.
I or you... or she will go.
I will go, or you,... or she.
I will go or you will go... or she will go.

In a variety of positions, such disjunctions of N are pronounced. They are zeroed only in insert-forms, and in Ω and before *wh*-insert. When this zeroing occurs, we may say that the disjunction is first replaced by an indefinite pronoun, and that this pronoun is then zeroed.[45] No loss of information results from such zeroing, since the disjunction could carry no information (beyond the grammatical presence of the category, which remains evident from the environing residual structure).

Dropping of insert-form indefinite pronouns (e.g. *someone's, by someone*) is seen when secondary K receive the form of adjectives or $P\,N$, and may be dropped, with a meaning equivalent to the indefinite pronoun of subject and Ω. Thus

The place has been taken.
←*The place has been taken by someone.*

← *The place has been taken by* N_1, *or by* N_2 ... *or by* N_n.
← *The place has been taken by* N_1 ... *or the place has been taken by* N_n.
← N_1 *took the place* ... *or* N_n *took the place.*[46]

Under certain sentence-operators, the insert-form subject of the operand *K* is zeroed when it is an indefinite pronoun, rather than when it is identical with the subject or Ω_1 of the operator.

He opposes drinking. ← *He opposes anyone's drinking.*
He says to wait. ← *He says for people to wait.*
The job requires having patience. ← *The job requires one's having patience.*

The same is the case for

To find the book is important.
← *For someone to find the book is important.*

When this subject of the *K* is not in insert form, the disjunction is pronounced but not zeroed:

The job requires that one have patience.

Other types of disjunction-zeroing take place in certain particular non-insert positions.

The most widespread of these is the zeroing of indefinite object, which occurs with many but not all *V: He reads* ← *He reads something* ← *He reads* N_1 *or* N_2 ... *or* N_n.[47] That this Ω-zeroing is indeed of the disjunction of objects for the given *V*, and not of a single Ω, is supported by the fact that metaphorical and idiomatic objects are not pronounable or zeroable: the idiomatic sense of *If I know how to read the signs correctly* is not preserved in *If I know how to read correctly.*

There is also a situation in which, given an indefinite pronoun[48] which carries a *wh*-insert, the pronoun is dropped, leaving the insert to carry the grammatical relations of the *N* (or, we might say, leaving a zero *N* whose presence is recognized from the insert).[49] This is the case of forms like

I read what he wrote.
← *I read that* (or: *the things*) *which he wrote.*
← *I read* N_1 *which he wrote and* N_2 *which he wrote* ... *and* N_n *which he wrote.*

That we indeed have here a zero *N*, invisible as to phonemes but tangible morphemically, is supported by the fact that certain transformations which

operate on *wh*-forms do not operate on those *wh*-forms which are merely inserts to a zeroed *N*. Thus, the transformation *W*, as in:

$$Sn^{\circ}\ V\ \Omega \rightarrow It\ V\ \Omega\ Sn^{\circ}$$

operates not only on Sn° under *W*, as in:

What he will say is not known. → *It is not known what he will say.*
Who will come doesn't interest me. → *It doesn't interest me who will come.*

but also on the extraction form of *K* (with *that* in place of *what*)[50]:

$wh\ \check{N}_i\ S\text{-}N_i\ is\ N_i \rightarrow It\ is\ N_i\ that\ S\text{-}N_i$
What he needs is money. → *It is money that he needs.*
(*) *Who said so was John himself.* → *It was John himself who said so.*

However, the transformation does not operate on

What he wrote was (widely) read.
$\sim\exists$ *It was (widely) read what he wrote.*[51]

even though the subject is of the same form as in the extraction. This is so because the subject here has zero *N*:

What he wrote was (widely) read. ← *That which he wrote was (widely) read.*

with *that* zeroed, but morphemically present. Indeed, when the pronoun is human, it is usually not zeroed:

The one whom they opposed was voted down.

5.3. *The Derivation Rule on the Elementary Operations*

We can now return to the four axiomatic transformational divisors, i.e. the elementary operations of § 5.1, and attempt a rule of derivation which specifies almost all transformations[52] on the basis of them.

Consider two sentence forms *A*, *B*, each containing some subcategory *X* and therefore written $A(X)$, $B(X)$. If between $A(X)$ and $B(X)$ there holds some succession of the elementary operations, then given the corresponding form $A(X')$ containing a subcategory X' similar to *X*, there is a possibility of finding *B* of X':

$$\frac{\begin{array}{l}A(X) \leftrightarrow B(X) \\ A(X')\end{array}}{B(X').}$$

It should be understood that while B(X′) is a transform of $A(X')$, it is not derived from $A(X')$ by a transformation, but is derived from the above rule. Derivation is therefore to be taken in the sense of this rule, and is not identical with transformation in its definition.

