Laboratory for Computer Science

September 30, 1976

A Theory of English Grammar

by

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Draft

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Abstract

The constructs specialization, modification, nexus, naming, productivity, and slot shift are defined and a theory of English grammar advanced in terms of these and related ideas. The theory provides a basis for the computer representation and manipulation of knowledge which can be conveyed explicitly by English sentences.

Acknowledgements

This work was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by the Office of Naval Research under Contract #N00014-75-C-0661. I especially wish to acknowledge the informed suggestions and steadfast support of William Carlson, the contract monitor.

Terry Winograd and Andee Rubin were helpful to me when I first became interested in computational linguistics. Early versions of this work were developed with G. A. Gorry and Rand Krumland. The current version was inspired by an attempt to reformulate the earlier work to conform to ideas of Lowell Hawkinson, and owes much to discussions with him, Gretchen Brown and Peter Szolovits. The notation was designed primarily by Hawkinson. Students in the MIT A/I lab, in particular Mitch Marcus and Candy Bullwinkle, have also been helpful.

Much of the material has been discussed and debated at numerous meetings of the OWL system development team. Their efforts at implementation have raised many important issues.

Finally, Ellen Lewis has been outstanding in helping with the many revisions of this long paper.

Preface

This is Part I of a longer work in preparation entitled A Computational Approach to Modern Linguistics: Theory and Implementation. Proposed parts are:

I. A Theory of English Grammar
II. A Basic Grammar of English
III. Parsing English
IV. Notes and Speculations on English Semantics
V. OWL, A Programming System Based on English
VI. Applications

Additional parts will not appear before the Spring of 1977.

The reader should be advised that while this paper is a good introduction to the representation of knowledge used in OWL, it does not discuss OWL as a programming languages, features of OWL introduced as solutions to problems of implementation, or features of OWL whose origin is in semantic issues or issues of computational efficiency. Therefore, anyone wanting to use OWL will have to seek additional information beyond that given here.

A Theory of English Grammar

1. Goals of Our Theory of Grammar

We have developed a programming system based on English. Since natural language is known to be quite complex and full of ambiguous constructions, this may appear to be a dubious achievement. It would seem to go against the long struggle of computer scientists for syntactic regularity and semantic precision in programming languages. We will argue, however, that for computer problem solving in areas such as law, medicine, or business our system is, in fact, quite appropriate. We will support our arguments with discussion of experimental problem solving programs which have been constructed using our system, or parts of it, as a base.

Even if the reader is convinced our system is useful, he may still feel it is needlessly complex. It does contain a large number of conventions, conventions of the type which ordinarily make a programming language difficult to learn. However, the details of these conventions do not present the major problem. If a system builder knows English, he already knows most of them!

The real difficulty comes not in the details, but in the fundamental structure of our system. We think of this structure as making explicit what a speaker of English already knows implicitly, although we can't prove this is so. We will continually motivate our constructs with examples of English usage, but ours is clearly only one possible model. Further investigation may make it possible to choose a best model, indeed, to show that some aspects of the model derive from what Chomsky (to appear) calls "universal grammar" - "a system of principles that determines (1) what counts as a grammar, and (2) how grammars function to generate

structural descriptions of sentences." In fact, we will confront many of the same issues confronted by Chomsky in his quest for universal grammar. Our goal here is to find the most elegant and effective set of computational primitives on which to base our system, given our commitment to mimic English. To do this, we have "reworked" modern linguistics from a computational perspective. The reader will be surprised at the elegance of the set of basic constructs which can be advanced.

2. Reference and Description

A familiar notion in grammar is the distinction between restrictive and amplifying relative clauses. This is brought out clearly by the sentences (Zandvoort 1966):

> I wish I knew the man who wrote that book.
> My uncle, who will be seventy tomorrow, is still a keen sportsman.

Zandvoort says

> "Of the two examples given of the use of relative who, the former contains a clause restricting the reference of the antecedent to one or more particular persons or things, and, therefore, is called a restrictive clause; the latter contains a clause which does not restrict the reference of the antecedent, but gives further relevant information about it; such a clause is called a continuative or amplifying clause.
>
> Restrictive clauses are subordinate in meaning to the clause containing the antecedent; continuative clauses are more independent; their contents might often be expressed by an independent statement."

In the second sentence the speaker makes the supposition that the phrase My uncle will be sufficient to identify the proper person in the mind of the listener. He then tells the listener the additional fact that the person will be seventy. The phrase My uncle can be thought of as a pattern. The listener may have in memory a description of someone which matches this pattern. Finding this description is called finding the referent of the pattern. What information is, in fact, used by the

listener to find a referent depends on his state of knowledge. He may misinterpret the speaker's intentions and, in any case, he need not comply with them. He can use all of the information including that intended as description if he wants, or he may not be able even to use what is suggested.

This example of finding the referent of a noun group brings out the distinction between information used to identify and information used to amplify or further describe. Let us look at an example of how computer programs have used information to identify. In the sentence

Is a red block in the box?

Winograd's SHRDLU (1972) would interpret the phrase a red block by finding blocks one at a time and checking each to see if it is red. Red is used to help identify blocks whose presence in the box is questioned.

Suppose we apply this same procedure to a red fire engine in

Is a red fire engine at the corner?

We find each engine and then check it to see if it is fire ---. Wait a minute, this is not right. Fire engine is used like one word. It's not that different from fireplug or firehouse which are written as one word. Furthermore, Lees (1960) has shown that the relation between a noun like engine and its classifying noun fire can be quite idiosyncratic. It is not possible to predict the meaning of the combination from the meaning of each alone, we must consider the words as a pair. For example, the meaning of fire in fire engine is different from that in fire ball. What we want to do is find all fire engines. A fire engine is a special kind of engine about which we know quite a bit. The intuitive feeling is that fire engine designates a concept which already exists per se in the listener's mind. Somehow from this concept the listener can get to information he has about

fire engines more readily than he can from the concept of engine alone. He is able to look for fire engines directly rather than separating them from other engines the way Winograd's SHRDLU separates the red blocks from the others.

3. A Model of Semantic Memory

Our thesis is that a listener cannot make appropriate use of the phrase fire engine unless he already has information associated with this specific word pair in his memory. We have very little idea how information is structured in people's minds but we can build a simple model of semantic memory, based on suggestions by Hawkinson (1975), which will allow us to give a precise form to our ideas about the structure of short phrases like fire engine and, in fact, whole sentences.

We let semantic memory be made up of concepts and symbols. Symbols are written as character strings between double quote marks, e.g., "ENGINE". As shown in Figure 1, the most general concept is SUMMUM-GENUS. Symbols and SUMMUM-GENUS are taken to be atomic in the sense that they cannot be decomposed in any way. Concepts other than SUMMUM-GENUS are non-atomic. They are constructed from SUMMUM-GENUS and symbols by using the binary operation, specialization. Specialization is written:

(genus specializer) — where genus is a concept and specializer is a concept or symbol.

We say that a concept is a specialization of the concept in its genus position.

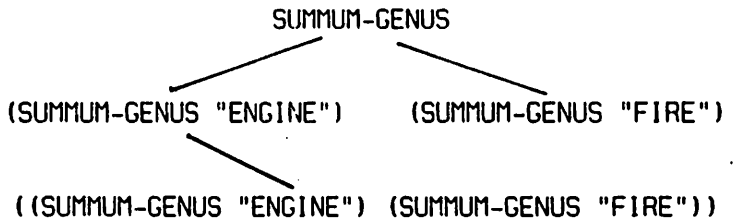


Figure 1

For example in Figure 1 we have constructed two specializations of SUMMUM-GENUS: (SUMMUM-GENUS "ENGINE") and (SUMMUM-GENUS "FIRE"). We have then specialized (SUMMUM-GENUS "ENGINE") by (SUMMUM-GENUS "FIRE").

Clearly, specializations form a tree. We say that any concept, C, forms a class which contains all the concepts in the branch of the tree whose root is C.

If specialization is carried to very many levels, the expression for a concept quickly becomes unwieldy. We avoid this through the familiar mechanism of labeling. The expression

label = concept

where label is any string of letters, digits, hyphens, periods, and asterisks not enclosed in quotes

assigns label to concept. A label is just a notational abbreviation for the parenthesized expression that exhibits the genus and specializer of a concept; it has no semantic significance in and of itself. Using labels we might rewrite Figure 1 as Figure 2.

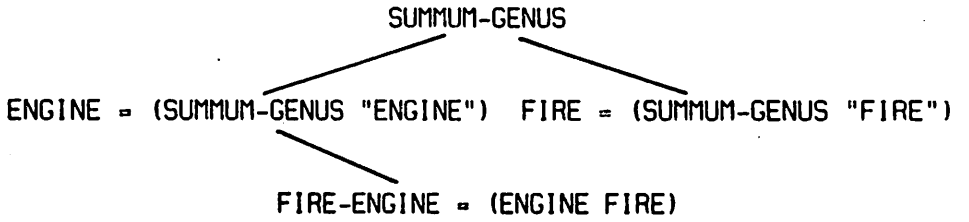


Figure 2

The phenomenon we model with specialization is called syntagma by Marchand (1969) in his study of compounds. Explaining it, he states

"2.1.1 The coining of new words proceeds by way of combining linguistic elements on the basis of a determinant/determinatum relationship called syntagma. When two or more words are combined into a morphological unit on the basis just stated, we speak of a compound. In the system of languages to which English belongs the determinant generally precedes the determinatum. The types which do not conform to this principle are either syntactical compounds (e.g. *father-in-law*) or loan compounds (e.g. *MacDonald, Fitzgerald*) with the 'inner form' of a non-English language.

2.1.2 The principle of combining two words arises from the natural human tendency to see a thing identical with another one already existing and at the same time different from it. If we take the word *steamboat*, for instance, identity is expressed by the basis *boat*, the difference by the word *steam*. *Steamboat* as compared with *boat* is a modified, expanded version of *boat* with its range of usage restricted (see below) so that *steamboat*, the syntagma, will be found in basically the same semantic contexts as the unexpanded *boat*. The syntagma *steamboat* also retains the syntactic primary feature of *boat*, *steamboat* belongs to the same word class 'substantive' to which *boat* belongs. An adjective such as *color-blind* is an expansion of *blind*. A person is called *color-blind* because he is basically seen as *blind* though only so with regard to colors. *Rewrite* as compared with *write* is basically the verb *write* with which it is to a great extent exchangeable except for the modification expressed by re-. This does not, however, affect the word class of the syntagma, which is that of a verb.

Combinations of types steamboat, colorblind, and rewrite which are mere morphological extensions of the words *boat, blind,* and *write* respectively, will be termed EXPANSIONS. An expansion will then be defined as a combination AB in which B is a free morpheme (word) and which is analysable on the basis of the formula AB = B. This means that AB belongs to the same word class and lexical class to which B belongs. Combinations of the kind illustrated by steamboat and colorblind which contain free morphemes both for the determinant and the determinatum will be termed compounds. Combinations of the type rewrite where the determinatum is a free morpheme while the determinant is a bound morpheme are prefixed words. Both compounds and prefixed words thus are subgroups of the larger class called 'expansions'.

2.1.3.1 A further clarification may not be out of place. Semantically speaking, the determinatum represents the element whose range of applicability is limited by the determinant. A *steamboat* is basically a *boat*. But whereas *boat* as an independent unit can be used with reference to an unlimited variety of boats, the applicability of *steamboat* is limited to those which are powered by steam, excluding those which are not steamboats. We might say that this exclusion in *steamboat* of 'non-steamboat' things constitutes the determination of *boat* as performed by the first element *steam*, which has therefore been called the determinant. *Boat*, as the element undergoing a semantic

restriction or determination, has been called the determinatum. However, as a syntagma is a grammatical, not a semantic entity, we would say that the terms determinatum and determinant should be defined as grammatical terms. Grammatically speaking, the determinatum is that element of the syntagma which is dominant in that it can stand for the whole syntagma in all positions, as has just been stated in a formula.

2.1.3.2. It is important to stress the grammatical character of a syntagma. Semantically speaking, the grammatical determinant is in many cases the part that can stand for the whole combination. This would first apply to compounds of the type girl friend. *Girl* may well fill the place of *girl friend*, but it has not become the grammatically dominant part. The semantic dominance of the determinant over the determinatum is, however, most in evidence in derivation containing an appreciative suffix, as in streamlet 'little stream'. A *streamlet* is basically a *stream* though an (emotionally) small one, and could therefore take the place of *stream*, if semantic considerations were the criterion of substitution. A *blackish suit* could substitute for *a black suit* as from a purely semantic point view *black* has merely been expanded into *blackish*. But grammatically speaking, *black* in *blackish* has lost its independence to -ish just as in *blacken* it has lost its independence to -en. In either case it is the suffix that dominates grammatically."

4. The Correspondence between Concepts and English Words and Phrases

Given a semantic memory structure such as that in Figure 2 we would like to set up a correspondence between English words and phrases, and concepts in memory. For Figure 2 the mapping we have in mind is

word or phrase		concept
fire	↔	FIRE
engine	↔	ENGINE
fire engine	↔	FIRE-ENGINE

Rather than list the correspondence exhaustively as we've done here, we want to establish a set of rules by which any needed correspondence can be constructed for Figure 2. The rules we need are

Rule 1: Associate each word with the symbol with the same spelling. Rule 1 is quite trivial.

Rule 2: Link each symbol with each concept it specializes, these are concepts corresponding to the word associated with that symbol.

Rule 3: One noun can classify another. The classifying noun precedes the classified noun, and a corresponding concept of it specializes a corresponding concept of the other.

Applying rules 1 and 2, we get from fire and engine to FIRE and ENGINE. Applying rule 3 and the classifying relationship fire engine, we get from FIRE and ENGINE to FIRE-ENGINE. Note that if FIRE-ENGINE is not in semantic memory then nothing will correspond to fire engine. This simple case is handled easily enough. In order to handle more complex cases we must make a number of additional distinctions.

5. Locating and Restricting

Returning to the phrase a red fire engine, we now have a method of writing the concept (ENGINE FIRE) and rules for a mapping between the phrase fire engine and that concept.

To handle red fire engine we could assume that the listener has the concept ((ENGINE FIRE) RED) and add

Rule 4: An adjective can classify a noun or noun phrase. The classifying adjective precedes the noun or noun phrase, and a corresponding concept of it specializes a corresponding concept of the noun or noun phrase.

In this case, however, the method of Winograd seems to make some sense. Red seems to give an attribute of the fire engine that the speaker is referring to, rather than to locate the concept ((ENGINE FIRE) RED) in the listener's semantic memory.

Earlier, we split the information in a noun phrase into that used to identify, and that used to further describe. Now we are suggesting a further split of the identifying information as shown in Figure 3.

