KYBERNETIKA ČÍSLO 2, ROČNÍK 1/1965

Current Developments in Generative Grammar*

EDWARD S. KLIMA

A system for the generation of sentences is proposed which operates on three levels (constituent, transformational, and lexical) in such a way that there results a simplification in formulation, which is accomplished by allowing the initial symbol *S* to dominate other occurences of the same symbol *S*, and by adopting the convention whereby first the constituent structure is generated from highest *S* to lowest pre-lexical symbol and then the lexical entries are entered and transformations applied within each *S* beginning with the lowest *S*.

My ultimate objective in this paper is to present a particular formalism for a transformational grammar – that is, a particular theory of language structure. One characteristic of the formalism to be proposed that I find of particular interest is that with it, even a grammar based on a transformational model lends itself to computer-programming. A full description of the model will be elaborated by Klima, Bever and Rosenbaum in a publication that will appear in the near future.

By way of introduction, I should like to examine briefly the developments in transformational grammar that have occurred since the publication in 1957 of Chomsky's *Syntactic Structures*. It is not my objective here to compare transformational theories of linguistic structure with non-transformational theories.

Let's consider first of all the use that will be made of the term "grammatical theory" in the following discussion. The end of a grammatical theory is to provide for the enumeration and structural description of the sentences of the language.

The formal apparatus of the theory will depend on observed characteristics of what is to be described – i.e. the characteristics of human language. A grammar, in this sense, will *not* be thought of as describing how individuals produce sentences in the act of communication or how they apprehend sentences. Rather, a grammar

* Communicated at the *Prague Colloquium on Algebraic Linguistics and Machine Translation*, September 18th—22nd, 1964.

This work was supported in part by the National Science Foundation and in part by the Joint Services Electronics Program under contract DH36-039-AMC-03200(E).

will be thought of as an abstract representation of the structure of a language, – a representation of what must be assumed to have been acquired by the child in growing into a linguistically normal adult who can, and constantly does, pronounce and understand fully grammatical sentences which he has neither heard nor produced before.

A grammar is a representation of this linguistic knowledge observed in normal speakers of a language – a representation in terms of a set of rules that generates the sentences of the language. The formal apparatus of the grammar is dictated by observed characteristics of language – such as the fact that there is an indefinite number of grammatical sentences; and the related fact that parts of sentences or even whole sentences, may be repeated within other sentences. The question one asks oneself in defining the formal apparatus of a grammar is the following: what is necessary – neither too much nor too little – in the theory in order to account for what we observe in language? The answer to this question has led to the observation that a more adequate account of the relationship among the elements of a sentence can be achieved if a theory is formulated that is more powerful than a simple phrase structure grammar – that is, more powerful than the set of rules describing syntactic structure solely in terms of the immediate constituents of the sentence – or to put it in another way, a theory more powerful than that ascribing to sentences a syntactic structure no deeper than that corresponding more or less to the result of traditional parsing.

The desired adequacy in the set of rules comprising the grammar is achieved by assuming, aside from a *phrase structure level*, also a *transformational level*. The phrase structure level consists of rules that operate on strings of symbols without reference to their vertical structure; the mode of operation of phrase structure rules is as follows: a *single* symbol is expanded into a string of symbols. The phrase structure expansion operates with or without restrictions imposed by other symbols that occur in its strings; i.e., with or without context–sensitivity; e.g.

(1)

$$\# \; S \; \#$$

$$S \rightarrow NP - Aux - VP$$

$$VP \rightarrow V \begin{Bmatrix} NP \\ Refl \end{Bmatrix} (PP) \; [\text{where } PP = \text{preposition phrase; } Refl \text{ represents the reflexive pronouns and "-}Refl\text{" defines reflexive verb.}]$$