The above is an analogic rule of a form relevant to linguistic change.[53] It is of a tenuous character, because we cannot specify what similarities are sufficient for this rule to operate, and what is the likelihood that the extension of the $A(X)$–$B(X)$ relation to $A(X')$ will indeed have much acceptability. These matters require investigation, although a complete specification of these two conditions is not be be expected, if the development of language is not internally determinate. Nevertheless, a reasonable interpretation of the similarity conditions for X, X' suffices to characterize the transformations of English from the four (or, with note 52, five) types of elementary operation by means of this rule.

If the relation in the major premise is $A \rightarrow B$ defined on X, in the sense that $B(X)$ is derivable from $A(X)$ by one or more of the operations, then $B(X')$ looks like an extension of the argument of these operations to include X' as well as X. E.g. the transformation on W operators

$$Sn^{\circ}\ V\ \Omega \rightarrow It\ V\ \Omega\ Sn^{\circ}$$

is extended to operate on sentences of the extraction form (2) *wh- S is X* as well as on (1) $Sn^{\circ}\ V\ \Omega$. The $Sn^{\circ}\ V\ \Omega$ itself includes *wh- S is A, wh- S is N: Whether he took it is unclear, Whether he took it is the question, What he took is the question, Who took it is the question*, etc. The sentences of the form (2) *wh- S is X* constitute an important set of sentences, pronouning at the head of S an X whose range is N, $P\ N$, *Ving* Ω, D, and certain Ω including *A: What he took is a book, Who said so is John, Where he stayed was with me, How he argued was quietly, What he is is clever*. Although these are very different from (1) $Sn^{\circ}\ V\ \Omega$ in range and in grammatical character, there are a number of structures in (1) and (2) which are similar, as sequences of symbols, i.e. of constants and categories. We thus find the *It* form (with *that* replacing the *wh*-words except for *who* and rarely *when, where*), yielding *It is X that S-X: It is a book that he took, It is John who said so, It was clearly that he argued*, etc.[54] We could have said from the start that the *It* transformation operates on both structures. However, since the extraction (2) has a complicated derivation we can describe the application to it of the *It* transformation as a separate step, derived from *It* on W operators.

If the relation is $A \leftarrow B$ defined on X, the deriving of $B(X')$ looks like an inverse transformation from $A(X')$. Thus, we can zero a repetitive subject under W:

(1) *We prefer our studying French.* → *We prefer studying French.*

while in the parallel *We prefer her studying French* there is no zeroing. Now given sentences under U:

(2) *We began studying French (last year).*
We had thoughts about it.

we derive

(3) *We began our studying French (last year).*
We had our thoughts about it.

The two-subject form (3) cannot be the source of the one-subject form (2), since there are no two independent subjects in (3): $\sim\exists$ *We had their thoughts about it*, and U is defined as not introducing a second subject. Hence we can only understand (3) as obtained from (2) as an extension of (1).

If the transformational relation between A and B on X is not a single divisor, the formation of $B(X')$ makes the A-B difference look like a single operation from $A(X')$, even if such a transformation does not exist. Thus, if we start first with certain U, as in

He laughed→He gave a laugh; He had a laugh

we have a transformational relation between *He gave a laugh* and *He had a laugh* even though no elementary operation takes us from one to the other (and indeed the only succession of elementary operations that would take us from one to the other would be the inverse of a member of *U: He gave a laugh→He laughed* followed by another member of *U: He laughed→He had a laugh*). Given now

He had a party

we extend the transformational relation above, which had been defined on *Vn*, to such N (like *party*) as are the Ω of sets of U-like members of V; in this way we can obtain

He gave a party

(or vice versa), even though no verb *partied* exists to connect these two by elementary operations. This yields derived transformation directly from one U-like V to another, before certain N.

A surprising result is that many transformational shapes of a sentence are best obtainable from the elementary operations by going through the W operators. This is so because many of these transforms are virtually identical with the *Sn* under W, except that the sentential form has *is*. Thus the *Sn* forms of *They purchased the gouaches* under a W include:

(1) *We reported their purchase of gouaches* (or: *their purchasing*)
We reported the purchase of the gouaches by them
We reported the purchase by them of the gouaches
We reported their gouache-purchase.