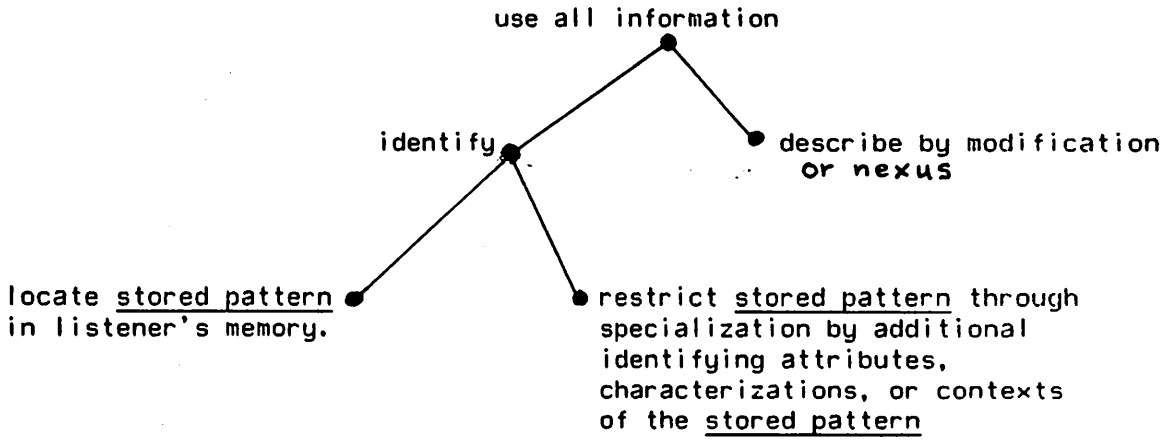


Figure 3

As mentioned before, the speaker can indicate how information is to be used but the final choice is the listener's and depends on his particular semantic model. For example, the listener can't locate the concepts (ENGINE FIRE) or ((ENGINE FIRE) RED) unless he has them. We are suggesting that a typical listener would have (ENGINE FIRE), but not ((ENGINE FIRE) RED). If he had ((ENGINE FIRE) RED) he could use RED in locating it. Otherwise, he would have to use RED as an additional restrictive attribute of the concept (ENGINE FIRE). He would locate (ENGINE FIRE) in memory and then specialize it by RED to form the pattern ((ENGINE FIRE) RED) to be used in finding the referent. In any case, the utilization of the information can be listener specific.

In Section 2 we distinguished restrictive from amplifying relative clauses. The same distinction must be made with adjectives. For example,

The philosophical greeks liked to talk.

can mean either

The greeks, who were philosophical, liked to talk.
The greeks who were philosophical liked to talk.

In order to distinguish restrictive from amplifying readings, we make the

convention that only restricitve elements can be used to specialize the stored pattern in order to form the pattern used in finding the referent. Amplifying elements are used to describe rather than identify. We say that amplifying elements modify the pattern used in finding the referent. The notation for modification is given in the next section.

There are cases where different readings arise depending on whether an adjective is used to locate or restrict. Consider the sentences

He is a fat man.
He is a very fat man.
He is a circus fat man.

In the first sentence the phrase fat man can be spoken with a slight pause between fat and man, referring to a man who is fat. Fat man can also be spoken quickly, as one word with the stress on fat, indicating someone who, for example, works at the circus along with the giant. These two readings are separated by the second and third sentences. The second sentence can only be read with a pause between fat and man, while the third sentence must be read without a pause. Let us refer, as we have done in Figure 3, to the concept located in the listener's memory as the stored pattern. Thus in the reading of fat man demonstrated by circus fat man the stored pattern is (MAN FAT); in the reading of fat man demonstrated by very fat man it is MAN. Clearly, it would be desirable to distinguish the stored pattern (MAN FAT) from the restriction (MAN FAT) since these correspond to two different readings. To do this we will refine our notion of specialization in Section 7.

6. Modification

We have introduced specialization as a means of creating a new concept. Modification is used to give an amplifying description of an existing concept. Referring to Figure 3, for the amplifying reading of

philosophical greek we want to locate the concept GREEK and then describe it as philosophical by modifying GREEK by PHILOSOPHICAL.

To indicate modification of a concept C by concepts C_1 to C_n we write [C C1 ... Cn]. C is called the subject of the modification and C1 ... Cn are called the modifiers of C. [C C1 ... Cn] is read C modified by C1, ..., Cn and can be used notationally wherever C can be used. Using this notation, the amplifying reading of philosophical greek is written [GREEK PHILOSOPHICAL].

7. Species, Stereotype, Restriction, Aspect, Instance, and Inflection

In this section we introduce rules for stating precisely what meaning can be inferred from the genus and specializer of a particular concept. Our first step is to divide concepts into six types: species, stereotype, restriction, aspect, instance, and inflection.

As shown in Figure 1, the specializations in semantic memory form a tree. Each concept can be thought of as classified "under" its genus. Thus a fire plug is classified under plug, John's health under health, etc. In this sense, both sheep dog and my pet, Fido, should come under dog. These specializations differ, however, in that sheep dog is a general category while my pet Fido is a dog instance, a specific dog.

We make this distinction in the semantic model. Specifically, Fido, the dog instance, is represented by

((DOG INSTANCE*) FIDO).

The generic concept DOG is specialized by the meta-attribute INSTANCE*, (DOG INSTANCE*). All instances and only instances of DOG are specializations of (DOG INSTANCE*). We will customarily create an instance

of a concept A by specializing the concept (A INSTANCE*) by a name or a number used as a name.

The use of INSTANCE* allows us to separate instances of a concept from other specializations of it. We need instances to describe the idiosyncracies of particular things. If Fido has his own concept, we can modify Fido by fat, without saying anything about the fatness of dogs in general.

As a notation, the form ((A INSTANCE*) B) is somewhat long winded. Also, it is slightly misleading to use the same notation for specialization by meta-attributes as for other specializations. We will therefore introduce a notational abbreviation. ((A INSTANCE*) B) will be written (A*I B) for any A and B. For example, we have the equivalent forms

((DOG INSTANCE*) FIDO)	(DOG*I FIDO)
(([GREEK PHILOSOPHICAL] INSTANCE*) MIKE)	([GREEK PHILOSOPHICAL]*I MIKE)

The six meta-attributes and their notational abbreviations are:

SPECIES*	*S
STEREOTYPE*	*T
RESTRICTION*	*R
ASPECT*	*A
INSTANCE*	*I
INFLECTION*	*X

Figure 4

Suppose next we want to represent a recipe which contains the phrase, beat an egg, which will be added later. Egg here is not an egg instance; it doesn't refer to a specific egg. Choosing a specific egg to match this phrase is part of following the recipe. On the other hand, if we represent this phrase by modifying the generic egg by which will be added later, we will have stated that all eggs are added later, clearly not what we want. Expressed in programming terms, what we need is a variable of type egg in the program corresponding to the recipe.

An analogous problem arises in giving any structural description. For example, one wants to describe the feet of a dog without describing feet in general. Our needs are filled by the notion of an aspect and the meta-attribute ASPECT*. A concept E is an aspect of a concept F if E = (C*A F) for some C. Suppose R1 is an instance of a recipe, then an egg aspect of R1 is (EGG*A R1).

To contrast instances and aspects, notice that HEALTH can be used to form aspects but not instances. We say "John's health was good", but not "That was a good health". HEALTH becomes specific only by being an aspect of something specific. John's health is specific because John is specific.

Stereotypes and species address a problem which has caused others (Raphael 1968) to reject tree-structured classification schemes like our specialization operation. Raphael observed that something could be, for example, simultaneously a dog, a pet, a father, a nuisance, and a barker. Under these circumstances it wasn't clear to Raphael how to form instances in any systematic way.

Our solution to this problem is to distinguish between species and stereotypes of a concept. For example, species of dog are sheep dog, bull dog, poodle, etc., while stereotypes of dog are lap dog, house dog, and barker. We require species but not stereotypes to be mutually exclusive. Species can be used to form instances but stereotypes cannot. In Figure 5 we show, for example, two species of animal, dog and cat. We also show bull dog as a species of dog and lap dog as a stereotype of dog. Fido we have made an instance of bull dog; he could not be an instance of lap dog, because lap dog is a stereotype. We can characterize him as a lap dog.

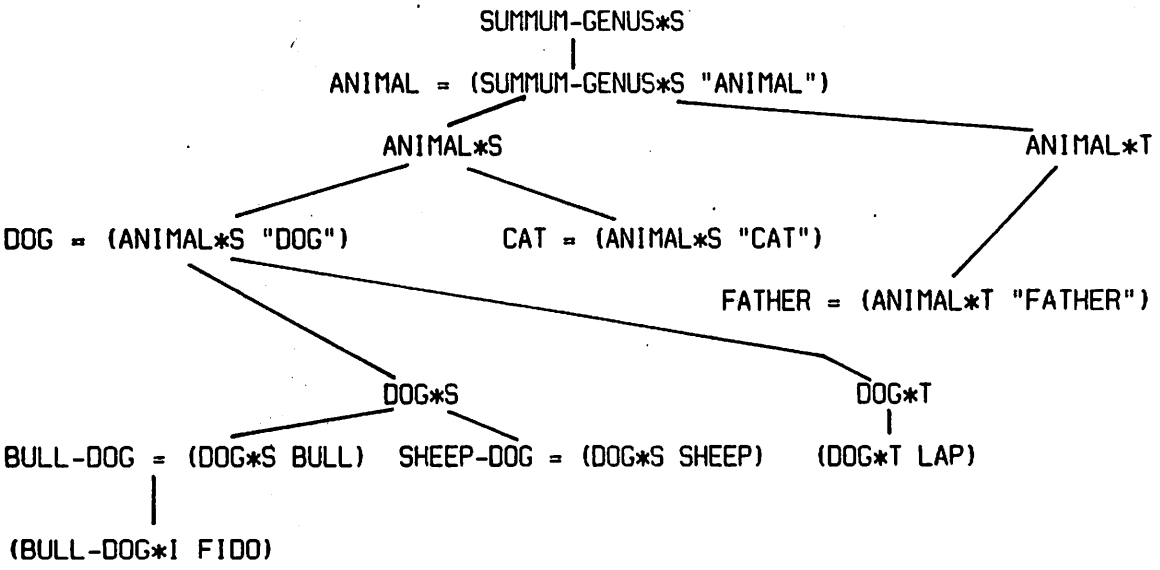


Figure 5
Fido is an instance of a bull dog

It is not always easy to distinguish stereotypes from species, or, indeed, what should be stereotypes and species; but we have been able to make a practical distinction in the problems we have considered. Stereotypes always focus on one characteristic, e.g. he sits in the lap, he stays in the house, he barks. Species usually involve many attributes, e.g. dog vs. cat.

The mutually exclusive classification of instances is done as a computational convenience. For example, one can quickly determine that an instance of a BULL-DOG is not a SHEEP-DOG because BULL-DOG and SHEEP-DOG are both species and neither is in the class of the other. On the otherhand, since FATHER is a stereotype it is not mutually exclusive with DOG and no such quick check is possible to determine that a DOG instance is not a FATHER. While one could alternatively form instances of DOG and characterize them with the stereotypes COLLIE, POODLE, etc. this would make it computationally more difficult to tell the breeds apart. The distinctions between breeds is perhaps not so important in general, but it

would be, for example, in a program expert in the management of dog shows. The choice between species and stereotypes therefore depends in part on the particular expertise to be embodied in a given semantic model.

The usefulness of the species/stereotype distinction is based primarily on the computational capabilities of current computer systems. Since the computational capabilities of people differ from those of computers it is difficult to say that the distinction is useful to people or even that they make it. The distinction does allow us to account for a phenomenon noted by Southworth (1967).

> "Similarly, a mutt is in one meaning a particular kind of dog (= mongrel), but in another meaning it is a way of talking about any dog (even a thoroughbred)."

We can form both meanings

```
(DOG*S "MUTT")
(DOG*T "MUTT")
```

Consider also the different senses of part in

> That brick was part of my homestead.
> They sell auto parts.

Auto parts are species of part, whereas part of my homestead is an aspect. While a species can stand alone, an aspect can be considered either a concrete object or only an aspect of another object. This distinction has been pointed out by Fillmore (1970). He shows that hit takes a location and break an object.

> "27) I broke the top of the table.
> 28) I hit the top of the table.
> In (27) the noun top must be referring to the top of a table as a more or less distinct object, while in (28), it can refer either to that or a portion of the surface area of the table."

Recall that in Section 5 we wanted to distinguish the readings of fat man found in circus fat man and very fat man. The reading in circus fat man we take to be a stereotype, (MAN*T FAT); the other we take to be a

restriction, (MAN*R FAT). A restriction (A*R B) can always be paraphrased, an A who/which is/are B, whereas a stereotype (A*T B) cannot. For example we have only the restrictive reading of a man who is fat.

The concrete nature of the types explained so far can be contrasted with an inflection which serves only to guide in the interpretation of the concept inflected.

Zandvoort (1966) explains the classical distinction between inflection and other types of affixation.

> "832. As was stated or implied in 803, we understand by composition the formation of a word by the close combination of two or more elements each of which is also used as a separate word: goldsmith.
>
> If only one of the elements can be used as a separate word, we speak of derivation. The other element, if the first, is called a prefix, if the last, a suffix: unkind, kindness.
>
> 833. As derivation is distinguished from composition on the one hand, so it is to be distinguished from inflexion on the other. Both make use of suffixes; but whereas derivation results in the formation of a different word (kind - kindness, sleep - sleepy), inflexion merely modifies a word (noun or verb) in the ways described in the chapters on those parts of speech (book - book's - books, hope - hopes - hoped - hoping). Hence we distinguish derivational from inflexional suffixes. Prefixes are always derivational in English (not, for instance, in Latin or Greek: cado - cecidi; cf also Dutch gelopen, German gelaufen)."

Inflected words seem to have two important properties. First, the inflected form controls the syntactic environment in which the word may correctly occur in a sentence. One says "dogs bark" and "dog barks", the s on dog going with the null on bark and vice versa. Consistent with what was done above the inflection would thus be the genus and the base would be the specializer. The second property of most inflected forms is that except for a particular piece of information carried by the inflection, the semantics derive from the base; which in the model used here means from the specializer. Typically, the information carried by the inflection

describes how to put a base in context, rather than adding to the description of it. For example, the suffix -ed says that an action was remote, either past or subjunctive, but doesn't say anything about what the action was. This is quite different from what happens in the case of compounds like fireman which appears where man can appear and derives most of its semantics from man. It is also different from the restriction fat man which adds the specific modifier fat to those of man. These considerations lead to the definition of inflection as the sixth type of concept. For all concepts, we let any modifier of A not contradicted by a modifier of (A B) be an inherited modifier of (A B). If (A B) is an inflection we also let any modifier of B not contradicted by a modifier of (A B) or one inherited from A be an inherited modifier of (A B). The question of when one modifier contradicts another is a semantic one which we won't treat here. The simple case is when the two modifiers are mutually exclusive, such as red and yellow, or thin and fat.

In forming an inflection C = (A*X B), A must be a species, stereotype, or restriction; but B may be any type of concept. However, the types of concepts which can be formed from C are the intersection of those permitted by A and those permitted by B. For example, we can have instances of flock of sheep, because flock and sheep are species, but not of party of one because one is a stereotype. We don't have instances of one of the sheep, again, because one is a stereotype.