$$PP \rightarrow P - NP \; [\text{where } P = \text{preposition}]$$

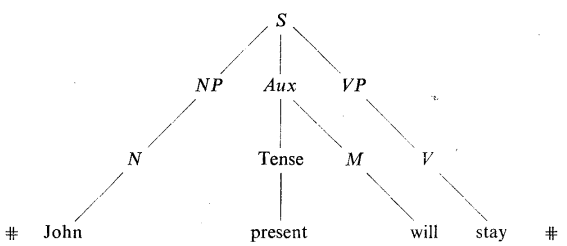
$$NP \rightarrow (Det) \; N$$

$$V \rightarrow \left\{ \begin{array}{l} \text{stay/in the environment: } - \; \# \\ \left\{ \begin{array}{l} \text{resemble/in env. } - \; (Det) \; N \\ \text{expect} \end{array} \right\} \\ \text{force/in env. } (Det) \; N \; - \; P \; (Det) \; N \end{array} \right\}$$

$$
\begin{aligned}
P &\rightarrow \text{into} \\
Aux &\rightarrow T(M) \\
N &\rightarrow \left\{\begin{matrix}\text{John}\\ \text{it}\\ \text{boy}\end{matrix}\right\} \\
M &\rightarrow \text{will} \\
T &\rightarrow \left\{\begin{matrix}\text{pres}\\ \text{past}\end{matrix}\right\}
\end{aligned}
$$

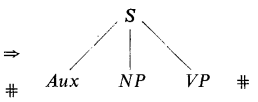
Such rules describe trees like the following

(2)



The transformational level consists of rules that operate on the structures described by the phrase structure rules. Transformational rules convert such structures into new derived structures by operations such as substitution, deletion, addition, and permutation; e.g. the question transformation converts the structure representend in diagram (2) into

(3)



i.e. "Will John stay?".

The rule for the question tranformation would be:

(4)

$$
\begin{array}{lccccc}
 & \# & NP & - & Aux & - & VP & \# \\
 & 1 & 2 & & 3 & & 4 & 5 \\
\Rightarrow & 1 & 3 & & 2 & & 4 & 5
\end{array}
$$

Let us consider now the salient features of the earliest transformation syntax, as represented by Chomsky's *Syntactic Structures* and Lees's *Grammar of English Nominalizations* (1960). In the first place phrase structure rules were used for the

sub-classification and final entry of the ultimate lexical items into the description; thus *N* would be expanded into *Pn* (Proper noun) or *Cn* (Common noun) to account for, e.g., the non-occurence versus occurence of restrictive relative clauses; *Pn* into *Hpn* (Human proper noun) or *Ipn* (Inanimate proper noun) and *Cn* into *Hcn* (Human common noun) or *Icn* (Inanimate common noun) to account for the distinction between *who* and *which* as relative pronouns depending on the nature of the antecedent noun; e.g. "the city which I mentioned ..." versus "the man whom I mentioned ...". Thus the exemplary outline of phrase structure rules presented in (1) would, in reality, also contain such rules as:

(5)

$$N \rightarrow \begin{Bmatrix} Pn \\ Cn \end{Bmatrix}$$

$$Pn \rightarrow \begin{Bmatrix} Hpn \\ Ipn \end{Bmatrix}$$

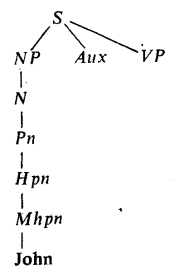
$$Hpn \rightarrow \begin{Bmatrix} Mhpn & \text{[Male human proper nouns; to account for} \\ & \textit{he}\text{- versus }\textit{she}\text{- distinction in pronominalization]} \\ Fhpn & \text{[Female human proper noun]} \end{Bmatrix}$$

$$Cn \rightarrow \begin{Bmatrix} Hcn \\ Icn \end{Bmatrix}$$

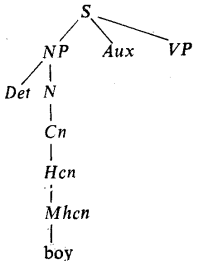
$$Hcn \rightarrow \begin{Bmatrix} Mhcn & \text{[Male human common noun]} \\ Fhcn & \text{[Female human common noun]} \\ Nhcn & \text{[Neuter human common noun, to account for} \\ & \text{"the baby lost }\textit{its}\text{ rattle"]} \end{Bmatrix}$$