Consider now a sentence beginning with *N is* under the *wh*-connective, with excision of *wh- is* (§ 5.212):

(2) *He tore a picture; The picture was on the wall* →
He tore the picture which was on the wall →
(3) *He tore the picture on the wall.*

Since all *Sn* have the morphological form of *N* with adjuncts, the set (1) is similar to (3) except for subcategory: both consist of N_1 plus *t V* plus N_2 with adjuncts. We therefore form from the set (1), on the analogy of the difference between (3) and (2), i.e. by the inverse of *wh- is* excision and of *wh* connective:

We reported the purchase. Their purchase was of the gouaches.
(or: *The purchase of the gouaches was theirs.*)
We reported the purchase. The purchase of the gouaches was by them (or: *The purchasing...*)
We reported the purchase. The purchase by them was of the gouaches.
We reported the purchase. The gouache-purchase was theirs.

And so for all *Sn*-forms, although some of these new sentence forms have low acceptability. Such derivations can yield the sentence modulations, as in *The purchase of gouaches was theirs.*

In addition to these directly derivable forms, there are transformational forms which show further operations upon these derivations. Thus, starting from

The purchasing by them was of gouaches

we may be able to obtain, by transformational steps similar to mirroring (§ 3.1) and a *be Va P* type of *U* (§ 3.2), the passive:

Gouaches were purchased by them

This derivation is particularly uncertain because the intermediate steps are similar but not identical to the known forms of mirroring and *U*. Nevertheless, the relation of the passive to the *Sn* noted above is supported by the following similarities. In both, the original subject takes *by* and becomes appended after the deverbalized *V*. Both reject the same pseudo-objects: From *The champion ran a mile, The candidate spoke two hours:*

(They reported) the running of a mile by the champion.
A mile was run by the champion.
$\sim\exists$ *(They reported) the speaking of two hours by the candidate.*
$\sim\exists$ *Two hours were spoken by the candidate.*

And neither applies if V=*be* or verbs of the *be*-set (*seem, become*). There is no Passive of *He was sick, He seemed sick*, and

$\sim\exists$ *They reported the being sick by him.*
$\sim\exists$ *They reported the seeming sick by him.*

As a somewhat different case, consider a peculiar English sentence form, whose character can be explained only by some kind of derivation from W. This is the form containing *is to: The bomb is to go off at three.* On the one hand, such sentences are peculiar in that no auxiliaries can be added: $\sim\exists$ *The bomb will be to go off at three.* On the other hand, each *is to* sentence carries the meaning of intention or of arranging for an outcome, even though the intender does not appear in the sentence. Now if we consider the W operators which take the form

(1) $N\ t\ V\ (P)\ N_i$ *that* N_i *should* $V\ \Omega \rightarrow$
(2) $N\ t\ V\ N_i$ *to* $V\ \Omega$,

we find that they have a characteristic meaning of arranging the $V\ \Omega$ for the N_i: *They set the bomb that it should go off at three*→*They set the bomb to go off at three, He fixed the show to open abroad*, etc. If on (2) we carry out successively the inverse of *wh- is* excision and the inverse of the *wh* connective, we obtain:

$N\ t\ V\ N_i$ *to* $V\ \Omega \rightarrow$
$N\ t\ V\ N_i$ *wh* $\check{N}_i$ *is to* $V\ \Omega \rightarrow$
$N\ t\ V\ N_i \cdot N_i$ *is to* $V\ \Omega$.
He set the bomb to go off at three →
He set the bomb, which is to go off at three →
He set the bomb. The bomb is to go off at three.

The form (2) is formed only out of (1) containing in its operand K the auxiliary *should* to which of course no further auxiliary can be added. The *to* (2) is a morphophonemic shape of this auxiliary *should* (in particular, *should* in the sense which it has in the operand of *set, arrange*) under certain operators, i.e. in certain new (insert-like) environments. The K-like form which the inverses produce out of (2) merely adds the V-constant *be* to this *to*. Hence no auxiliaries can be added to *is to*, and the meaning of the source *arrange that N should* is retained in *N is to*.

A remark on the direction of derivation: The great similarity between these sentence forms and *Sn* under *W* makes it clear that one should be derived from the other. One might think of deriving the *Sn* from the independent *S* forms, by saying that we could go in the opposite direction, and obtain the *Sn* by *wh*-connective between such sentences as *We reported the purchase, They set the bomb* (instead of the *W* operators) and these new *S* forms. However, since the same verbs *report, set*, etc. appear also as undoubted *W* operators on *that they purchased, that the bomb should go off* (and each with different *Sn*° deformations of the operand *S*, at that), we would have to have the *W* operators in *S* anyhow, and it is far simpler to have a single transformation *Sn*°→*Sn*, and then the new *S* forms from the *Sn*.