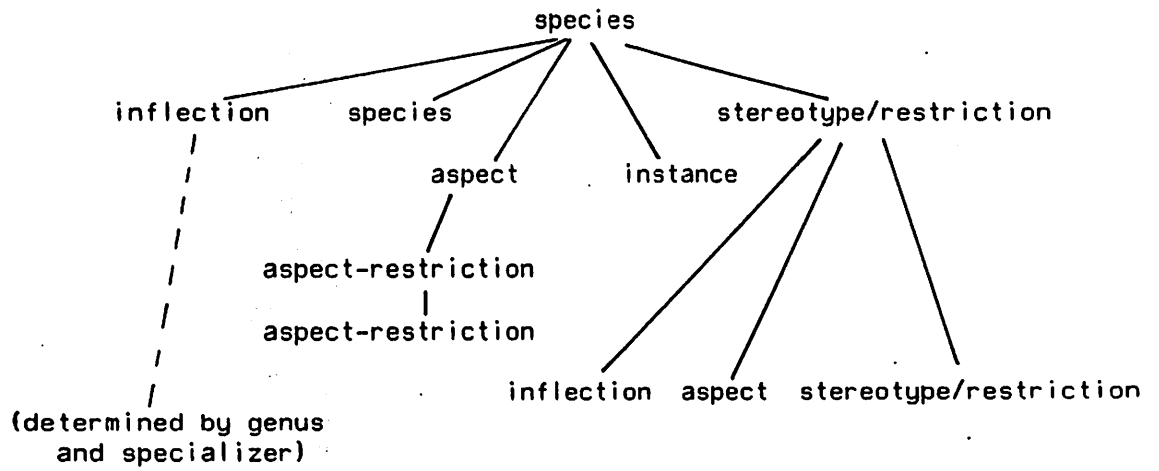


Figure 6

Rules for the formation of the six types of concepts are shown in Figure 6. Instances and species can be formed as a subconcept only of species or inflections of species. Stereotypes, restrictions, inflections, and aspects can be formed as a subconcept of species, stereotypes, restrictions and their inflections. When an aspect is formed it can only be restricted to produce a subtype of aspect, refered to as an aspect-restriction, which can in turn only be restricted.

The rules for inheritance of modifiers are:

1) Any concept A inherits from its genus any modifier not explicitly contradicted by a modifier of A.

2) An inflection (A B) also inherits from its specializer B any modifier not explicitly contradicted by a modifier of (A B) or a modifier inherited from A.

3) Restrictions (A B) inherit their specializer B as a modifier.

The sequence instance, species, stereotype, restriction, aspect, inflection is in order of decreasing importance of the genus and increasing importance of the specializer in determining the properties of the resulting concept. One could envision a formulation where a point on this scale was given by a continuous parameter of the specialization rather than by the six types of concept used here.

Each type of concept occurs only in certain types of English phrases.

Instance:
(A*I B) is written A B with B in restrictive apposition to A; where there is no ambiguity this may be abbreviated to B. E.g., (BLOCK*I A) is written block A or just A.

Species:
a) (A*S "X") is written X, e.g., (DOG*S "COLLIE") is written collie.
b) (A*S B) is written B A, e.g. (DOG*S BULL) is written bull dog.

Stereotype:
a) (A*T "X") is written X, e.g., (ANIMAL*T "FATHER") is written father.
b) (A*T B) is written A B if A is a verb, B A otherwise; or just A if B can be inferred from grammar rules and other sentence elements. For example, (DOG*T LAP) is written lap dog, but [MUSIC (SOFT*T SOUND)] is written soft music not sound soft music.

Restriction:
a) (A*R B) is written B A, if B is an adjective or a noun, e.g., (MAN*R FAT) is written fat man.
b) Otherwise (A*R B) is written A B, e.g., (MAN*R ALIVE) is written man alive.

Aspect:
a) (A*A B) is written as described in the section on lambda abstraction if B is a clause containing A.
b) Otherwise, (A*A B) is written A of B or B's A, e.g. (HEALTH*A BOB) is written Bob's health or health of Bob. The choice is dictated by factors such as whether or not B is higher animate.

Inflection:
a) (A*X B) is written as dictated by B and morphology if B is an affix. E.g. (-ING*X HIT) is written hitting.
b) (A*X B) is written A of B

1) if A is a quantifier and B is definite, e.g., (SOME*X (THE*X MEN)) is written some of the men.

2) or if A is a partitive like flock, or a member of some similar class.

c) Otherwise, (A*X B) is written A B, e.g., (TO*X TOWN) is written to town.

8. An Alternative to Nodes and Links

We introduce the notion of aspect partly in response to an important problem pointed out by Woods (1975).

"Much of the structure of semantic networks is based on, or at least similar to, the notion of attribute and value which has become a standard concept in a variety of computer science applications and which was the basis of Raphael's SIR (Raphael, 1964) -- perhaps the earliest forerunner of today's semantic networks. Facts about an object can frequently be stored on a "property list" of the object by specifying such attribute-value pairs as HEIGHT: 6 FEET; HAIRCOLOR: BROWN, OCCUPATION: SCIENTIST, etc. (Such lists are provided, for example, for all atoms in the LISP programming language.) One way of thinking of these pairs is that the attribute name (i.e. the first element of the pair) is the name of a "link" or "pointer" which points to the "value" of the attribute (i.e. the second element of the pair.) Such a description of a person named John might be laid out graphically as:

```
JOHN
     HEIGHT          6 FEET
     HAIRCOLOR       BROWN
     OCCUPATION      SCIENTIST
```

The above examples seem to imply that the thing which occurs as the second element of an attribute-value pair is the name or at least some unique handle on the value of that attribute. What will I do, however, with an input sentence "John's height is greater than 6 feet"? Most people would not hesitate to construct a representation such as:

```
JOHN
     HEIGHT (GREATERTHAN 6 FEET)
```

Notice, however, that our interpretation of what our network notations mean has just taken a great leap. No longer is the second element of the attribute value pair a name or a pointer to a value, but rather it is a predicate which is asserted to be true of the value. One can think of the names such as 6 FEET and BROWN in the previous examples as special cases of identity predicates which are abbreviated for the sake of conciseness, and thereby consider the thing at the end of the pointer to be always a predicate rather than a name. Thus there are at least two possible interpretations of the meaning of the thing at the end of the link -- either as the name of the value or as a predicate which must be true of the value. The former will not handle the (GREATERTHAN 6 FEET) example while the latter will.

Let us consider now another example -- "John's height is greater than Sue's." We now have a new set of problems. We can still think of a link named HEIGHT pointing from JOHN to a predicate whose interpretation is "greater than Sue's height", but what does the reference to Sue's height inside this predicate have to do with the way that we represented John's height? In a functional form we would simply represent this as HEIGHT (JOHN) > HEIGHT (SUE), or in LISP type "Cambridge Polish" notation,

```
(GREATER (HEIGHT JOHN) (HEIGHT SUE))
```

but that is departing completely from the notion of attribute-value links. There is another possible interpretation of the thing at the end of the HEIGHT link which would be capable of dealing with this type of situation. That is, the HEIGHT link can point from JOHN to a node which represents the intentional object "John's height". In a similar way, we can have a link named HEIGHT from SUE to a node which represents "Sue's height" and then we can establish a relation GREATER between these two intensional nodes. (Notice that even if the heights were the same, the two intensional objects would be different, just as in the morning star/evening star example.) This requires a major reinterpretation of the semantics of our notation and a new set of conventions for how we set up networks. We must now introduce a new intensional node at the end of each attribute link and then establish predicates as facts that are true about such intensional objects. It also raises for us a need to somewhere indicate about this new node that it was created to represent the concept of John's height, and that the additional information that it is greater than Sue's height is not one of its defining properties but rather a separate assertion about the node. Thus a distinction between defining and asserted properties of the node becomes important here. In my conception of semantic networks I have used the concept of an EGO link to indicate for the benefit of the human researcher and eventually for the benefit of the system itself what a given node is created to stand for. Thus the EGOs of these two nodes are John's height and Sue's height respectively. The EGO link represents the intentional identity of the node."

Following Hawkinson (1975), we can use specialization and modification to solve this problem neatly, and in a way which parallels Woods' approach. First we create the concepts (HEIGHT*A JOHN) and (HEIGHT*A SUE). These correspond to Woods' intensional objects. The information gotten through Woods' EGO link is obtained from the genus and specializer. The genus of (HEIGHT*A JOHN) is HEIGHT*A, indicating that (HEIGHT*A JOHN) is a height. The specializer of (HEIGHT*A JOHN) is JOHN, indicating that JOHN is the thing which makes this height unique.

To get from JOHN to (HEIGHT*A JOHN) we use an index reference: JOHN is modified by (HEIGHT*A JOHN), i.e., [JOHN (HEIGHT*A JOHN)]. We have an index reference whenever a concept A is modified by a concept (B A) which has A as a specializer. To find information about John's height we look through the modifiers of JOHN for one whose genus is HEIGHT*A and whose specializer is JOHN.

The effect of this construction is to do away with the distinction between nodes and links, which is highly desirable since anything one would want to say about a node, one also wants to be able to say about a link. The index reference construction seems so fundamental that we make the convention that the formation of an aspect automatically implies the creation of the corresponding index reference.

To indicate that John's height is greater than Sue's, we modify (HEIGHT*A JOHN).

```
[(HEIGHT*A JOHN)
     ((MORE*X GREAT)*T (THAN*X (HEIGHT*A SUE)))
```

It is in this last step that our representation departs the most from Woods'. We use the subject/modifier form rather than a functional notation.

9. Value and Effect

We now set down rules for incorporation of an expression composed of specialization and modification operations into semantic memory.

specialization: (genus specializer) Look up the indicated concept in memory. If it is already there, return it as the value of the specialization. Otherwise, create it as effect, return it as value. This rule insures that all concepts are stored uniquely in semantic memory.

modification: [C C1 ... Cn] Associate modifiers C1 ... Cn with C, as effect, and return C as value.

Just as we introduced labels to keep expressions from becoming unwieldy in size, we now introduce a shorthand for creating aspects of the subject of a modification. Given [C ... C_i ...], any concept in any of the C_i of the form (A*A C), i.e., any aspect of the subject C, can be written in the shorthand form A: For example, [C (A*A C)] can be written [C A:], and [C (A (B*A C))] can be written [C (A B:)]. Generalizing on this, we

use :, ::, :::, etc. for aspects of the subject of the top-level modification, next-to-top-level modification, etc. For example [C [B (A*A B)(A*A C))]] can be written [C [B (A:: A:)]].

10. Productive Categories and the Notion of Grammatical

Chomsky (1957) claims that the sentence Colorless green ideas sleep furiously is syntactically correct, but semantically meaningless. Minsky (1975) points out that one is able to form some image of this activity, though it is clear that this represents a productive process. One is not able to locate a familiar, already existing image as one can with I brushed my teeth.

In this section we will introduce a rule for how the semantic model can be used to determine what specializations are to be allowed if only syntactically correct sentences are to be generated. We call this rule a meta grammar rule because it determines the form which rules of grammar must take in our world model. It corresponds in level, for example, to the definition of what constitutes a context free grammar or a transformational grammar. Our notion of syntactically correct will allow access to the kind of productive processes noted by Minsky, although it is not clear how to implement them except for simple cases.

Our meta-grammar rule can be viewed as an extension of a phenomenon widely recognized to exist at the word level.

Quoting Zandvoort (1966),

> "836. Prefixes and suffixes fall into two groups, according as they can or cannot be used to form new words. In the former case they are called living or productive, in the latter dead or unproductive. All the prefixes (mentioned above) are productive. Examples of unproductive prefixes and suffixes are for-, as in forget, forgive; with-, as in withdraw, withhold; -ant or -end, as in servant, different; -le, as in handle; -t, as in gift (cf. to give)."

Figure 7 shows a classification of the uses of -age which helps make clear the distinction between productive and unproductive.

1) A measure of the amount of activity characterized by X, seen as loss or gain.

   a) a fee for X:
      postage, towage

   b) a loss from X:
      shrinkage, breakage, spoilage, pilferage

   c) measure of usage in units of X
      milage, footage

   d) a gain from social position X
      heritage, peerage, advantage

2) Orphanage, parsonage, cottage

3) Passage, pilgrimage, marriage

4) Hostage

Figure 7
Uses of -age

We would say that group 1 b) is productive, because we can form new terms like lossage and crackage, which, while not in the language, are readily understood. The same is true of 1 c). On the other hand, class 2), for example, is unproductive.

The words shrink, break, spoil, and pilfer in association with -age form what Whorf (1956) calls an implicit grammatical class. Somehow speakers of English are able to determine that crack is also in this class.

We see from this that productivity is a property of a class together with a suffix or prefix, not simply of the suffix or prefix itself.

We will always take a suffix to be the genus. Thus shrinkage would be modeled as (-AGE*X SHRINK). A suffix always controls the grammatical class of the word.

We now introduce the notion that a specialization is either productive or unproductive. To indicate that a specialization (A B) is productive we modify it with P*, [(A B) P*]. We can then say a specialization (A B) is grammatical with respect to a given semantic model if 1) (A B) is explicitly in the semantic model, or 2) if (A C) is in the semantic model, (A C) is productive, and B or a characterization of B is in the class defined by C. Remember that B is in the class defined by C if B can be written $B = (...((C\ S_1)\ S_2)...S_n)$ for zero or more specializers S_i.

As was observed above, most English speakers would agree on the meaning of crackage while knowing it is not a word. We model this by assuming that specializations which occur in practice will occur explicitly in the semantic model, even if there is a productive specialization which makes them grammatical. Thus breakage, for example, would be explicitly present, while crackage would be formed productively.

11. Naming

Naming is a simple and well known process which plays a very important role in our development. In our parsing program a significant portion of the computational effort is given over to replacing names by their referents.

Any concept, A, can name another concept, B. We write [(NAME*A B) A] and [A (NAME*A B)], characterizing the name of B as A, and A as the name of B. As a special case, we also say that if the specializer of a concept is a symbol, then the symbol names the concept. For example, (ANIMAL*S "DOG") implies that "DOG" names (ANIMAL*S "DOG"). A concept specialized by a symbol is termed a basic concept. All others are termed compound concepts.

Through our rule for linking words with symbols having the same

spelling, we know that the word for (ANIMAL*S "DOG") is dog. It is quite possible for two concepts to have the same word, e.g. (MODAL*S "MAY") and (MONTH*S "MAY"). It is convenient to think of concepts named by the same word as different senses of the word.

We will write concepts corresponding to a prefix as the prefix followed by "-", e.g. RE- = (PREFIX*S "RE-"). Suffixes will be preceded by a "-", e.g. -S = (SUFFIX*S "-S"). We refer to the word or word string corresponding to a concept as the spelling of the concept. In spelling, a suffix or prefix appears as such, whether it is a specializer or a generalizer. Given these conventions we can form the word corresponding to (-S*X DOG), dogs. When a compound concept specializes a suffix, some suffixes apply to the last word in the spelling of the compound, e.g. (-'S*X (KING*A DENMARK)) King of Denmark's. The same thing happens with prefixes, e.g., (((LOOK*T UP)*T RE-)*A (THE*X NAME)) relook up the name. Note the two meanings of unbending which arise from this behavior of compounds, and affixes. ((-ING*X BEND)*X -UN), he is unbending as in he won't bend, and (-ING*X (BEND*X -UN)), I am unbending, as in I unbend.

We have established a convention whereby symbols name basic concepts, so that the meanings of affixes and words are basic concepts. It is also useful to have word meanings which are compound concepts. We indicate that a symbol, e.g. "KILL", names a compound concept, e.g. (CAUSE*T DIE), by writing

[(NAME*A (CAUSE*T DIE))(SYMBOL*S "KILL")]

KILL = (CAUSE*T DIE) is then a word sense of kill.

It is fairly common for a concept to be named by its specializer, e.g. a general officer is called a general, an empty container is called an empty. When this happens, it implies that, in most contexts of use, the

spelling of the specializer alone is enough to identify the concept. In effect, the spelling of the concept undergoes a deletion which the hearer is expected to reconstruct from context. The so-called bahuvrihi compounds fall into this class. A bahuvrihi compound names an entire thing by specifying some feature, e.g. blockhead, hunchback, pot-belly, fathead, loudmouth, and paleface. We would represent loudmouth, for example, as (PERSON*T LOUDMOUTH) and state further

[(NAME*A (PERSON*T LOUDMOUTH)) LOUDMOUTH],
and [LOUDMOUTH (NAME*A (PERSON*T LOUDMOUTH))].