Each of these expansions, in the earliest transformational syntax, represented a single, discrete, unanalyzable symbol. Thus the phrase structure derivation of John in "John stayed" would describe the tree numbered (6) while that of boy in "the boy stayed" would have tree (7) associated with it

(6)



(7)



According to this system, the progressive expansions of the categories dominated by *N* have the same status as major categories, such as *NP* and *VP*, except that they do not branch. These non-branching categories represent, in terms of phrase structure rules, the traditional notion of the subclassification of nouns. The category *V* was expanded into a similar chain of non-branching nodes. The second salient feature of the earliest transformational syntax was the notion of generalized transformation. Generalized transformations constituted a class of transformational rules whereby one *fully constituted* sentence is embedded, with varying distortions, as a constituent in another *fully constituted* sentence. Thus, "I expect John to stay" is described as the embedding of "John will stay" in place of the constituent *it* in "I expect it"

(8)

$$\underbrace{\#\ [\mathrm{I}]_{NP}\ Aux\ [[\mathrm{expect}]_{V}}_{1}\ \underbrace{\mathrm{it}]_{VP}}_{2}\ \underset{3}{\#}$$

$$\#\ \underset{4}{[\mathrm{John}]_{NP}}\ \underbrace{[\mathrm{Tense\ will}]_{Aux}}_{6}\ \underbrace{[[\mathrm{stay}]_{V}]_{VP}}_{7}\ \underset{8}{\#}$$

$$\Rightarrow 1, 5 \quad \text{to} \quad 7, 3$$

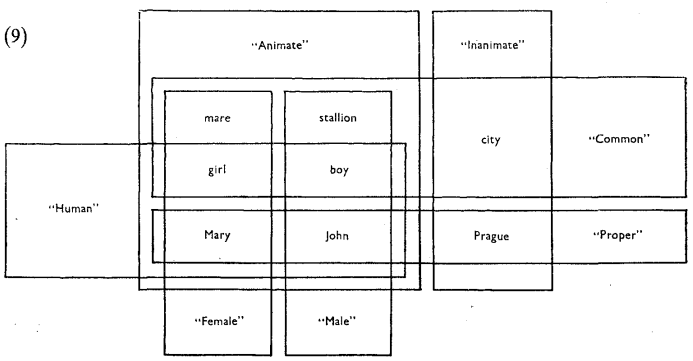
These then were the salient features of the earliest transformational syntax.

THE COMPLEX SYMBOL

The first change in the theory of transformational syntax was motivated by the phenomena of intersecting categories – that is by the following observation about language: a great many syntactically relevant features intersect, in such a way that is not adequately expressed in the single-symbol expansions provided by phrase structure rules. Thus the fact that the same feature "Male", as opposed to "Female", is shared by John and boy in diagrams (6) and (7).

Consider the following intersecting categories:

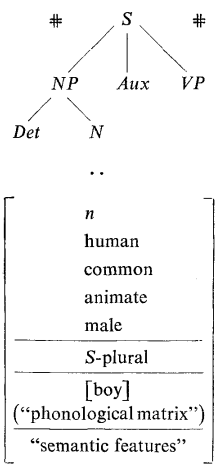
(9)



No matter where primacy is ascribed among features, there is no *non-arbitrary* way, to describe these intersecting relationships with phrase structure rules, which expand a single unit symbol into several (or in this case one) other unit symbol (s).

To remedy this inadequacy, a new concept was introduced into transformational theory: the complex symbol. The complex symbol, as opposed to the unit symbol, replaces the long chains of non-branching categories under *N*(oun), *V*(erb) and the other parts of speech. The complex symbol consists of a matrix specifying the inherent and environmental features of the part of speech in question. Thus *boy* might have the following description:

(10)



By the convention of the complex symbol, the difference between *boy* and *John* is simply that of a single feature-opposition; "common" versus "proper". Similarly the difference between John and Mary is that of "male" versus "female". The complex symbol obviates the necessity of assuming an arbitrary hierarchy involving all such characteristics syntactically relevant for a representative of a given part of speech.