If we now make a quick check of the unaries in § 3.1, we find that they are all either successions of the elementary operations or else derivable from them by the rule of § 5.3, and so for the unaries of § 3.5. Thus the asyntactic require the fifth operation (note 52). The pleonastic *N's* is the inverse of the repetition zeroing under *W*. Pronouning can be considered a process like zeroing, but not simply a stage toward it, since the conditions for the two differ in important respects (see note 44). The derivation of the modulations and the passive have been discussed above. The middle can be obtained via *S*→*Sn is* A_m followed by an inverse:

He fitted the door snugly
→ *His fitting of the door was snug*
→ *The fitting of the door was snug*
→ *The door fitted snugly*

the last being the inverse of the same *S*→*Sn is* A_m transformation on intransitive *V*, as in *The chirping of the birds was cheery*←*The birds chirped cheerily*.

6. THE SET OF SENTENCES UNDER THE ELEMENTARY OPERATIONS

When we consider the set of sentences under the elementary operations we find a new situation. In the case of the set of sentences under transformations (§ 4), we saw that if two sentences were related, it was always possible to state a transformation or succession of these from one to the other. Because of the nature of the derivation rule on the elementary operations, we now have sentences which are related to each other in the theory of elementary operations, without one being derived from the other by any succession of elementary operations (as in the interchange of *U*, § 5.3). What does hold between any two related sentences, however, is that the difference between them is always a sum of elementary differences, where an elementary difference is the

difference between the operand and resultant of an elementary operation. We might therefore reach an analysis of sentences as a sum of elementary sentences and elementary differences; in some cases the order of accumulating the differences is nonunique, though the problem of alternative ways of deriving a form may become complicated only where certain inverses are involved.

NOTES

* The details of transformational analysis which the present paper summarizes have appeared or are to appear in various issues of *Transformations and Discourse Analysis Papers*, Department of Linguistics, University of Pennsylvania, and of *Papers on Formal Linguistics*, Mouton & Co., The Hague. I wish to thank Henry Hiż for valuable criticisms of the present manuscript.

[1] This is a simplified statement, omitting various restrictive conditions.

[2] The immediate-constituent analysis would give:

> Subject: *a sample which a young naturalist can obtain directly*
> Predicate: *is often of value,*

with *a sample* and *is* and *of value* eventually appearing as heads. The existence of a sentence *A sample is of value*, and its relation to the analyzed sentence, are not expressed by the constituent analysis.

[3] A distinction should also be made here between hierarchical operations and simple classification. The fact that some strings are partially similar, or that some strings occur in the same positions, may be expressed by collecting these strings into a class or schema. This serves only for an abbreviation of a linguistic description that could be made without such classification, so that there is no hierarchical linguistic operation here.

[4] This is not to say that there are no further subtleties of sentence structure which have yet to be treated. There remain problems concerning morphological and other restrictions on the application of transformations, concerning quasi-idiomatic constructions, concerning classifier-relations between words, etc.

[5] The pitting of one linguistic tool against another has in it something of the absolutist postwar temper of social institutions, but is not required by the character and range of these tools of analysis.

[6] The complete statement is a bit more complicated, because certain sentences have a string structure different from the one shown here (though closely related to it); e.g. *This I like*. Correspondingly, certain transformations produce or act upon these other string structures. The actual transformations of a language are of course a small subset of the ones admitted by the above statement, a subset distinguished by certain additional string restrictions and by the essential transformational properties described below in this paper.

[7] Because of the mass of idiomatic and quasi-idiomatic expressions in language, each type of description has to treat of various special small categories of words, and in some cases even of unique words. But in the case of string and transformational analyses, and less adequately in the case of constituent analysis, the statements for aberrant and idiomatic material can be made in the terms of the given description (constituent, string, or transformation) or in limited extension or weakenings of the rules of that description. In these analyses, the treatment of difficult material does not require us to go completely outside the terms of the given description into the terms of another or into the metalanguage.

[8] A program for string analysis by computer exists, and a transformational program has been designed. A transformational program can utilize in part the results of a string analysis. The less detailed program which analyzed sentences on the Univac in 1959 used a combination of string analysis and constituent analysis.