This type of naming is sufficiently common that it is useful to have a special notation for it. To create the loudmouth concept and its name, we can write [(PERSON*T LOUDMOUTH!)]. Whenever an exclamation point follows a concept in input notation, it is taken as a shorthand for the creation of two naming modifications. [(A B!)] expands into [(A B)], with side-effects [(NAME*A (A B)) B], and [B (NAME*A (A B))].

While the bahuvrihi compounds use a distinguishing feature as the name, other compounds have acquired names through associations no longer apparent to the average speaker of English. For example, a hot dog, could be a food item, a skier, or a surfer. We would write

[(FOOD-ITEM*S (DOG*T HOT)!)]
[(SKIER*T (DOG*T HOT)!)]
[(SURFER*T (DOG*T HOT)!)]

(Skier and surfer probably form a productive class.)

We will also use naming to represent the phenomenon known as conversion. Conversion occurs when a word standing for a concept which is one part of speech comes to stand for a closely related concept which is a different part of speech. Quoting Jespersen (1933):

> "7.8.3 In this way we may even have three words derived from one another. Thus smoke is first a substance (the smoke from the chimney), then a verb (the chimney smokes, he smokes a pipe), and finally a new substance formed from the verb in the last sense

(he likes a smoke after dinner). Gossip was at first a substantive meaning 'godfather', this came to mean 'an idle talker', and from this a verb was formed meaning 'to talk idly'; from this again we have a substantive, 'idle talk'. Brush (1) instrument (2) verb, (3) a new substantive; give your hat a brush. Wire (1) metallic thread, (2) telegraph, (3) telegram."

A slightly different perspective is given by Zandvoort (1966).

"771. Many English words belong to more than one part of speech. Thus hope, love, sleep, etc may be nouns as well as verbs; chief, general, vegetable, etc., nouns as well as adjectives; clean, dead, wide, etc. adjectives as well as adverbs; while may be either a noun, a verb, or a conjunction; since may be an adverb, a preposition, or a conjunction; etc.

Owing to their more extensive use of inflexions, examples are much rarer in other languages.

772. The appurtenance of words to more than one part of speech, which is mainly owing to the paucity of inflections, should be distinguished from another feature that is even more typically English, viz. the deliberate transfer of a word from one part of speech to another, technically known as conversion. Examples: I want a share (verb > noun); Don't sir me, its hardly English (noun > verb); He never gave anything to the poor (adj. > noun); the train slowed down (adj. > verb); etc., etc. A moment's reflection suffices to realize that shave is primarily a verb, sir a noun, poor and slow adjectives, and their functioning as other parts of speech is something subsidiary and occasional. On the other hand, sleep as a verb, and the same word as a noun, are each felt to exist in their own right, and neither is felt to be really the other transferred to a different part of speech. This is not to say that all words that are used as more than one part of speech easily fall into either of these categories. Like metaphors, conversions may becomes stereotyped and cease to be felt as such. In doubtful cases it is the linguistic sense of native speakers, not the historical dictionary that forms the ultimate test.

773. We should distinguish cases of complete conversion from those of partial conversion. In the former the converted word has to all intents and purposes become another part of speech, taking the adjuncts and endings proper to that part of speech, and has ceased to belong to its original part of speech. Thus, when slow is used as a verb, it may take any of the forms and functions of a verb, and can no longer take those of an adjective; and similarly when adverbs like up and down are converted into nouns (the ups and downs of life).

In cases of partial conversion, however, the converted word takes on only some of the characteristics of the other part of speech, so that it really belongs to two parts of speech at the same time. Thus, the poor, though plural in meaning, does not take a plural ending: it becomes a noun to some extent only,

while remaining to some extent an adjective, (cf. the poorest of the poor)."

We will represent poor in the poor as [(PEOPLE*T POOR!)]. That is, the poor, means the stereotype poor people. Other examples of partial conversion are handled similarly.

Total conversion can be handled the same as partial conversion, or as two separate word meanings. For example, just as a description is the result and event of describing, the noun sleep can be considered the result and event of sleeping. We can postulate a concept, say, XX. corresponding to -TION and then write

SLEEP-NOUN = [(XX.*X VERB-SLEEP!)].

In this approach the noun is considered just an inflected form of the verb. According to this view English has as many inflections as other languages. They are just deleted by naming from the spellings of concepts.

Alternatively, a converted word can be taken to have two word meanings. It would make sense to take this course whenever it is awkward to postulate a named concept which is related semantically to its naming specializer. For example, it seems plausible to say that the chimney smokes is equivalent to the chimney emits smoke, where smoke is the object of emit, which according to the conventions of Section 19 can be written [(EMIT*T SMOKE!)], but the relationship between John smokes and smoke is not as clear. If the best we can do is say that smoke is associated with the act of smoking, perhaps it is just as well to use a separate word meaning (ACT*T "SMOKE").

12. Structural Decomposition of a Concept

We have introduced two basic operations: specialization and modification. We will need one more operation, the structural decomposition of a concept into constituent components.

Usually a concept will have more than one decomposition. For example, a tree might be decomposed into roots, trunk, limbs, and leaves. Alternatively, we can speak of the top and bottom of a tree. The body might be decomposed into parts - a head, neck, etc. - or into the components - muscle, bone, skin, blood, etc. - all of which are in each body part.

Although multiple decomposition is the general rule, there are some concepts which have only one decomposition. In fact, they often draw their identity primarily from their constituent parts. For example, consider the name, William Arthur Martin. This full name is made up of a first name, middle name, and last name. Note that whereas there is a natural ordering to the parts of a full name, the same cannot be said for the body components (muscle, bone, skin, blood, etc.).

We will represent ordered decomposition of concepts which draw their identity from their constituent parts by separating the constituents with slashes; William/Arthur/Martin. We will represent unordered decomposition by separating the constituents with plus signs, e.g., muscle + bone + skin + blood.

It would be possible for us to express decompositions using only the specialization and modification operations, but we can achieve a clearer notation and presentation by putting decomposition on essentially an equal footing with the other two.

13. Jespersen's Junction and Nexus

Otto Jespersen was probably the foremost authority on the English language in the first half of this century. He didn't make the clear distinction between syntax and semantics which has been so popular recently and thus many of his ideas have given an additional perspective which has

been helpful in this development. We have already had occasion to quote him above. Jespersen (1933) identified two basic operations, junction and nexus. The following passages show that specialization and modification, as used so far, correspond to Jespersen's junction. His nexus we take to be an example of ordered decomposition.

"9.1 A secondary can be joined to a primary in two essentially different ways, for which we use the terms junction and nexus. As separate names for the secondary in these two functions we shall use the terms adjunct and adnex respectively.

9.2.1 In a junction the joining of the two elements is so close that they may be considered one composite name for what might in many cases just as well have been called by a single name. Compare thus:

A silly person: a fool.
The warmest season: summer.
A very tall person: a giant.
An offensive smell: a stench.

9.2.2 Adjuncts may be either restrictive or non-restrictive. The former kind gives a necessary determination to its primary, which it specifies so as to keep it distinct from other things or beings having the same name; e.g. a red rose as distinct from a white rose. The addition of a non-restrictive adjunct does not serve that purpose; it is more emotional, whereas a restrictive is purely intellectual.

Examples:

No, my poor little girl.
Beautiful Evelyn Hope is dead!

9.7.1 We shall now look at the second way in which a secondary can be joined to a primary: we shall call this nexus, and for the secondary in these combinations we shall use the term adnex.

If we compare the red door and the barking dog, on the one hand (junction), and on the other the door is red and the dog barks or the the dog is barking (nexus), we find that the former kind is more rigid or stiff, and the latter more pliable; there is, as it were, more life in it. A junction is like a picture, a nexus is like a drama or

process. In a nexus something new is added to the conception contained in the primary: the difference between that and a junction is seen clearly by comparing, e.g.

The blue dress is the oldest.
The oldest dress is blue.
A dancing woman charms.
A charming woman dances.

9.7.2 In examples like "the door is red" and "the dog barks" the nexus is independent and forms a whole sentence, i.e. it gives a complete bit of information. But it is important to notice that a nexus may also be dependent, and in that case does not give a complete piece of information. The simplest instances of this are found in so-called clauses, which resemble sentences in their construction, but form only part of a communication, e.g.

I see that the door is red.
I know that the dog barks.
She is afraid when the dog barks. etc.

But the same relation between a primary and a secondary obtains also in various other combinations, in which we are therefore entitled to speak of a dependent nexus. These will be considered in some detail in Chaps XXIX-XXXII; here we shall give only a few examples to show their intrinsic similarity to dependent clauses:

I paint the door red (paint it so that afterwards it is red)
I hear the dog bark (cp. hear that he barks)
I make the dog bark.

Very often a substantive in itself contains the idea of a (dependent) nexus. Examples of such nexus-substantives:

The dog's barking was heard all over the place.
I saw the king's arrival (cp. I saw that the king arrived).
On account of her pride (cp. because she was proud)."

Jespersen refers to nexus as "like a drama or process." One can often think of nexus as having a procedural interpretation. The listener finds the substantive referred to by the subject and then applies the predicate to it. For example, referring to Figure 3, in The blue dress is the oldest the listener would locate the concept DRESS, restrict it with

BLUE and inflect it with THE. This would be the subject. Next he would obtain the concept corresponding to is the oldest. This would be the predicate. From these two parts the nexus is formed - but note that this nexus must be interpreted. The predicate does not describe the concept the blue dress itself, but rather the dress referred to by this concept. To find this dress we must know the context in which the nexus is interpreted. Similarly, it is not possible to understand the predicate is the oldest out of context. A nexus, then, is an ordered pair of concepts, which ordered pair can be interpreted by a listener in a given context.

14. Predicates

In his discussion of nexus Jespersen contrasted

The blue dress is oldest.
The oldest dress is blue.

These illustrate the attributive and predicative uses of blue, respectively. From these examples one might conclude that if an adjective can be used attributively it can also be used predicatively with the same noun. Unfortunately, life is not so simple, as is shown by

1.	a rural policeman	*that policeman is rural
	a chemical engineer	*that engineer is chemical
	a subterranean explorer	*that explorer is subterranean
	bodily harm	*that harm is bodily
	a corporate lawyer	*that lawyer is corporate
	a dental appointment	*that appointment is dental
	oceanic studies	*those studies are oceanic
2.	a civil engineer	an engineer who is civil
	a criminal lawyer	a lawyer who is criminal
	a nervous system	a system which is nervous
	a logical fallacy	a fallacy which is logical (?)
	a constitutional amendment	an amendment which is constitutional
	dramatic criticism	criticism which is dramatic
3.a)	a total stranger	*the stranger was total
	an utter fool	*a fool who is utter
	a sheer fraud	*a fraud who is sheer
	a true poet	*the poet is true

b) the main reason	*the reason is main
the prime suspect	*the suspect is prime
a principal cause	*the cause is principal
c) a former employee	*the employee is former
her eventual husband	*her husband who is eventual
a joint undertaking	*the undertaking is joint
an occasional visitor	*the visitor is occasional

The adjectives in 1) are often called denominal adjectives because it is felt that in some way they are derived from nouns. When such an adjective precedes a noun it is generally possible to exhibit a semantically parallel construction in which a noun precedes the noun (Levi 1973).

rural policeman	harbor policeman
chemical engineer	mining engineer
subterranean explorer	jungle explorer
corporate lawyer	government lawyer
dental appointment	hair appointment
oceanic studies	river studies

One would not think of constructing "the policeman is harbor" any more than he would construct "the plug is fire" to cite an example used to introduce specialization. Rural and harbor are used to identify a type of policeman. As Quirk and Greenbaum (1973) say,

> "In general, adjectives that are restricted to attributive position or that occur predominately in attributive position do not characterize the referent of the noun directly. For example, an old friend ("one who has been a friend for a long period of time") does not necessarily imply that the person is old, so that we cannot relate my old friend to my friend is old. Old refers to the friendship and does not characterize the person. In that use, old is attributive only. On the other hand, in that old man, old is a central adjective (the opposite of young) and we can relate that old man to that man is old.
>
> Adjectives that characterize the referent of the noun directly are termed inherent, those that do not are termed non-inherent.

The grammaticality of attributive use of adjectives is more complex than it might seem and our explanation must be delayed to Section 23. We state the grammaticality of predicative use with an index reference to the SUBJECT of the adjective. For example to indicate that (SOFT*T SOUND) has

a predicative use, we would write

[(SOFT*T SOUND)(SUBJECT*A (SOFT*T SOUND))]. We then modify the concept (SUBJECT*A (SOFT*T SOUND)) to indicate what are appropriate subjects for the predicate (SOFT*T SOUND). For example, we might have simply [(SUBJECT*A (SOFT*T SOUND)) SOUND]. We call a concept which has a subject a predicate. Concepts which may take subjects are verbs, adjectives, and prepositions. For example, we might have

```
[(SUBJECT*A NEIGH) HORSE]
[(SUBJECT*A (SOFT*T SOUND)) SOUND]
[(SUBJECT*A (IN*T TROUBLE)) PERSON]
```

The description of what can be the subject of a predicate is obviously more complicated than indicated by these examples. We will take this up at some length in Part IV.

15. Types of Modifiers

Recall that a modification takes the form of a subject and one or more modifiers. Each modifier is related to the subject in one of three possible ways.

1) The modifier is a non-verbal predicate on the subject.

2) The modifier is a characterization of the subject. As opposed to a predicate, a characterization can stand as an alternative representation of the subject. The distinction between predicate and characterization is seen in

He is male.	(predicate)
He is a male.	(characterization)

The characterization a male suggests more strongly than the predicate male that maleness is sufficient to understand him in the current context and that the properties of interest about him are those found in males. A male is a stereotype. A characterization, B, of a concept A is grammatical if

a) the head of A is in the class formed by either the head of B or a characterization of the head of B.
b) the head of A is in a class of a concept C of which the head of B is a stereotype.
c) the head of B is in the class formed by the head of A.

To define the head of a concept recall that a basic concept is one whose specializer is a symbol. Concepts which are not basic are termed compound concepts. A basic concept is its own head. To find the head of a compound concept repeat the following step until you come to a basic concept

step: If the concept is an inflection take the specializer, otherwise take the genus.

3) The modifier is an index reference of the subject.

16. Nouns and Predicates as "Frames"

In his well known paper "A Framework for Representing Knowledge" Minsky (1975) reviews the evidence that much of human thinking proceeds through the use of stereotype situations or frames. In his conception, frames have a number of slots which are instantiated for a particular situation. If the information is lacking to instantiate a particular slot, default values are used. For example, hearing He neighed. we think of a horse. Given The father hopped 14 feet at a bound. We ask "What can be the subject of hop (or bound) which can also be a father." The word father suggests the presence of children. We know quite a bit about what can fill each slot of a predicate. This knowledge can be, and often is, unique to the predicate. This is in part what makes it so hard to get real mastery of a language.

Not all of the information in a nexus refers to the slots of the predicate. Some of it we take to modify the nexus itself. For example, we would say that in Surprisingly, John walked, surprisingly modifies the nexus John walked. Quirk and Greenbaum (1973) divide the elements in a sentence into adjuncts, conjuncts, and disjuncts. Adjuncts are closely associated with the verb, like John. Conjuncts are related thoughts, usually joined by a conjunction. Disjuncts give a comment on the main

information, like surprisingly. Clearly, it is the adjuncts which refer to the frame of a verb.