BLOCKING GRAMMARS

The most recent innovation in transformational theory, concerns the description of embedding; i.e. the description of the occurrence – with varying deformation – of one sentence as a constituent of another. The earliest transformational syntax, it

will be recalled, analyzed embedding in terms of two fully constituent, independent sentences; e.g., the sentence "I forced John to behave himself" was described in terms of the optional embedding of the sentence "John behaved himself" into the sentence "I forced John into it". Recursiveness – that characteristic associated with the observation that there are indefinitely many different sentences – was accounted for in the earliest theory by the fact that sentences containing embedded structures could themselves be embedded. This process would be repeated indefinitely. Thus "I forced John to behave himself" is contained in "Mary expected me to force John to behave himself". The innovation in the mechanism describing embedded structures consisted of permitting one particular symbol – namely *S*, the category representing the sentence – to recur in the phrase structure rules. In previous theories of transformational syntax, recursiveness was not permitted in the phrase structure level. It was assumed in this more recent theory that the recursiveness of *S* represents a *language universal.*

Thus by this innovation rules like the following involving the category *S* became possible:

(11)

$$\# \quad S \quad \#$$

$$S \quad \rightarrow NP - Aux - VP$$

$$VP \quad \rightarrow V - \begin{Bmatrix} NP \\ Refl \end{Bmatrix} - PP$$

$$PP \quad \rightarrow \begin{Bmatrix} Comp \\ P - NP \end{Bmatrix} \text{ [where } P \text{ is, e.g., } into\text{]}$$

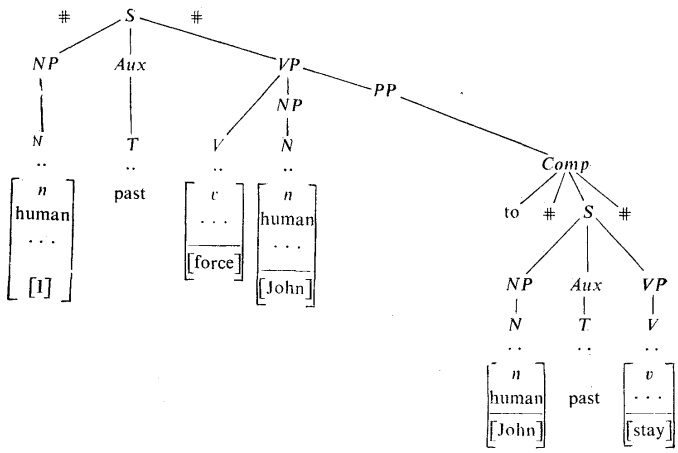
$$NP \quad \rightarrow \begin{Bmatrix} Comp \\ (Det)\, N\, (Rel) \end{Bmatrix}$$

$$Comp \rightarrow \begin{Bmatrix} \text{to} \\ \text{that} \end{Bmatrix} \# \, S \, \#$$

$$Rel \quad \rightarrow \text{wh} \, \# \, S \, \#$$

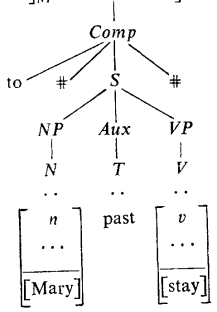
The phrase structure tree representing "I forced John to stay" would have approximately the following form:

(12)



Embedding in this system is conceived of as resulting in the removal of the sentence boundaries – i.e. the set of double crosses accompanying the included *S* (entence) – *provided* that certain conditions are met: in the case of the example in (12), those conditions include the identity of the grammatical object of the including sentence and the grammatical subject of the included sentence. When this identity relation does not obtain, then the sentence boundaries – i.e. the double crosses – associated with the included sentence are not removed and the whole derivation is rejected, as a non-sentence. Since the constituents of each *S* are generated freely, under each initial *S* that contains an *S* the grammar generates indefinitely many structures that do not represent sentences. Transformations in this theory thus act as a sort of filter or *blocking* device. Thus among the structures possibly generated would be the following:

(13) # $[[I]_{NP}$ – past – $[\text{force}]_V$ $[\text{John}]_{NP}$ PP] S #



In (13) the identity relation does not hold and therefore sentencehood is blocked.