[9] This applies, for example, to the formulation of grammar in terms of partially ordered homomorphisms which was sketched in Z. S. Harris, 'From Morpheme to Utterance', *Lg.* **22** (1946), 161–83 (Paper VI of this volume) and which has been given an explicit form in Noam Chomsky's rewriting rules; also to the precise theory of generative grammar proposed and formulated by Chomsky in a series of major papers, especially in his *Syntactic Structures*, The Hague 1957. Cf. also his interesting 'Three Models for the Description of Language', *IRE Transactions on Information Theory*, IT-2 (1956).

[10] This formulation has to be extended, as it readily can be, to two further cases: where the second sentence form lacks one of the word categories (due to zeroing); and where we start with two sentence forms, A_1 and A_2, each with its own scale of satisfiers, plus a connective, and compare with a sentence form B containing the word categories of both (or at least, allowing for zeroing, the word categories of one form) where the acceptability-order of the n-tuples of B is summed in some regular way (related to the connective) from the acceptability-order of the corresponding n-tuples of A_1 and A_2. This criterion of a preserved acceptability-ordering is not easy to investigate and use. However, it clearly holds for all the pairs of satisfier-sets X, Y, where we would clearly want a transformational relation between X and Y. And if we find n-tuples which satisfy one form (with satisfiers X) with different acceptability-ordering than when they satisfy another form (with satisfiers Y), we indeed do not wish to call Y a transform of X, e.g. we may hesitate to consider the use of the passive form in scientific writing as a passive transform of the active.

[11] Such extension of a type of analysis into parts of the language where the analysis could not have been independently established does not make the analysis arbitrary. The existence of the relation in question has already been established over a large part of the language. Once we have seen, in this large part of the language, what are the effects of this relation, we may be able to show that similar effects exist in the rest of the language and may be attributed to the same relation.

[12] One might say *Can Helen Keller see a person with her fingers?*, but the acceptability would be rather special, and even more so for a simple *Did Helen Keller see John?* There is also *Can Helen Keller 'see' a person with her fingers?*; but this can be derived, by a transformation that produces quotation, from something like *Can Helen Keller do something which is called seeing a person with her fingers?*

[13] One might propose, as such a property: personal names used purely as examples for this discussion, and not identified with any real or fictional person. But such n-tuples have no acceptability difference among them in any sentence-form, so that they do not provide a basis for saying that (9)↔(10).

[14] Note in particular the formulations proposed by Henry Hiż in 'Congrammaticality, Batteries of Transformations, and Grammatical Categories', in *Proceedings of Symposia in Applied Mathematics*, vol. 12, American Mathematical Society 1961; also in his 'The Role of Paraphrase in Grammar', *Monograph Series on Languages and Linguistics*, vol. 17 (1964). The definition of transformation can also be adjusted for various purposes. Starting with transformations defined as an equivalence relation between satisfier-sets (the X and Y above), we can speak of transformations between sentences (corresponding members of these sets) or between sentence forms (for certain n-tuples satisfying them). In a different way, we can speak of transformations operating on sentences, or operating on elementary sentences and on transformations (§ 3.5 below).

[15] This holds also for the transformations as they appear in the theory of Noam Chomsky and in the applications by his students, even though in this case they are set up formally not as a relation between sentences but as instructions in the course of generating sentences (from already-generated simpler sentences). See Noam Chomsky, 'A Transformational Approach to Syntax', in A. A. Hill (ed.), *Proceedings of the Third Texas Conference on Problems of Linguistic Analysis in English, 1958* 1962, 124–58, reprinted in J. A. Fodor and J. J. Katz (eds.), *The Structure of Language*, 1964.

[16] Acceptability-difference is a refinement of the criterion of co-occurrence, which had been used in the original presentation of transformations in Z. S. Harris, 'Distributional Structure', *Word* **10** (1954), 146–62 (Paper XXXVI of this volume); 'Co-occurrence

and Transformation in Linguistic Structure', *Lg.* **33** (1957), 283–340 (Paper XXIII of this volume). The criterion of co-occurrence presented difficulties, because it is doubtful if we can say that a certain n-tuple does not occur at all in a given sentence form. A more important reason for seeking a refinement on co-occurrence is that transformation preserves not only the occurrability of n-tuples but also the degree to which they can occur and the sense and nuance with which they occur. See end of note 10.