We will need a surprisingly small set of slots to hold the information conveyed by the adjuncts. Only verbs take this full range of slots and not all verbs take all slots. The parts of speech which take slots and the slots they can take are given in Figure 8.

verb	
SUBJECT	The window broke.
OBJECT	John broke the window.
DATIVE	John struck the window a heavy blow
OBJECT-COMPLEMENT	We elected John chairman.
METHOD	He did it skillfully.
MEANS	He went by car.
TOPIC	We talked about a bear.
INSTRUMENT	John broke the window with a rock.
CONSTITUENT	John baked a cake with butter
TRAJECTORY	John ran through the field.
ORIGIN	John died of cancer.
SOURCE	John ran from the house.
DESTINATION	John ran to the barn.
INTENDED-DESTINATION	John ran for the barn.
SPECIFIC-PLACE	I rode on an elephant.
CONDITION	John ran without permission.
QUANTITY	He drinks beer a lot.
preposition	
SUBJECT	Margaret is in.
OBJECT	Margaret is in trouble.
ORIGIN	Margaret is within 3 feet of Tom.
DESTINATION	Margaret is out to lunch.
TRAJECTORY	Margaret is two dollars over her budget.
SPECIFIC-PLACE	Margaret is down on cats.
adjective	
SUBJECT	Margaret is old.
OBJECT	Margaret is happy you came.
DESTINATION	Margaret is good to her puppy.
TOPIC	Margaret is wild about candy.
AGENT	Dams are built by beavers.
INSTRUMENT	Margaret is good with tools.
TRAJECTORY	Margaret is mad at her puppy.
SPECIFIC-PLACE	Margaret is crazy over him.

noun	
SOURCE	a letter from home.
DESTINATION	a letter to his mother.
INTENDED-DESTINATION	a letter for his mother.
TRAJECTORY	a path through the woods.
TOPIC	a story about a bear.
SPECIFIC-PLACE	the weather in England.
CONSTITUENT	a cake with butter.
AGENT	portrait by Picasso.

verb-preposition-adjective-noun	
PLACE	I rode in a dog sled in Alaska.
	I was in a dog sled in Alaska.
	I was happy in Alaska.
	I was a tourist in Alaska.
TIME	I rode in a dog sled last year.
	I was in a dog sled last year.
	I was happy last year.
	I was a tourist last year.
DURATION	I rode in a dog sled for two hours.
	I was in a dog sled for two hours.
	I was happy for two hours.
	I was a tourist for two hours.
FREQUENCY	I rode in a dog sled every day.
	I was in a dog sled every day.
	I was frequently happy.
	I was frequently a winner.
INTENSITY	I loved you very much.
	I was very much in love.
	I was very much afraid.
	She was very much a woman.
PURPOSE	I rode to have fun.
	I was in the game to have fun.
	I was nice to appease my wife.
	I was a peanut farmer to make money.

Figure 8
Parts of Speech and Their Slots

In old English the subject, object, and dative were marked by case inflections, but now these inflections have disappeared except for some which got trapped in pronouns.

It is currently fashionable to speak of dative shift. For example,

I sent a package to Mary.
I sent Mary a package.

apparently have equivalent meaning. By dative shift we mean that in the second to is deleted and Mary moves up to the position after sent. However, note that

I sent a package to Houston.
I sent Houston a package.

are not semantically equivalent. In the first to Houston can describe only the destination of the send, while in the second it must be the dative, usually defined as a noun affected by the action. Further examples of dative are

I made Bob a cake.
I asked Tom a question.
I played Sam a game of tennis.
I gave the house a coat of paint.
I envy you your beauty.
He called her names.
Margaret struck Max a heavy blow.
She kept me company.

Note that the last five do not really have an adequate prepositional equivalent. This leads us to view dative shift as a movement out-of rather than into the position immediately following the verb. It is, however, possible for the dative to occur in the prepositional form only.

She gave birth to a son.
It seems fine to me.

We will deal with the details of dative shift later. Here we hope only to convey a sense of how the dative slot is used.

17. Description of Slots

In his famous paper "The Case for Case", Fillmore (1967) proposes

> "The sentence in its basic structure consists of a verb and one or more noun phrases, each associated with the verb in a particular case relationship. The 'explanatory' use of this framework resides in the necessary claim that although there can be compound instances of a single case (through noun phrase conjunction), each case relationship occurs only once in a simple sentence."

Following Fillmore, we will adopt the hypothesis that each slot appears at most once in a simple sentence. We also assume that there is a small finite collection of slots in English. (The ones in Figure 8 are

probably close to the correct set.) A grammar of English must specify for each slot, what sentence elements can describe it. It seems useful to split these specifications into two parts:

a) Restrictions on what can describe a slot which are independent of what frame a slot is associated with.

b) Further restrictions or preferences placed on slots when they are used in the frame of a particular concept.

In our model all restrictions will be like those explained for the subject. The descriptor must be in a class of a concept which characterizes the slot. Since there are only a few slots, but at least tens of thousands of frames for individual concepts, the existence of restrictions which depend only on the slot is extremely important.

A sentence element can describe only one slot, but which slot it describes may be ambiguous. For example, in

The sandwich was eaten by John.

by John could describe the AGENT, or by John could be the PLACE where the sandwich was eaten. We know that John could be the AGENT because the preposition by is always used to mark the AGENT in the case frame of the SECOND-PARTICIPLE.

Fillmore's hypothesis is that if two phrases describe the same slot they must be joined by a conjunction, e.g. in the first of

The sandwich was eaten by John and the sea.
The sandwich was eaten by John by the sea.

the sea and John are both AGENT's or both PLACE's, while in the second they must necessarily be one an AGENT and one a PLACE. The requirement for conjunction provides a means of testing properties of slots and proposed new slots. If a sentence element thought to describe a new slot must be conjoined with an element describing a known slot, then the proposed slot

is in fact identical with the known one. For example, suppose we felt that a restriction on the AGENT slot was that it had to be animate. Then by the acid in

The sandwich was eaten by the acid.

would describe a slot other than AGENT while retaining the notion of consumption of the sandwich, acid not being animate. However, by adding by John to this,

The sandwich was eaten by John by the acid.

we see that the AGENT sense of by John cannot be maintained unless by John is conjoined with by the acid. Therefore by the acid describes the AGENT slot, no new slot exists, and it is false that the AGENT must be animate.

An apparent exception to the rule that only one element describes a slot occurs in the case of TIME, PLACE, and TRAJECTORY. One can say

I went on Friday at 5 o'clock in the afternoon.
The ball is on the floor under the table.
He went through the field along the fence.

Here, however, one is using a sequence of elements to describe the same segment of time, place, or trajectory. The segment is constrained to be in the intersection of the descriptions, e.g. it must be on a Friday, and also at 5 o'clock. This leaves two possibilities, but in the afternoon brings it down to one. These slots, then, are an exception only in the sense that more than one element can be used to describe a given time or space segment. If something was done at two distinct times, places, or segments of trajectory, a conjunction must still be used.

A given slot can be described by more than one part of speech. For example,

I treated her immediately.	(adverb) (TIME)
I treated her yesterday.	(noun) (TIME)
I treated her by noon.	(preposition) (TIME)
I treated her when she came in.	(clause) (TIME)
I treated her surgically.	(adverb) (MEANS)

I treated her by surgery. (preposition) (MEANS)
I treated her by surgical means. (preposition) (MEANS)

The reader can verify that the slot conjunction rule holds between different parts of speech as well as between the same parts.

Elements which describe a specific slot such as the subject may be constrained to appear only at specific locations within a given sentence type. This is a great help in resolving ambiguities as to what slot an element describes. Further, slots other than TIME, PLACE, SPECIFIC-PLACE, and TRAJECTORY are described by only one preposition. A list of the slots and the prepositions they take is given in Figure 9

DATIVE	none
OBJECT-COMPLEMENT	none
TRAJECTORY	(many preps.)
SOURCE	from
ORIGIN	of
DESTINATION	to
INTENDED-DESTINATION	for
METHOD	by
MEANS	by
INSTRUMENT	with
SPECIFIC-PLACE	(many preps.)
SUBJECT	none
AGENT	by
CONSTITUENT	with
TOPIC	about
PLACE	(many preps.)
DURATION	for
TIME	(many preps.)
PURPOSE	to
INTENSITY	none
FREQUENCY	none
QUANTITY	none

Figure 9
Slots and the prepositions they take

It is possible for a slot to be specialized, e.g. a specialization of the DESTINATION is the INTENDED-DESTINATION. The conjunction rule holds between these two but they take different prepositions.

I ran to the tree. DESTINATION
I ran for the tree. INTENDED-DESTINATION

For all slots which are flagged by only one preposition, the preposition is only an inflection indicating which slot, just as case inflections do in other languages. Use of the preposition in describing the slot is redundant and so we will drop it. For the other slots the preposition is not an inflection and many prepositions are possible. Forthese we retain the preposition in describing the slot.

18. Levels of Abstraction and the Specialization of Predicates

Rosch and Mervis (1975) argue

> "that there is a basic level of abstraction at which the concrete objects of the world are most naturally divided into categories. A working assumption has been that, in the domains of both man-made and biological objects, there occur information-rich bundles of attributes that form natural discontinuities. These bundles are both perceptual and functional. It is proposed that basic cuts are made at this level. Basic objects (for example, chair, car) are the most inclusive level of abstraction at which categories can mirror the correlational structure (Garner, 1974) of the environment and the most inclusive level at which there can be many attributes common to all or most members of the categories. The most abstract combinations of basic level objects (e.g. categories such as furniture and vehicle used in Experiments 1 and 2) are superordinates which share only a few attributes; the common attributes are rather abstract ones. Categories below the basic level are subordinates (e.g. kitchen chair, sports car). Subordinates are also bundles of predictable attributes and functions but contain little more information than the basic level object to which they are subordinate. Basic categories are, thus, the categories for which the cue validity of attributes within categories is maximized: superordinate categories have lower cue validity than basic because they have fewer common attributes within the category; subordinate categories have lower cue validity than basic because they share attributes with contrasting subordinate categories (e.g. kitchen chair shares most of its attributes with living room chair).
>
> In a converging series of experiments, it was confirmed that basic objects are the most inclusive categories in which clusters of attributes occur which subjects agree are possessed by members of the category; sets of common motor movements are made when using or interacting with objects of that type; commonalities in the shape, and thus, the overall look, of objects occur; it is possible to recognize an averaged shape of an object of that class; and it is possible to form a representation of a typical member of the class which is sufficiently concrete to aid in the detection of the object in visual noise. In addition, basic objects were shown to be the

first categorizations made by young children and basic object names the level of abstraction at which objects are first named by children and usually named by adults."

Under this hypothesis, house is a basic object. In our model, the straightforward approach would make dog house a subordinate object, a specialization of house. This is incorrect, a dog house does not have many of the most important properties of a house as the concept is learned by children and typically used by adults. For example, people don't live in a dog house. When I say my house, I almost never mean my dog house.

People are very good at recognizing similarity. This skill forms an important role in thinking and the formation of new categories. A dog house, is a house-like structure used by dogs for a purpose similar to what people use houses for. Both house and dog house are on the basic level. What we have in fact is shown in Figure 10.

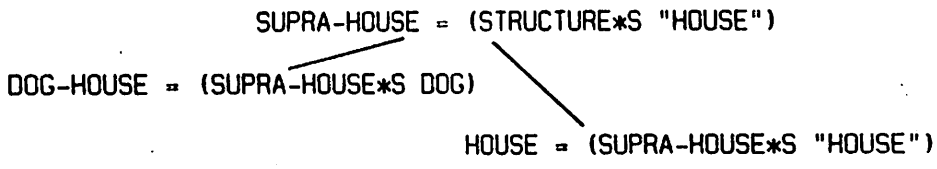


Figure 10

The basic level concept house is stripped down to a more abstract superordinate concept which retains features shared by house and the concept formed by analogy, dog house. Various types of houses, e.g. dog house, cat house, road house, and mad house, have relatively few attributes in common. Wittgenstein (1953) suggested that each item has at least one and probably several elements in common with one or more other items, but no or few elements are common to all items. An interesting example is animal. All living things are divided into plants and animals. The animals are divided into people, birds, bugs, fish, etc., and animals. The supra-level animal has almost none of the properties of birds, etc.

With these thoughts in mind, let us examine the intransitive verb run. As we will discuss at length in the section on semantics, one of the most basic notions in English appears to be the idea of instantaneous change as expressed mathematically by the first derivative; although, as pointed out by Miller (1972), no verb seems to convey this notion alone. Come and go are quite abstract, but imply direction with respect to a deixis point. We thus postulate a predicate COME-GO which means that some aspect of its subject or a part of its subject has a first derivative. RUN we take to be a specialization of COME-GO which adds to the first derivative an implication of relative speed, and the presence of some additional systematic, recurrent, or in some sense predictable behavior; thus when a machine is running, it has a systematic behavior and the positions of some of its parts have first derivatives.

A typical dictionary lists over twenty senses of intransitive run. Some of these are shown in Figure 11. The diversity of these run senses shows clearly that RUN is a supra-level concept, so abstract as to convey only the little meaning discussed above. In fact, there are no slots in a case frame which can be usefully specified at the level of RUN - RUN is just too general. The best we can do is to say that the SUBJECT must be a noun. Case frames can, however, be assigned to the base level concepts which are specializations of RUN.

```
run                                  → 1) stocking runs
    2) ideas run through the mind
    3) tongue runs on
    4) run into state
            run aground
            run into debt
            run into trouble
    5) ~ extend
            line runs East
            family line runs back
            vine runs up wall
    6) ~ flow
            sap runs
            stream runs
            tears run                → 7) face runs with tears
            8) ~ melt and flow
                    butter runs
    9) run like a machine
            engine runs
            boat runs                → 10) ~ make trips
                                             boat runs every hour
    11) run like an animal           → 12) ~ flee
                                             he ran to Mexico
                                     → 13) run in race →14) place in race
                                                            he ran third
                                     → 15) run free
                                             we let Fido run
                                     → 16) run for quick visit
                                             run over to my mother's
    17) run like a fish
            the herring are running
```

Figure 11
Dictionary Senses of Intransitive Run

The role of the specializer in these specializations of run is to separate a sense of run from others with the same genus. The senses of run in Figure 11 use the following specializers.

SUBJECT-COMPLEMENT
run aground
run into debt
run into trouble
run third

SUBJECT
stocking runs
tongue runs
line runs
family line runs
vine runs
sap runs
stream runs
tears run
butter runs
engine runs
herring run
animal run

SPECIFIC-PLACE
run in a race

SUBJECT and FREQUENCY
conveyance runs every hour

SUBJECT and DESTINATION
person runs to the store
conveyance runs to Boston

SUBJECT and TRAJECTORY
ideas run through mind

Figure 12
Specializers of Intransitive Run

It is important to remember that the specializer does not define a concept; at most it permits the inheritance of one or more properties. The main role of the specializer is to distinguish concepts with the same genus from one another. For example, the running of streams is quite different from the running of animals. Given the stream ran and the animal ran, the listener must pick the correct sense of run for each. Since these phrases differ only in the substitution of stream for animal, these words must be used to pick the correct run sense.

Usually, the specializations of a predicate will be productive. When the listener hears the milk ran, he might not have run specialized by milk in his semantic model, but he would probably have a productive specialization of run by liquid. He could use this by recognizing that milk is a liquid. Sometimes a sentence will be ambiguous because more than one specialization could apply. For example,

The stream runs to the bottom of the hill.

could be taken parallel to either

The street runs to the bottom of the hill.

or

The stream flows to the bottom of the hill.

depending on whether we recognize a stream as something which has direction and extent like a street, or as something which flows. That is, ambiguity can arise when different characterizations of stream pick different senses of run.