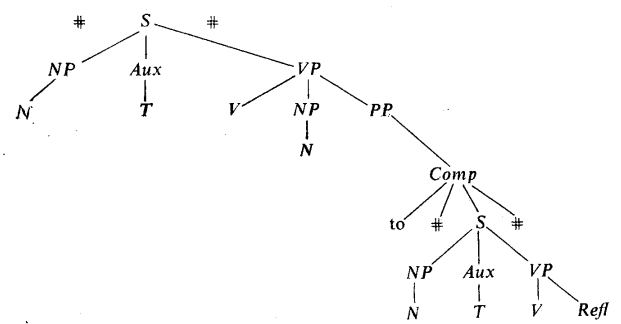
From the point of view of the computer-programming of grammars, there is an obvious disadvantage to the blocking grammar just described – namely, that indefinitely many blocked derivations (i.e. non-sentences) may be generated before an acceptible sentence is described. Moreover, the blocking grammar, with its simple bilateral *identity relation* does not reflect the sort of determinacy which, I would claim, proceeds from noun-head to noun-modifiers; from the first occurence of a noun to the pronouns which refer to that noun.

NON-BLOCKING GRAMMAR

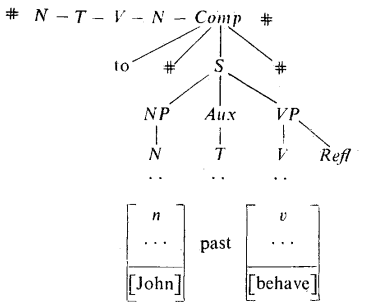
I should like now to sketch very briefly some changes in transformational syntax which I would offer as a solution to the problems just mentioned. The grammar differs from that just described in being *non-blocking*. That is to say, where the previous system generates also structures that do not ultimately represent grammatical sentences, the new grammar to be discussed below generates only sentence-describing structures. The special characteristic of the non-blocking grammar is the particular ordering of grammar rules; namely, that first each *S*(entence) is expanded down to the symbols representing the parts of speech; the complex symbols representing the ultimate *words*, at this point in the derivation, are left unspecified.

The sentence "I forced John to behave himself" would have the following description:

(14) **A. Phrase structure**



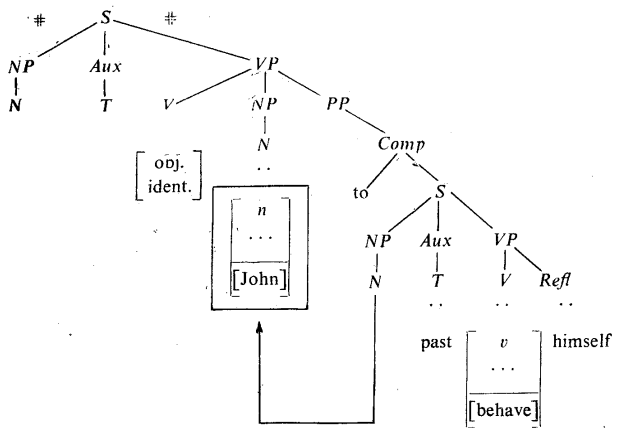
(i) First, in the most included S (i.e. one that does not itself include an S surrounded by sentence boundaries), the parts of speech are expanded into complex symbols representing words:



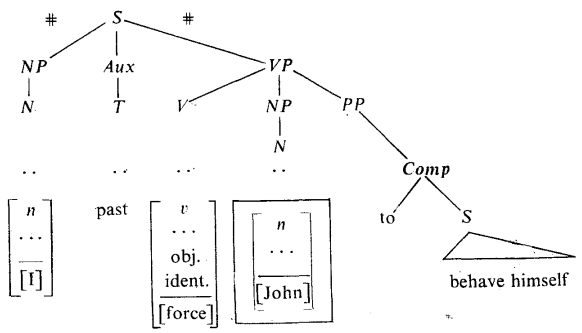
(ii) Next, simple transformations apply – in this example, reflexivization:

$\# \ldots \# [\text{John}]_{NP} - \text{past} - V - \textit{Refl} \# \ldots \# \Rightarrow \# \text{John} - \text{past} - V - [\text{himself}]_{\textit{Refl}} \# \ldots \#$

(iii) Then, the included S undergoes an embedding transformation which may include the reproduction of certain of its constituents as constituents of the next highest S; and certain parts of speech of the including S may be partially specified; e.g., the fact that the principle verb is one whose *object* is identical to the *subject* of the *Comp(lement)* sentence (*force, persuade*) and not one whose subject is identical to the latter (*promise*); the T of the included sentence is deleted when the complement is introduced by *to*:



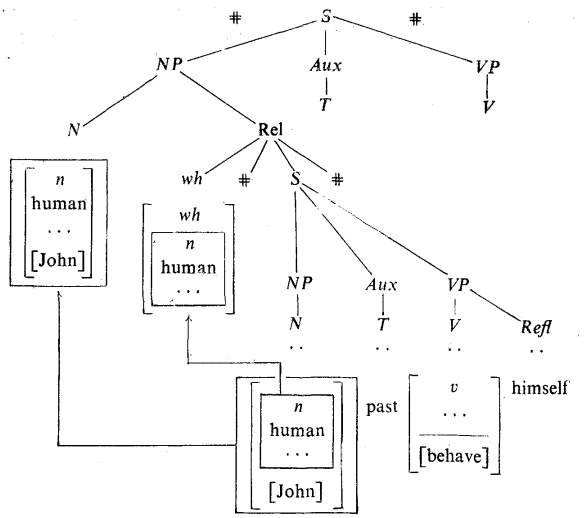
(iv) Next, the parts of speech of the including *S* which have not already been specified or are only partially specified are expanded into complex symbols:



(v) Then the *cycle* is repeated for the including sentence to which simple transformations and embedding transformations are applied. The cycle progresses up the derivation until all instances of *S* have been described.

In the non-blocking grammar, the embedding of relative clauses, as in "John, who behaved himself, stayed", operates in the following way:

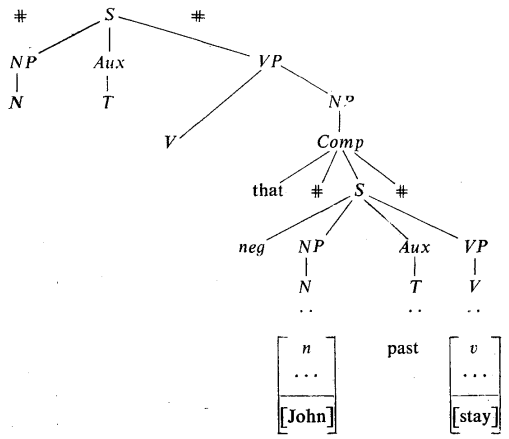
(15)



That is, from the included sentence (a) the syntactic (and semantic) features of one *N* are duplicated under the relative pronoun constituent *wh* (b) the whole complex symbol is duplicated under the *N* of the including *S*, as antecedent, (c) the duplicated *N* of the included *S* is ultimately deleted and (d) the sentence boundaries around the included *S* are deleted.

By its mentioned ability to partially specify syntactic features in embedding, the non-blocking grammar offers a satisfying solution to problems like the following involving negation. For semantic and syntactic reasons, the following three sentences should emerge from sentence derivation as very similar in their basic structures: (1) "I suppose John didn't stay", (2) "I don't suppose John stayed" (3) "I doubt that John stayed", although their superficial syntactic structures differ considerably. Example (1) is a case of clausal negation; (2) represents sentence negation and (3) presents affirmatives in both the principal and subordinate clauses but with a verb "with negative import" in the former. Furthermore the special position of *not* in elliptical (4) "I suppose not" varying with regular "I don't suppose so" must be explained. We can explain these facts by assuming the following underlying structure, in which the phrase structure rules have been extended by including in the rewriting of *S* an optional initial negative marker *neg* (i.e., $S \rightarrow (neg)\, NP - Aux - VP$):

(16)



The structure represented in (16), plus a rule that appropriately locates *neg* (as *not*) after *Aux* (neg-placement Rule) and then a rule that inserts *do* if *Aux* neither contains a verb nor directly precedes a verb (*do*-support Rule), describes "I suppose that John didn't stay".