[17] The specific lists for English, on which the present commentary draws, are given in various papers, from Z. S. Harris, 'Discourse Analysis', *Lg.* **28** (1952), 1–30, § 7.3 (Paper XIX of this volume), and through various issues of the *Transformations and Discourse Analysis Papers*. In the following discussion, the terminology of operations and the symbol → will often be used instead of the terminology of (equivalence) relations and the symbol ↔. This is only because once we have a transformational relation between forms *A* and *B*, it is convenient (in order to define a useful set of base transformations, § 5) to develop a formulation in which *B* is obtained from *A* by an operation, with *A* being the simpler or descriptively prior form. In terms of the elementary operations (§ 5), the primitive is no longer the equivalence relation but a set of incremental and zeroing operations (§ 5.1), which produce one form out of another, $A \rightarrow B$. However, this direct operational formulation does not suffice for the extensions of § 5.3.

[18] *Vn* for nominalized verb, i.e. *V* with zero or other affix occurring in the positions of *N*; and so for *Va*, etc. (*P*) in the formulas below indicates that some cases covered by the formula have *P* and others do not. *S* for sentence. The words 'subject' and 'object' (or Ω) represent not constituents but the pre-*t* and post-*V* material in the elementary sentence forms, and material brought into these positions by specified operations on these forms.

[19] One could also analyze this structure not as *N V* or *V* Ω operating on *S*, but as *N V X* and *X V* Ω (as sentences) with an *S* replacing the *X*. E.g. *I know that he came = I know something* plus *He came. That he came is a fact = Something is a fact* plus *He came.* Among the various difficulties with such an analysis is the fact that for some of these *W* verbs there is no natural *X*: e.g. *I hope that he will come* would require at best *I hope for something.* The difference in analysis is one of convenience of description. It does not affect the essential existence or properties of transformations.

[20] More precisely, the *if* entry is *if* S_1 *or* S_2 ... *or* S_n. There is a *whether* variant of *if*, and in certain situations a *whether* variant of *that*. Also, *that N V* Ω has the variant *that N should V* Ω and in certain positions necessarily *for N to V* Ω. *Sn'* is distinct from *Sn*, because it can contain *Y*: *His having been present was denied. Sn* includes *Ving* as well as *Vn*, with *of* before objects beginning with *N*: *His purchasing of the books was deliberate, His retention of the report was deliberate. Sn* can be taken to include also the deformation *N's An* (*His quickness*) from *N is A*, and *N's Nn* (*His manhood*) from *N is N*.

[21] Other limited or variant objects of *W* can be seen in, for example, *I prefer it that he should come.* Also *P* N_1 *that* $N_1(t)$ *V* Ω has a variant N_1 *to V* Ω: *I believe about him that he is wrong, I believe him to be wrong, I know him to have come late*; this variant is comfortable primarily if *V = be* or if *Y* has operated on *V*. For a particular subcategory of *W*, *to be* in this object is zeroed, yielding: *I believe him wrong, I consider him an authority, I find him at fault.* Note that *I ordered them present* is obtained here from *I ordered* (*about them*) *that they be present*, while *I ordered them to be present* is obtained from *I ordered them that they be present* (in the object list below); the latter means that the order was addressed to them, but the former does not.

[22] For the necessary zeroing of N_1's when the subject of *W* is N_1, see below.

[23] Among limited objects of particular *W* there is *I let go of it* (in addition to *I let it go*).

[24] This is a crude statement of the differences required by *but*.

[25] There is also a possibility of operating on three sentences at once, e.g. S_1 *related* S_2 *to* S_3.

[26] A similar permutation in the question *Would he see her?* etc. will be seen below to be occasioned by the dropping of *if*. Permutations like *This I like* in the elementary sentence could also be considered to depend upon the addition of a stress morpheme, and so based upon an increment. The position of *not* in respect to tense in *He did not go*, etc., can be ana-

lyzed as the original position and not a permutation; but there are other special transformations on *not*.

[27] Or rather than *D*: second morpheme of *V*.

[28] This can happen as the result of permutation, as when the passive $N_1\ t\ V\ N_2 \rightarrow N_2\ t$ *Ven by* N_1 puts as the domain of the first *N* of the resultant the word category which had been the domain of the second *N* in the operand. It happens as the result of zeroing, as when the zeroing of *P* in *P N* of measure, $N\ V\ P\ N \rightarrow N\ V\ N$, brings into the apparent Ω position to *V* a noun of measure which had not been in the domain of the Ω of that *V* (e.g. *minute* is in the domain of the Ω of *tick off*, as in *The clock ticked off a minute* → *A minute was ticked off by the clock*, but it is not in the Ω of *pause*, as in *He paused for a minute* → *He paused a minute* where ~ ∃ *A minute was paused by him*). It also happens as the result of adding constants, as in *He smoked cigars* → *He began the smoking of cigars*, where *began* becomes the value of *V* and we can say that *the smoking* becomes the value of Ω in respect to any transformation which is defined on Ω and accepts *the smoking* as Ω of *began*.