19. Order and Type of Verb Specializers

Verbs require some special discussion because of the number and variety of specializers they can take. Specializers of the verb may be divided into six types

a) Prefix	Replay the tape
b) Particle	Play out his option.
c) Noun phrase	Play a game.
d) Prepositional phrase	Play to his strength
e) Symbol	(COME-GO*T "RUN")
f) Object complement	Paint the barn red.

In order to select an appropriate verb specialization the listener must compare the elements of a sentence with the various specializations of that verb he has in his semantic model. Suppose his semantic model contained (PLAY*T PERSON). What should that mean? PERSON is a noun phrase, but this could mean that the subject is to be a person, or the object is to be a person, or possibly even the indirect object or object complement is to be a person. We pointed out in the last section that verb specializations correspond to restrictions on particular slots. Therefore, it is necessary to establish conventions for associating specializers of a verb with particular slots.

Prefixes, particles, and symbols are easily distinguished and

present no concern. The difficulty is to associate noun phrases and prepositional phrases used as specializers with particular slots. Part of our solution is motivated by knowledge that historically the dative was marked by inflections until it settled into a position right after the verb (Fries 1940). It became distinguished by position rather than prepositions or inflectional endings. Since our semantic model does not contain positional information this was a disadvantage to us. Therefore, we will reverse history and inflect the dative when using it as a specializer. We use the inflection EUM, which is a combination of the Old English dative singular and plural endings. Similarly, we inflect the object complement with OBJECT-CMP. Assuming further that time and place expressions which don't use prepositions, such as here, are really names for phrases like at this place, we have only the subject and object as noun groups which are not inflected.

To avoid confusion between these we stipulate that transitive verbs must be specialized by the object before they can be specialized by the subject. It is quite possible that specialization by the subject is not useful with transitive verbs.

The remaining potential ambiguity among verb specializations in semantic memory arises because a preposition can be associated with more than one slot, cp.

He went by train.	MEANS
He went by the store.	TRAJECTORY

Thus, inflection by by is not sufficient to determine a slot. This ambiguity can be eliminated by using specializations of prepositions to inflect noun groups specializing verbs in semantic memory;

```
MEANS-BY = (BY*S MEANS)
(GO*T (MEANS-BY*X TRAIN))
```

As shown in Figure 12, a verb is often specialized more than once to select a particular meaning. It is convenient to impose an order of specialization so that the search for a concept can be more systematic. Efficient use of semantic memory dictates that the concept heirarchy should be organized so that the maximum number of modifiers can be inherited. This puts a requirement on the order of specializations. Another requirement is to specialize first by sentence elements near the verb as these are more easily located by a parser. A third requirement comes from the specializations which seem to occur in English. In the absence of comprehensive data on these factors one can only speculate about the best order. We have selected: particle, prefix, object, object-complement, specific-place, subject, other.

20. Verb Frame Idioms and Slot Shift

A sentence may be viewed as an ordered string of words or groups of words. It traditionally has been. The word string is referred to as the surface structure (or spelling) of the sentence. Stripping a simple English sentence of all but the most essential adjuncts, one finds several forms of surface structure, e.g.

Subject Verb Direct-Object
Subject Verb Indirect-Object Direct-Object
Subject Verb Particle Direct-Object
Subject Verb Particle Prepositional-Phrase
Subject Verb Complement
Subject Verb Direct-Object Complement

It seems helpful to view specializations of the verb in terms of these surface categories.

Quirk and Greenbaum (1973) distinguish the following patterns of verb specialization (although they do not describe them in precisely these terms.)

1) Verb, particle, subject

The children were sitting down.
Did he catch on?
The plane has now taken off.
The prisoner finally broke down.
When will they give in.

2) Verb, particle, direct-object

We will set up a new unit.
Find out whether they are coming.
Drink up your milk quickly.
They turned on the light.
He can't live down his past.

3) Verb, prepositional phrase

They called on the man.
They looked at the picture.
He asked for the waiter.
He lived on rice.
He referred to the dictionary.

When the verb is specialized by a prepositional phrase it is not possible to move the preposition after its object. In contrast, when the verb is specialized by a particle and object the particle can occur after the object, unless the object is a pronoun, cp.

They called on the man.	They called up the man.
*They called the man on.	They called the man up.

4) Verb, particle, prepositional phrase

He puts up with a lot of teasing.
We look forward to your next party.
He stood up for his rights.
She checked up on him.
He broke in on our discussion.
He got away with it.

5) Verb, direct-object, prepositional phrase

a) The hostess showed me to the door.
He saw Mary home.
John put the car into the garage.
We kept them out of trouble.

b) Mary took advantage of him.
They made good use of the house.
He gave way to the truck.
They made allowance for his age.
They made a fuss over him.
We lost touch with him.

6) Verb, subject

My stocking ran.
The bill died in committee.
The sun rose at 5:00.

7) Verb, direct-object

We shot pool.
We shot the rapids.
We shot a gun.
We shot a rabbit.
We hit the jackpot.

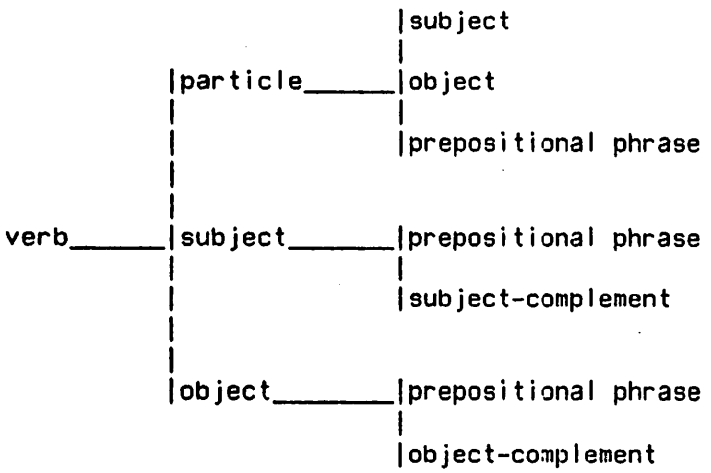
8) Verb, subject complement

He looks good.
He came a cropper.
He turned traitor.

9) Verb, direct-object, object-complement

He put his best foot forward.

In summary, we can diagram a rather complete set of possibilities:



The sentence He looked at the girl. is an example of specialization by a prepositional phrase. We know it can't involve specialization by a particle and object because the preposition cannot be interchanged with the object.

*He looked the girl at.

However, as Quirk and Greenbaum (1973) point out, the girl intuitively seems to be the object. Indeed, we have the passive construction,

The girl was looked at by everyone.

We will model this by saying that at the girl is used to select the appropriate specialization of look. For example, the listener must distinguish between

a) He looked fat.	(LOOK*X ADJECTIVE)
b) He looked at the girl.	(LOOK*T (TRAJECTORY-AT*T PHYSICAL-OBJECT))

Let us call the look in b) LOOK-AT. In addition to selecting the specialization LOOK-AT, at the girl describes the trajectory slot of LOOK-AT and simultaneously the girl describes the object slot. The frame for the semantic model of the LOOK-AT is, in part,

```
[(LOOK*T (TRAJECTORY-AT*T PHYSICAL-OBJECT))
        [TRAJECTORY: (AT*T [PHYSICAL-OBJECT:
                                [OBJECT: SHIFTED* ]])]]
```

This says that the trajectory of LOOK-AT is predicated to be at a physical-object which is characterized as the shifted object of LOOK-AT. The object of LOOK-AT is given the predicate SHIFTED* to indicate that it does not occur in the normal direct object position, but rather, within the trajectory.

The phenomenon called dative shift which we mentioned briefly in Section 16, is quite well known. Examples are:

Normal	Shifted	to Slot
Send Tom a ball.	Send a ball to Tom.	Destination
Make Tom a cake.	Make a cake for Tom.	Intended-destination

These forms can have either a dative in indirect-object position or a destination, but not both. In the case of send, however, the destination need not imply a shifted dative. As mentioned above, this may be seen by comparing

a) I sent a package to Houston.
b) I sent Houston a package.

Sentence a) has two readings. In one, Houston is the destination and the shifted dative. The meaning is close to that of b), where Houston is the

dative. The other reading of a) is the more common; Houston is only the destination. We indicate the three possibilities in the semantic model with three specializations of send.

1) Send Bob a package.
```
[((SEND*T PACKAGE)*T (EUM*X BOB))
     [DATIVE: BOB]]
```

2) Send a package to Bob.
```
[((SEND*T PACKAGE)*T (DESTINATION-TO*X BOB)
     [DESTINATION: [BOB: [DATIVE: SHIFTED*]]]]
```

3) Send a package to Houston.
```
[((SEND*T PACKAGE)*T (DESTINATION-TO*X HOUSTON))
     [DESTINATION: HOUSTON]]
```

We choose to place all three of these representations explicitly in the semantic model because dative shift does not operate very systematically and because we want, where possible, to reduce the role of the listener to one of locating concepts in memory. The fact that dative shift operates somewhat systematically would be exploited in learning these representations.

Let us turn now to the second group of verb, direct-object, prepositional phrase specializations given above in (5b). These are remarkable in that the object of the preposition may be used to form a passive, e.g.

> Bob gave way to the truck.
> The truck was given way to.

In all of these expressions the direct object, here way, is idiomatic. That is, a certain verbatim expression must be used. Slot shift gives us a simple explanation of this behavior. The object slot is shifted giving us the same passive behavior seen in LOOK-AT. The element in surface direct object position retains only its role as a specializer, it no longer describes a slot. To say this another way, some sentence elements are used only to select a specialization of the verb. Some are used both to select

a specialization of the verb and to describe a slot. Some are used only to describe a slot. The object of give-way-to being shifted, the element way in surface direct object position, which one might ordinarily expect to describe the object slot, is instead used only to select the specialization of give, e.g.

```
[((GIVE*T WAY)*T (DESTINATION-TO*X VEHICLE))
        [DESTINATION: [VEHICLE: [OBJECT: SHIFTED*]]]]
```

In some of these forms the unshifted and shifted specializations co-exist as they do with the dative. This is evidenced by the existence of both passives. For example,

Advantage was taken of Sam.
Sam was taken advantage of.

The sentence Sam takes pride in his work has an idiomatic direct-object, pride. Here, the object slot is not shifted, it has merely dropped out. The sentence has no passive. Take pride is effectively an intransitive verb, in that the direct-object pride is used only to select a specialization of pride, just as if take pride were a word for this specialization. An interesting idiomatic specialization involving both a particle and a direct-object is

The lady danced up a storm.

Katz (1973) suggested marking certain sentence elements as idiomatic in order to prohibit the formation of alternative forms such as the passive. What we have done here can be looked on as an implementation of Katz's suggestion. When an element is used as a specializer, it in general has no independent meaning. It is used only to denote a larger unit which does have meaning. It doesn't make sense to move it around as an independent unit. An unproductive specialization is idiomatic by definition.

21. Participles and Nominalizations .

The first (or present) participle occurs in the constructions:

He is running.
I found him running.

We model the first participle with the inflection [(FIRST-PARTICIPLE*X VERB.) P*)]. This inflection is productive, indicating that all verbs can form a first participle. The slot frame of a first participle is exactly the same as that of the verb which is its specializer. Remember that an inflection inherits modifiers from its specializer. Thus, we model this inheritance of slots by making the first participle of a verb an inflection of the verb, and giving the first participle no slots of its own. It then inherits all its slots from the verb.

The second, or past, participle occurs in the constructions

The window was broken by Sam.
I found the window broken.

Proceeding as for the first participle we construct [(SECOND-PARTICIPLE*X TRANSITIVE-VERB.) P*], indicating that any transitive verb has a second participle. With regard to slots, the second participle presents a difficulty not encountered with the first participle. As shown in Figure 13 the object of the specializing verb becomes the subject of the second participle and the subject of the specializing verb ends up as the object of the preposition by. This exchange is known as the passive transformation.

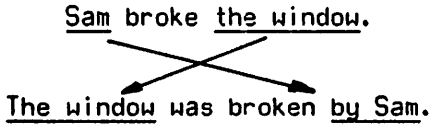


Figure 13

The notion of slot shift can be used to handle this behavior,

provided we show how it applies to inflections. Our only difficulty is in expressing shifting of slots to a concept from its specializer. The transformation must be able to refer both to the concept (to say where the slots go) and its specializer (to say where they came from). In our previous use of slot shift we referred only to the slots of a single concept, which we made the subject of a modification. If we make the concept to which slots are shifted the subject of a modification, we must be able to refer to slots of the subject, as before, and also to slots of the specializer of the subject. We have chosen to do this using what is known as a path address. We refer to the specializer of a concept C as (SPECIALIZER**A C). More precisely, to specify the slot shift known as the passive transformation we would write

```
[(SECOND-PARTICIPLE*X TRANSITIVE-VERB.) P*
     [SUBJECT: [(OBJECT*A SPECIALIZER*:) SHIFTED*]]
     [AGENT:   [(SUBJECT*A SPECIALIZER*:) SHIFTED*]]]
```

This says that the second participle of a transitive verb has a subject which is characterized as the object of the verb and an agent which is characterized as the subject of the verb. Thus in The window was broken by John, the window is simultaneously the subject of broken and the shifted object of break. By John is an agent of broken, and John is the shifted subject of break.

The passive may be formed both with the direct object and with the indirect object.

They gave the butler a reward.
A reward was given the butler.
The butler was given a reward.

To allow for either of these we must expand the passive transformation to include alternative characterizations of the subject of the second participle:

```
[(SECOND-PARTICIPLE*X TRANSITIVE-VERB.) P*
    [SUBJECT:  [(OBJECT*A SPECIALIZER*:) SHIFTED*]
```

```
                [(DATIVE*A SPECIALIZER*:) SHIFTED*]]
    [AGENT:     [(SUBJECT*A SPECIALIZER*:) SHIFTED*]]]
```

When the subject could be either the dative or the object the sentence is ambiguous. Thus

John was given an apple.
An apple was given John.

are disambiguated because an apple lies below John on the scale of animacy. We see the ambiguity in John was given Mary.

The gerund occurs in the constructions:

Her singing was unbearable
Her singing that song was untimely.
His playing of the Star Spangled Banner was thoughtful.
His killing was expected.
The killing of the deer was required.
The coughing of the crowd drowned out the speaker.
Catching fish is a lot of fun.

Let us look at some further examples from Jespersen (1933). First, the object of a gerund is very rarely put in the possessive.

They were eager after his undoing (Thackeray).

Usually the object occurs in normal direct object position.

He entered the room without greeting anybody.

However, if a "nominal" reading is indicated (by for example, the) the object is preceded by of.

On account of his deliberate buying up of stocks.
This will certainly be the making of you.

The subject of a gerund usually occurs in the possessive.

We were naturally surprised by John's asking us to dinner.

However, the subject of the gerund of an intransitive verb can be indicated by of.

On the breaking out of the war.

In summary, we have three gerunds in common use:

a) The "nominal" reading of the gerund of intransitive verbs, the subject of the verb marked by either the genitive of or the genitive, 's.

b) The normal reading of the gerund of transitive verbs, the object of the verb in direct object position.

c) The "nominal" reading of the gerund of transitive verbs, the object of the verb marked by of.

There is general agreement among linguists that higher beings typically take the 's genitive while the lower beings take the of genitive. For example, the phrases

> The mist's rising.
> The rising of Bob.

sound odd compared with

> The rising of the mist.
> Bob's rising.