Optionally, however, before the operation of the *neg*-placement Rule, one of two sets of rearrangement rules may operate on *neg*:

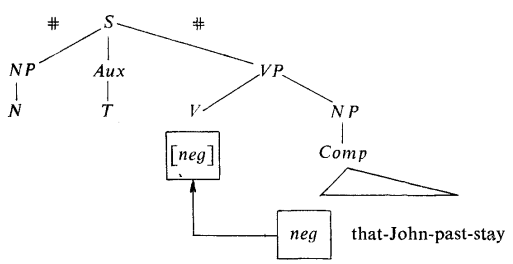
(a) either *neg* may be relocated in initial position within the *Comp*, provided that the principle clause does not itself begin with *neg*: # *NP* – *Aux* – *V* – *neg* that # # *S* # # (*neg* – relocation Rule), where *V* – *neg* – that # *S* # defines the class of verbs including *suppose, think, imagine* versus *realize, announce*; the relocated *neg* may retain this initial position within *Comp* if the subordinate clause has been deleted, as in "I suppose not", "I imagine not"; otherwise *neg* from the sequence ... *V* – *neg* – that ... becomes a sentence-negative for the principal clause, by being moved to initial position (Negativizing rule):

NP – *Aux* – *V* – *neg* – that – *S* # ⇒ # *neg* – *NP* – *Aux* – *V* – that – *S*

where once again the *neg*-placement Rule and then the *do*-support Rule operate to yield e.g. "I don't suppose that John stayed".

(b) Or *neg* may be incorporated as a feature in the *V* of the including *S*, yielding:

(17)



where $\begin{bmatrix} v \\ neg \end{bmatrix}$ defines the class of inherently negative verbs including *doubt* and *deny*.

In the illustrative material presented here as representing a non-blocking grammar, of course, the details regarding restrictions on various transformation have been left out. Moreover, nothing at all has been said about the *Det*(erminer) system (which I believe to be a subsystem), the phrase structure development of which occur *after* the embedding of included sentences; i.e. the phrase structure rules are expanded down to *N, V, P, S, Det* (and probably *Aux*) as in (14) A – except that there *Aux* is already expanded for expository reasons – then any *S* included therein is embedded not until after the embedding of such instances of included *S* are *Det* and *Aux* expanded. The reason for this is that an *N* developed within a *Comp* may itself serve as the antecedent of a relative clause, in which case it would be undesirable to have

developed independently a restrictive relative clause included within the *Det-* (erminer), only to slough it off in the subsequent embedding procedure. I propose to consider this ordering in the development of *N* versus *Det* to correspond to the notion of *head* versus *modifier*. With certain minor adjustments, the same principle would define the *Aux* as a modifier to the verb (or sentential) head. But these problems will not be further considered in this sketch.

(Received September 22nd, 1964.)

VÝTAH

Současný vývoj v generativní gramatice

EDWARD S. KLIMA

V článku je navrženo schéma pro generování vět. Toto schéma pracuje se třemi rovinami (struktura bezprostředních složek, transformační struktura a lexikální struktura). Zjednodušení formulace se dosahuje jednak tím, že symbol *S* může být nadřazen jinému symbolu *S* (v témže stromu), a jednak tím, že je struktura bezprostředních složek generována od nejvyššího *S* k nejnižšímu předlexikálnímu symbolu. Tento symbol se nahradí lexikálními jednotkami a nakonec se provádějí transformace pro každé *S*, při čemž se začíná od nejnižšího z nich.

E. S. Klima, Massachusetts Institute of Technology and Watson Research Center, IBM, Cambridge, Massachusetts, U.S.A.