[29] Since every transformation leaves its effect, if only in the choice of subcategory for a given category symbol, the precise statement of arguments and of operands and resultants for each transformation opens the way to computation of transformational decomposition. There exist cases of φ_i followed by a zeroing which has the effect of an inverse of φ_i, but these have to be recognized only when a trace has been left, i.e. when some φ_j has intervened (for an example, see end of § 5.213).

[30] Under *W* we have to include *is* A_m of manner, and also the binary verbs.

[31] A sentence can be ambiguous because of the range of meanings of a word in it (e.g. *I like the sound; I like the Sound*) or because of a degeneracy (homonymity) resulting from transformations (e.g. *They have shined shoes.* ← *They have shoes which are shined*, by zeroing of *which are* ← *wh* (*They have shoes. The shoes are shined.*); and also *They have shined shoes* ← *They shined shoes* by the *Y* operator *have Ven*). In the former type, dictionary ambiguity, the ambiguity disappears when some of the other words in the *n*-tuple are varied (e.g. *The boat sank in the Sound*). In the latter, grammatical ambiguity, the ambiguity remains no matter how the n-tuple is varied, so long as the altered n-tuples can occur at all in the two grammatical sources.

[32] For this analysis of *the*, see the papers of Beverly Robbins in the *Transformations and Discourse Analysis Papers*, and in her *The Definite Article in English Transformations*, Papers on Formal Linguistics, No. 4, Mouton & Co., The Hague, 1968.

[33] In this form we no longer have binary transformations. Each binary is the result of a divisor of type 3 (whose resultant is not a sentence) followed by a divisor of type 1 (operating on a sentence, with a deformed sentence as increment).

[34] 'Local synonymity' is used for synonymity in respect to the particular environing words in a structure.

[35] This is an extreme example of the fact that when a word occurs in a sentence, it does not carry its full dictionary meaning, but only such meaning as can constitute a normally accepted (or, depending on the discourse, a jocular, shocking, etc.) meaning in relation to the other words with which it is grammatically juxtaposed.

[36] Though the determiners of X_{ap} may be the other words of the *K*, the zeroing does not occur in a *K* by itself, but only when one form is juxtaposed to another (as happens also in morphophonemics). Within a *K* or an insert or operator by itself there is no redundancy which is removable. In those *K* in which a particular subcategory of Ω, or a particular subject-object pair, determine that a particular *V* (or set of locally synonymous *V*) is the main one, the *V* may be replaced by a constant of low semantic specificity (e.g. *have* or *be* or *is P*); but the *V* will not be zeroed (something which would produce a new kind of *V*-less sentence): *He wrote a poem* → *He did a poem*; ~ ∃ *He poem*.

[37] Here the V_{ap}*ing* and *to* V_{ap} do not have the form of inserts. However, dropping them only changes the form of the subject or object to *N*, which is a respectable grammatical form. Note that the plural agreement is a late morphophonemic operation, after the zeroing.

[38] Although the evidence that one form has been derived from another by the dropping of some material is of the same kind here as throughout, it is less obvious in the cases discussed here. The evidence that (1) N_1 *caused* $N_2 \leftarrow$ (2) *The* V_{ap}*ing of* N_1 *caused* N_2 is that for every sentence of form (1) there exists a sentence of form (2), the difference in acceptability between various N_1, N_2 choices in (1) being the same as in (2). Furthermore, this holds only for $V =$ *occur, happen, act,* etc. and not for $V =$ *end, is brief,* etc. In contrast, for N_1 *ate* N_2 we don't find *The Ving of* N_1 *ate* N_2. Hence *cause* here is not a V which simply occurs in a K, but is a sentence operator. I.e. its subject (and Ω) is a deformed K. When we find N (other than 'human' N) as its subject, this N is obtained from the deformed K by dropping the *Ving*; and the *Ving* drops only if it is the appropriate one for *cause*.

[39] Dropping *to* V_{ap} is different from zeroing repetitive V_1 or *to* V_1 after an antecedent *to* V_1 (§ 5.22): *I spoke and I expect him to.*

[40] Going beyond language to specialized subject-matter languages which contain greater restrictions, methods of this kind could be used to achieve more simply characterizable subjects, objects, etc. Thus *to measure a room* could be taken as reduced from *to measure the length* (etc.) *of a room; to rig the convention* from *to rig the voting* (or *the activity* etc.) *of the convention, to load the gun* from *to load the cylinder of the gun.* In this way the Ω of the V would also become more explicit.