This leads us to state

```
[(GERUND*X INTRANSITIVE-VERB.) P*
    [GENITIVE:
      (-'S*X [HIGHER-BEING: [(SUBJECT*A SPECIALIZER*:) SHIFTED*]])
      (OF*X [LOWER-BEING: [(SUBJECT*A SPECIALIZER*:) SHIFTED*]])
                  ]]
```

The gerund is an example of a nominalization, a noun created from a verb. Jespersen (1933) explains that nominalizations can be used to express complicated ideas in a simpler way. Compare

> The doctor's extremely quick arrival and uncommonly careful examination of the patient brought about her very speedy recovery.

with

> The doctor arrived extremely quickly and examined the patient uncommonly carefully; the result was that she recovered very speedily.

Such "action nouns" have not escaped the attention of transformational grammarians. A controversy arose over whether or not they should be transformationally derived from verb phrases. The lexicalist hypothesis of Chomsky says they should not. If the nouns are transformationally derived, the canons of transformational grammar say that

the transformation must be reversible and meaning preserving. The lexicalists say this is not possible. One must settle for entering the words in a lexicon in as uniform a way as possible. What this means in our terms is that (a) most nominalizations are not as productive as the gerund or are not productive at all, and (b) a nominalization (A*X B) does not inherit all of its modifiers from A and B but instead has some which are unique to it.

As an example of the idiosyncracies which must be modeled, a nominal can be derived either from verb or act to cause verb, e.g. reference is derived from refer, while referral is derived from act to cause refer. Similarly, continuity is derived from continue while continuation is derived from act to cause continue. This explains why we have

John amused the children with his stories.
John's amusing of the children with his stories.

but not

John's amusement of the children with his stories.

Amusement derives from intransitive amuse, as in John amuses easily, giving

John's amusement at the children's antics.

Webster's Collegiate dictionary defines blow as "a forcible stroke"; there is no corresponding verb. Following the dictionary we take blow as a specialization of stroke, which in turn is a nominalization of strike.

Lakoff (1970) points out that there is no verb aggress corresponding to aggression and aggressor. To relate the two, it is necessary to postulate a concept AGGRESS which has no corresponding word.

22. Shift to Trajectory

The path of a motion is described by three slots: SOURCE, TRAJECTORY, and DESTINATION. The SOURCE is marked by from and the DESTINATION by to.

The deer ran from the woods across the road to the stream.

Compare

He took the ball from the box.
He took the ball out of the box.
He took the ball off of the box.

The reader can verify, using the Fillmorean test, that the underlined expressions characterize the same slot. Off and out, as used above, we take to describe a trajectory, as in

He ran off.
He ran out.

If we interpret off as not on and out as not in then out of the box might be taken as not in the box and off of the box as not on the box. The phrase of the box can then be argued to simultaneously

1) describe the ORIGIN slot of out or off,
2) describe the shifted OBJECT of the underlying in or on, and
3) describe the shifted SOURCE slot of the verb.

Similarly for the destination we have

He ran to the tree. (DESTINATION)
He ran at the tree. (TRAJECTORY and shifted DESTINATION)

He put the ball into the box. (TRAJECTORY and shifted DESTINATION)
He put the ball onto the box. (TRAJECTORY and shifted DESTINATION)

23. Inflection, Affixation, Derivation, and Compounding

We have separated concepts into six types: species, stereotypes, restrictions, aspects, instances, and inflections. We have explained productive specializations, our conventions for naming and the slots of predicates and nouns. Let us now examine word formation in light of these

ideas. We will show that the processes which operate within words also operate between words.

It is traditional to distinguish four types of word formation.

1) inflection — A suffix is added to the word to show
   a) the number or genitive of nouns
      dog-dogs-dog's
   b) the tense or participle of verbs
      crack-cracks-cracked-cracking
   c) comparison or superlative of adjectives
      big-bigger-biggest
   Some words inflect irregularly.

2) conversion — Assigning a base to a different word class without changing its form, (e.g. cut, verb → cut, noun)

3) compounding — Adding one base to another (e.g. fire + man → fireman)

4) affixation
   a) Adding a prefix to the base with or without a change of word-class (e.g. author → co-author)
   b) Adding a suffix to the base, with or without a change in word-class (e.g. break → breaker)

   The distinction between affixation and inflection was made above in the extract from Zandvoort.

Since we have taken inflection as one of the six types of concepts, our representation of inflected words is quite straight forward; dogs → (-S*X DOG). It appears important, however, to distinguish between syntactic and semantic inflections. For example, hits can be either the present singular third person of the verb hit or the plural of the noun hit. The suffix -s is thus semantically ambiguous. This ambiguity is represented by making -s the name of two semantic inflections, one for the verb and one for the noun. The details of this are presented in the next section.

To see that inflection operates between words compare

I want John to run	(TO*X RUN)
I made John run.	RUN

The "bare infinitive", run, and the "to infinitive", to run, are not interchangeable. The concept (TO*X RUN) inherits properties from TO that require and allow it to appear in different environments than the concept RUN. (TO*X NON-MODAL-AUXILLIARY-VERB.) is productive; we can form the to infinitive of any non-modal-auxilliary-verb. Most of the semantics of to infinitives are obviously inherited from the verb.

A second example of word-level inflection is the copula be. For every sentence containing be, e.g.

The barn is red.

We have another without be but with the same semantic relationship between the predicate and what it is applied to.

I wanted the barn red.

Clearly, the main semantics are not carried by be. The same can be said of modal or 'meaningless' do.

I run.
I can run and I do run.

In fact, we will handle all the modals and auxilliaries as inflections.

Another example of inflection occurs in what have been called partitive expressions; cp.

I opened a can of beans.
I ate a can of beans.

One opens a can, but eats beans. This phenomenon occurs for any container and also for words implying a set, group, collection, etc. Note the distinction between.

coke bottle	(BOTTLE*S COKE)
bottle of coke	([(PORTION*T BOTTLE!)]*X COKE)

Words like kind, type, and class also form inflections.

I don't eat that kind of mushroom.
I don't fix that kind of car.

Conversion we have treated in the section on naming, but there we did not give examples involving more than one word. We have in mind:

He gave me the run around.
I need a little pick me up.
He is a show off.
I will horse whip you.

These are handled just the same as one word conversions, e.g.

[(PERSON*T (SHOW*T OFF)!)]

When one noun precedes another, four relationships are possible between them. These are illustrated by:

bull dog	(species)
lap dog	(stereotype)
woman lawyer	(restriction)
cat kicker	(slot description)

We have discussed species and stereotypes above. A concept can be restricted by any concept which is a grammatical characterization of it or a grammatical non-verbal predicate on it. For example, we can describe a ball with the predicate red by forming the nexus, a ball is red, since ball is a grammatical subject for this predicate. Alternatively, we can use the predicate, red, to identify a ball, a red ball by restricting ball with red. Used in this way a predicate refers to the referent of the concept it restricts.

Since Collie can characterize dog, the dog is a Collie, we can form the restriction, Collie dog. It is interesting to note that since every Collie is a dog, the restriction Collie dog could be replaced with Collie alone. The two are not entirely equivalent, however, because dog is a base level concept and Collie is a sub-base level concept. If a speaker wants to indicate to the listener a level of detail intermediate between dog and Collie he can use Collie dog.

In cat kicker, cat describes the object slot of kicker, which is

inherited from kick since kicker is an inflection of kick. Note that woman doctor is ambiguous because woman can either restrict doctor or describe its object slot. Snake poisen is ambiguous because snake can describe either the source or intended destination of the poisen. Slot description must be done before restriction, as can be seen by comparing, woman horse doctor, horse woman doctor and woman woman doctor. Just as with predicates, a concept can both specialize a noun and fill a slot of the resulting specialization, e.g. rum runner. When specialization occurs the two nouns are sometimes written as one, e.g. fireman, rather than two, e.g., fire plug.

In Section 14, we listed a number of adjectives which can be used attributively, but not as predicates. e.g., we have rural policeman but not the policeman is rural. Some of these were referred to as denominal adjectives because there are nouns preforming a similar function:

rural policeman	harbor policeman
oceanic studies	river studies

Clearly, these adjectives are used to form species and stereotypes and to characterize slots, just as the corresponding nouns are. The denominal adjectives can be viewed as idiomatic inflected nouns performing the same function as the corresponding uninflected ones. For example, according to Webster's Collegiate Dictionary the adjective rural comes from rur-, rus, meaning open land, and the suffix -al, meaning of, relating to, or characterized by.

The attributive adjectives total, utter, and sheer apply to stereotypes and describe the INTENSITY slot of the stereotype. Note the parallel between total stranger and cat kicker.

The attributive adjective actual applies to any characterization and describes how to interpret it, rather than giving details of the

characterization itself. For example, Webster's New World Dictionary states

> SYN. - true, actual, and real are often used interchangeably to imply correspondence with fact, but in discriminating use, true implies conformity with a standard of model (he is not a true democrat) or with what actually exists (a true story), actual stresses existence or occurrence and is, hence, strictly applied to concrete things (actual and hypothetical examples), and real implies conformity between what something is and what it seems or pretends to be (real rubber, real courage).

Thus, actual fits our criteria for inflections and we will take it as such, e.g., the actual example, (THE*X (ACTUAL*X EXAMPLE)). Main, prime, and principal will be treated similarly as inflections.

In summary, an attributive adjective can be a specializer, an inflection, or it can describe a slot.

Just as classifing nouns and attributive adjectives can be related to a noun in several ways, so a prefix can be related to its base in several ways. In Figure 14 we show prefix/base combinations classified under word pairs which are related in the same way as the prefix and base. Notable here is how prefixes function like prepositions, verbs, or adjectives. For example, compare

transalpine railway	railway across the alps
tranship the goods	ship the goods across
antechanber	point after

where prefixes are used to form words paralling, respectively, a prepositional phrase describing a slot of a noun, a particle specializing a verb, and a particle specializing a noun. Note that, in transalpine, trans- is the genus, while in transplant, trans- is the specializer.

In the case of suffixes, the suffix is always the genus. The grammatical behavior of suffixes is as described in Section 21. Participles and Nominalization. There, suffixes were used only to form nouns from verbs. They also form verbs, adjectives, and adverbs.

a) describes INTENSITY slot
like very fashionable
ultrafashionable
semi-official
superconservative
hyper-critical
b) inflection
like not happy
unhappy
non-payment
amoral
c) prepositional phrase
like in line (code)
transalpine
post-war
pre-German
interschool
extra-tropical
supernatural
anti-aircraft
ante-reformation
d) describes time slot
like former schoolteacher
ex-schoolteacher
e) inflection
like main enemy
archenemy
f) restriction on noun
like bad luck
maladjustment
autobiography
g) restriction on verb
like build again
rebuild
misread
h) specialization of verb by particle
like run over
transplant
postdate
intermarry
co-educate
antedate
counter-attack
i) specialization of noun by particle
like point after
superstructure
superstructure
subsoil
antechamber
foreward
j) verb object
like remove priviledge
unbutton
endanger
dishonor
denationalize
k) part/whole
like top of box
semi-circle
forearm
l) inflection
like to boil
aboil
m) inflection
like two man (team)
bilingual
n) names a noun
like stop gap
anti-toxin
antechoir
o) stereotype
like on to
become
bemoan

Figure 14

24. Structure of the Noun Phrase and the Finite Verb Phrase

The noun phrase and the finite verb phrase are distinguished by inflections carrying the attributes person (first, second, third) and number (singular, plural). In a nexus, the noun and verb phrase must agree in person and number.

To describe the grammatical behavior of determiners and quantifiers we need the attributes number and decomposability (count, mass, neutral). The decomposabilities are shown in Figure 15.

Decomposability:	Count	Mass	Neutral
Test:	A few ___	A little___	not count or mass
Example:	dog	water	health

Figure 15

A given noun will usually have senses of more than one decomposability, e.g.

The hen laid a few eggs.	(count)
He had a little egg on his face.	(mass)

Count nouns may be inflected with -s to indicate the plural.

Finite verb phrases carry a tense in addition to person and number. Verbs are inflected with -ed to indicate the past tense and -s to indicate the present tense third person singular. Thus, the suffix -s is used to inflect both verb and noun phrases. For count nouns it carries the attribute plural. For verbs it carries the attributes present tense third-person singular. These -s inflections differ in the number attribute. To resolve this, it seems reasonable to postulate that -s names two concepts, one used to inflect nouns, the other used to inflect verbs. Suppose we call these (PRO.*R PLURAL) and (((TENSE.*R PRESENT)*R SINGULAR)*R THIRD-PERSON) respectively. It is but one more step to postulate that every noun phrase is an inflection of a concept in the class PRO., and every finite verb phrase is an inflection of a concept in the class TENSE.

Let us turn first to the noun phrase. If we postulate a null inflection, which we will write -null, then every head noun of a noun phrase is inflected by either -s or -null. We form the correspondence

PRO. form	name
PL= (PRO.*R PLURAL)	-s
TPS= ((PRO.*R SINGULAR)*R THIRD-PERSON)	-null

With these conventions the noun phrases dog and dogs would be

(((PRO.*R SINGULAR)*R THIRD-PERSON)*X DOG), and
((PRO.*R PLURAL)*X DOG).

These forms make readily available the attributes needed to insure person-number agreement in a nexus.

It is consonant with our models thus far developed to take determiners and quantifiers as inflections. Noun phrases which are determined and/or quantified occur in quite different environments from those which are not, a typical effect of inflections. Also, the information conveyed by determiners and quantifiers tells us how to use or interpret the concept they inflect rather than adding to the description of that concept. This is also behavior typical of inflections. The grammaticality of determiners and quantifiers is given by productive specializations of the form:

```
[(A*X (TPS*X COUNT-NOUN.)) P*]
[(A*X FEW) P*]
[(FEW*X (TPS*X COUNT-NOUN.)) P*]
```

where TPS is the PRO. defined above. Note that determiners and quantifiers do not control such attributes as person-number, as can be seen from the following

Some water is
Some dogs are
Some of the water is
Some of the dogs are
The water is
The dogs are.

The genitive case further inflects a determined or quantified expression.

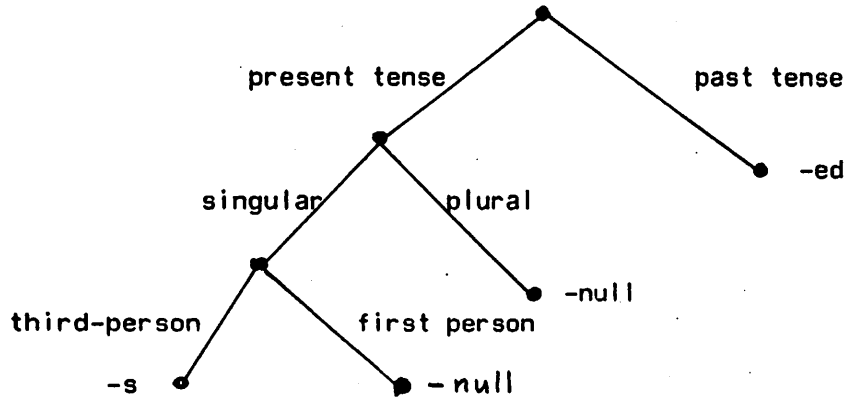
```
[(S-GENITIVE*X DETERMINER.) P*]
[(S-GENITIVE*X QUANTIFIER.) P*]
[(S-GENITIVE*X PRO.) P*]
```

With these conventions pronouns can be formed as follows:

```
[(NAME*A (NOMINATIVE*X (((PRO.*R SINGULAR)*R
    FIRST-PERSON)*X NOUN.))) (SYMBOL "I")]
[(NAME*A (ACCUSATIVE*X (((PRO.*R SINGULAR)*R
    FIRST-PERSON)*X NOUN.))) (SYMBOL "ME")]
```

```
[(NAME*A (S-GENITIVE*X (((PRO.*R SINGULAR)*R
    FIRST-PERSON)*X NOUN.))) (SYMBOL "MY")]
```

Figure 16 shows the inflection of verbs sorted by tense, number, and person.