[41] Under certain sentence operators, the K is only (or primarily) of the *be* type; and after certain of these the *be* is then always dropped: *I call him a fool; I consider him a fool, I consider him to be a fool.*

[42] But if the V of K_2 is not *be* or the appropriate verb, the *wh*-word remains: *I saw the man who buys milk* (unless this man has been familiarly regarded as being the person with a characteristic relation to milk, in this case an inveterate buyer of it: he might then be referred to as *the milkman*).

[43] The collecting of the disjunctional N, the formation of the *wh*-words, the $N\,t$ permutation (when N is available, hence no permutation in *Who will go?*), are all transformations which appear elsewhere too. The W needed for the question are those that take *if.* The W needed for the imperative are those that permit *please* in the operand. That the lost subject of the operand is uniquely *you* is seen from *Wash yourself!* etc.; it is therefore zeroable as N_{ap}.

[44] We can define a set of proword substitutions which are similar to various types of zeroing, but operate under somewhat different conditions. Thus the disjunctions and conjunctions of § 5.23 may be replaced by indefinite pronouns and by certain words operating as classifiers (e.g. *people* in the sense of *someone*; *act* in the sense of *do something*) in all syntactic situations, and by zero in only certain syntactic ones. Words of almost all categories (chiefly N) can be replaced by prowords of that category and by words that are semantically inclusive in respect to them; this is more likely to occur if the word is referent-repeating. The zeroing of repetitive material (§ 5.22) is similar only to this last, but occurs also in some syntactic situations in which pronouning does not occur (e.g. *while Ving*) and also in various categories which have no proword. The zeroing of 'appropriate' words (§ 5.21) is related to a much more general system of locally appropriate sub-categories, which includes synonyms and certain kinds of antonyms as well as sets of words based on looser local semantic similarity.

[45] This relation of zero to pronoun does not hold in § 5.22, where a word is zeroed only if it is the same word as the antecedent; nor in § 5.21.

[46] The ambiguity of *Every place has been taken by someone* arises from the two possible orderings of the disjunctional operation (which yielded *someone*) and the conjunctional operation (which yielded *every*). We begin with

$$A_i \textit{ place has been taken by } N_j$$

If we first make a conjunction on the A (i.e. A_1 *place has been taken by* N_1 *and* A_2 *place has been taken by* N_1 *... and* A_n *place has been taken by* N_1) we obtain

$$\textit{Every place has been taken by } N_1.$$

If here we make a disjunction on the *N* (i.e. *Every place has been taken by* N_1 *or every place has been taken by* N_2 *... or every place has been taken by* N_m) we obtain

Every place has been taken by someone

in the sense of

($\exists$ *N*) ($\forall$ *A*) *A place has been taken by N.*

However, if in the original sentence we first make a disjunction on the *N*, yielding

A_1 *place has been taken by someone*

and on this a conjunction on the *A*, we obtain

Every place has been taken by someone

in the sense of

($\forall$ *A*) ($\exists$ *N*) *A place has been taken by N.*

[47] There is a possibility that this Ω-zeroing can be derived through the *Sn* form, where Ω has insert form.

[48] In the example given here, *what* can be replaced by *whatever*; and what has been dropped is *anything, the things*, etc., which are pronouns for disjunctions of *N*. However, there are also cases in which *what* can be replaced by *the single thing that*, or the like; in such cases, what has been dropped is a pronoun or a classifier N_{cl} for a single *N*: *I heard what he said and you heard it too; What he planted has grown to be quite a tree.*

[49] A partly similar case is the rare dropping of pronoun or N_{cl} which may occur after certain *the A*, where the *the* indicates a lost *wh*-insert connected to that *N*: *the true* ← *the things which are true. This is mine* ← *This is my* N_1 *or* N_2 *... or* N_n; *This is his* ← *This is his* N_1 *or* N_2 *... or* N_n.

[50] $\check{X}$ for pronoun of *X*. *S*-N_i indicates *S* with N_i omitted.

[51] The apposition with comma is different: *It was (widely) read, what he wrote.*

[52] Almost all, because there remain a few pure permutational (asyntactic) transformations. To derive these, we would have to add a fifth type of elementary transformation which carries out restricted permutations.

[53] See in particular Henry M. Hoenigswald, *Language Change and Linguistic Reconstruction*, Chicago 1960.

[54] As an example of a limitation on similarity, note that the *It* transformation does not extend to zero *N* plus *wh-S*: see the end of § 5.23.