TENSE form	name
(TENSE.*R PAST)	-ed
((TENSE.*R PRESENT)*R PLURAL)	-null
(((TENSE.*R PRESENT)*R SINGULAR)*R THIRD-PERSON)	-s
(((TENSE.*R PRESENT)*R SINGULAR)*R FIRST-PERSON)	-null

Figure 16

Note that -NULL names two forms. The choice between the two is determined by subject/predicate agreement. This makes it important for a parser to have the subject on hand when -NULL is replaced by what it names.

Chomsky (1972) has proposed that the noun phrase and the verb phrase have a similar structure. In our formulation this is only partially realized. Figure 17 shows the principal parts of each in our model.

noun phrase	verb phrase
stored pattern	stored pattern
slot descriptions	slot descriptions
restrictions	auxilliary
inflections	modal
PRO.	TENSE.
quantifier	
determiner	
case	

Figure 17

25. The Subject and Object Complements

The problems addressed in this section are put in perspective by the following discussion from Zandvoort (1966).

"581. In some sentences, such as The dogs barked furiously, My sister married young, They saw a light, it seems as if we have not two nuclei, but three. In the first example, however, furiously merely adds something to the idea expressed by barked; it may, therefore, be considered as part of the second nucleus. But this is not the case with the other two: young is just as essential as married, a light equally important as saw.

Here are a few more examples of the second type of sentence; the third will be dealt with in 584.

a. The party arrived safe and sound.
   The idea sounds all right.
b. We parted the best of friends.
   He left home a beggar; he came back a millionaire.

It will be seen that, whereas furiously in the above example only refers to barked, the adjectives and nouns in a. and b. refer to the subject of the sentence as well as to the verbal predicate. (Note the alternative construction illustrated by All our aircraft returned safely.) They are called respectively predicate adjectives and predicate nouns.

582. The verb in the second sentence of 581a. is to be pronounced with fairly strong stress (suggesting: but still I have my doubts). The sentence may also be pronounced on a less skeptical tone, in which case the emphasis shifts to the predicate adjective, and we see the three nucleus type of sentence shifting to the commoner two nucleus type, with the predicate noun or adjective as the principal part of the second nucleus. This intermediate type is found especially after verbs like to seem, to become, to get (= to become), to keep (= to remain), to feel, to lie, etc.

The situation seemed hopeless.
It is getting dark (578).
She kept very quiet.
The snow lay thick upon the ground.
Old Jolyon sat alone.
Do you feel tired.

Note the same construction with a number of verbs of movement, whose meaning in combination with certain predicative adjectives and nouns is weakened to that of to become:

The dog went mad.
His brother fell ill.
All my misgivings came true.
Our provisions ran short.

Morris turned socialist (cf. 351).

583. The return to the two-nucleus type (with the verbal part of the predicate comparatively insignificant, apart from the expression of person, number, tense and mood) is practically complete when the verb is the copula to be, which merely serves as a link between the subject and the nominal part of the predicate. Besides nouns and adjectives, the latter may also consist of an adverb, a pronoun, a numeral, or a noun preceded by a preposition, so long as these express a quality or condition of the subject.

Are you tired?
His brother was a sailor.
These books are mine.
Is Mr. Smith in? (or at home?) (cf. 597)
So be it.
I shall be fifty next Sunday.

The limit to which English can go is shown by such a sentence as He a gentleman! - in which the predicate-nucleus is purely nominal, a type which occurs especially in indignant exclamations and in exclamatory questions (His father dead?) uttered in response to a preceding sentence with a finite verb (Do you know that his father is dead.)

The transitions discussed in 581, 582, and 583 may be summed up by the following examples: He awoke very tired - He felt very tired - He was very tired - He tired!"

Besides these constructions involving predicate nouns and predicate adjectives we have two other related types. First are those taking infinitives which refer to the subject.

The puppy seems to be hungry.
I want to leave.
I promise you to leave.

Second, we have adverbial phrases and clauses which refer to the subject.

Melvin struck me as honest.
He showed up at work drinking.
He showed up at work with a tie on.

Grammarians are not yet in agreement on the structures underlying these various forms. Our presentation has been influenced most strongly by

Chomsky (1972, 1973, to appear), although we do not attempt to follow his treatment exactly. Discussing John felt sad, Chomsky suggests that one has a choice of specifying feel as an item that can appear before the predicate sad in what he calls the deep structure, or one can assume that John felt sad is transformationally derived from something like John felt he was sad. Chomsky himself prefers the first option since to feel sad is not necessarily to feel that one is sad or to feel oneself to be sad. The distinction is sharper between the progressives

John is feeling sad.
?John is feeling that he is sad.
?John is feeling himself to be sad.

Recall now our discussion of inflections. An inflection (A*X B) inherits modifiers from both A and B, but it also has certain properties of its own. We have used inflections to model plural and tense markers, partitives like flock of sheep and can of beans, and participles and nominalizations.

We have also taken the copula, be, and the use of to in the to-infinitive to be inflections.

If we now also treat modals as inflections, we will have

I run.	RUN
I do run.	(MODAL-DO*X RUN)
I can run.	(CAN*X RUN)
I ought to run.	(OUGHT*X (TO*X RUN))

For Zandvoort's progression, parallel to the above we have:

John sad!	SAD
John is sad.	(BE*X SAD)
John feels sad.	(FEEL*X SAD)
John awoke sad.	(AWAKE*X SAD)
John seems to be sad.	(SEEM*X (TO*X (BE*X SAD)))

This is our realization of Chomsky's first alternative above.

One might suppose that John seems to be sad should be modeled according to Chomsky's second alternative, a transform of John seems John

to be sad. However, since according to our theory to and be are inflective in to be sad, to be sad can replace sad in seems sad yielding seems to be sad with only a small change in meaning.

Regarding want and promise, however, the second alternative seems more desirable. We have the parallels

I want Bob to leave.
I want to leave.

I promise you I will leave.
I promise you to leave.

Both want and promise take a nexus as object. You is the indirect object of promise. In the forms

I want to leave.
I promise you to leave.

we take the subject of to leave to be shifted to describe the subject of want or promise. There is a choice of whether to make an infinitive, e.g. to leave, or a nexus, e.g. I to leave, the object of want or promise. We have chosen the infinitive. In summary,

```
[(WANT*T (TO*X VERB.))
     [OBJECT: (TO*X VERB.)]
     [SUBJECT: [HIGHER-BEING: (SUBJECT*A OBJECT:)]]]
```

For sentences with adverbial phrases:

Melvin struck me as honest.
He showed up at work drinking.
He showed up at work with a tie on.

we take the adverbial phrase to describe the CONDITION slot. The subject is shifted, just as the subject of the object of want is shifted, to the subject of the main clause.

Some verbs specify a current predicate, whereas others express a resulting predicate. Predicates may apply to either the subject or the object. Examples of the four possibilities are:

a) current predicate on subject
   He felt tired.
   He awoke very tired.
   He showed up at work very tired.
   He showed up at work with a tie on.
   He left town a poor man.
   Melvin struck me as honest.

b) resulting predicate on subject
   The dog went mad
   His brother fell ill.
   All my misgivings came true.
   Our provisions ran short.
   Morris turned socialist.
   He became President.
   He got into trouble.
   I started to go.

c) current predicate on object
   I consider John a good fellow.

d) resulting predicate on object
   We elected John chairman.
   I forced John to go.
   We painted the barn red.
   I put the ball in the box.

The treatment of the object complement is similar to that of the subject complement.

As was pointed out by Jackendoff (1974), the grammaticality of a complement is controlled both by the verb and by the subject or object it applies to. For example, consider the sentences

*I put a knife red.
 I put a knife in the drawer.
 I put a knife in the door.
 I put a hole in the drawer.

Put requires the object complement to describe a place. Furthermore, there must be a sense in which the object can be at this place or going to this place. The interpretation of a complement requires the combination of two sources of knowledge; the description of the verb and what is known about how the the given object relates to the given complement. For example, in a sentence like I put a hole in the drawer, one may think first of the verb

frame put with the hand, realize this won't work on holes, then relate the object to the complement by asking how a hole can come to be in a drawer, and finally take the sentence to be a statement of achieved goal, carried out perhaps with a brace and bit.

In I consider Bob qualified, one can argue that what you consider is not Bob, but the nexus, Bob qualified. That is, the tightest binding is between the object and object-complement rather than between the verb and object. Jespersen (1933) makes a good case for this in

> "29.1.2 The object of a verb is often a nexus expressed by a simple collocation of a primary and its adnex. As a first example we may take "I found the cage empty" which is easily distinguished from "I found the empty cage" in which empty is an adjunct. In the former sentence the whole combination the cage empty is naturally the object (cf. "I found that the cage was empty" and "I found the cage to be empty"). This is particularly clear in sentences like "I found her gone." (thus did not find her!). Further examples:
>
> I saw my face reflected in the mirror.
> I heard it spoken of in the club.
> We think this a great shame.
> They held the Government responsible for all the outrages.
> They called (baptized) him James.
> Will you keep me informed about the affair?"

In cases like these the grammarian must decide whether to make the nexus the object of the verb or to use an object object-complement construction. Postal (1974) has written an entire book on considerations surrounding this issue. He would claim for example that I allowed Bob to leave is ambiguous depending on whether or not permission is understood to have been given directly to Bob. The ambiguity is expressed in the choice of taking Bob to leave as the object, or taking Bob as the object (thus acted on by allow) and to leave as an object complement. The complement interpretation is stronger with make, e.g.

I made Sylvia kiss John.
?I made John be kissed by Sylvia.

For a verb like persuade, in

I persuaded Bob to examine Gladys.

it is suggested that the underlying semantics have the force of

I caused Bob to agree to examine Gladys.

thus permitting the semantics of persuade to be formed from those of cause and agree by complement construction.

Postal also contrasts

I found Julius Caesar boring.
I found that Julius Caesar was boring.

Clearly the first sentence carries a stronger implication that the speaker knew Caesar personally.

Our solution to this situation is to allow verbs to take a nexus either as object or as object-complement with the subject of the nexus shifted to characterize the object of the verb.

26. Quantities, Quantifiers, and Determiners

Vendler (1967) has made some good observations about quantifiers. He quotes Quine as saying

> "Quantification cuts across the venacular use of 'all', 'every', 'any', and also 'some', 'a certain', etc.... in such a fashion as to clear away the baffling tangle of ambiguities and obscurities. ...The device of quantification subjects this level of discourse, for the first time, to a clear and general algorithm."

Vendler goes on to say

> "As the same text shows in detail, some ambiguities and obscurities are indeed cleared away by the technical devices at our disposal. Elated by this success one is naturally inclined to force all sentences in which these particles occur into the strait jacket prescribed by the theory of quantification, surpressing thereby, I fear, other aspects, among them logically important ones, that enter into the common understanding of these words."

We would agree with Vendler on this point. Further, it has been our practical experience that expressions involving mathematical quantification operators are difficult to manipulate symbolically and are thus hard to use

in operations like reasoning by analogy which arise in natural language understanding. We reject, in fact, the notion that objects in the world always admit of a precise description and that only English introduces vagueness. One must be very careful about setting unduly hard problems for a linguistic theory by forcing artificial precision. Therefore, we will use the quantification concepts occurring in English.

A typical use of mathematical quantification operators is the resolution of ambiguous sentences such as

Every boy in town is wild about some girl on our block.

which can mean either

(For some X such that X is a girl on our block it is true that (for all y such that y is a boy in town, y is wild about X))

or

(For all y such that y is a boy in town it is true that (for some X such that X is a girl in town, y is wild about X))

Using formal quantification the ambiguity is resolved by including exactly one of the quantifiers in the scope of the other. However, it is precisely this explicit scoping that is so difficult to deal with during pattern matching.

Although our formalism admits explit scoping through a variant of lambda abstraction described below, we postulate that this does not occur in the semantic models of sentences such as the above. We postulate that the rules for the semantic interpretation of English quantifiers specify how referents for the quantified expression shall be picked. Further, the subject/predicate form of a nexus affects meaning as is shown by the difference in meaning of

Many men read few books.
Few books are read by many men.

A referent is picked for the subject and then the predicate is applied to it. However, when a quantifier which specifies a set such as each, every, or all is used the rules of interpretation do not tell us how the picking of different referents from this set is related to the picking of referents for other expressions in the sentence. This makes the semantic model of sentences like

Every boy in town is wild about some girl on our block.

truly ambiguous. If the speaker intended to be unambiguous he went wrong by picking the phrase some girl. He should have been more precise. He could have said, Mary Jones, this one girl, or one girl or another. Precision of description is the alternative to explicit scoping for the resolution of such ambiguities.

There are three classes of concepts used in specifying quantities; quantities, quantifiers, and determiners. Examples of the first class are flock, herd, set, crowd, pool, pail, and spoon. These are nouns and normally do not stand at the beginning of a noun group in a surface sentence. When one adds two spoons of sugar to a batter, only the sugar goes in. From this we see that this meaning of spoon is a species of quantity named by the physical object spoon, i.e. spoon of sugar is

([(QUANTITY*S SPOON!)]*X SUGAR)

Examples of quantifiers are all, none, one, each, 5, several, more, and most. These are stereotypes used to inflect a noun group. Each quantifier also names a corresponding pronoun. To see that quantifiers are stereotypes compare:

Sam is the father of the boys.
Sam is one of the boys.

Sam is being characterized as a father or as one of a group.

Determiners are such concepts as no, a, the, my, and every. These

can inflect a noun group, but do not name corresponding pronouns. Many pronouns such as this, that, these, those, we, and you also name determiners.

A speaker selects a quantifier or determiner not only to indicate a quantity to a hearer, but also to advise him in determining what instance (if any) the noun group fronted by the quantifier or determiner may refer to. In this regard he may indicate whether something is given or new and whether or not it is specific. As Halliday (1967) says

> "The terms 'given' and 'new' are to be interpreted, not as 'previously mentioned' and 'not previously mentioned', but as 'assigned' or 'not assigned', by the status of being derivable from the preceding discourse."

For example, when I say

> I went into the restaurant and the waitress asked me what I wanted.

I use "the waitress" to indicate that it is the one in the role the hearer expects in that environment. Determiners like the which make this indication we will give the property definite.

In a similar way, the property specific indicates that the speaker advises the hearer to refer the noun group to an instance. In this regard note that the Wizard of Oz is an instance of a story character, though not of a living being.

The difference between "Do you want any flowers," and "Do you want some flowers," shows us that some is specific and any is not specific. A is not marked either way. If I say "Take any two apples from the basket," you know you are completely free to select which two. Once you pick, however, the two are known and it would be unnatural to answer "I took any two."

In the phrases some man and any man, some and any definitely do not

have a partitive sense. However the specific/non-specific distinction made above still holds. We will take some and any modifying the singular to be determiners which are derived from the some and any which are quantifiers.

There has been a good deal of uncertainty about the relationship between some man, some men, and some of the men. There is the question of whether some should be the head of the phrase. Jespersen (1937) says

> "Further, if we write a dozen bottles like twelve bottles, is it not a little strange to treat dozens of bottles in another way? After a good deal of hesitation, I have finally adopted the plan of everywhere taking the quantifier as secondary and the quantified as primary, no matter how expressed...
>
> Sweet says 'The nucleus of the group a piece of bread is bread, for piece, although grammatically the head word of the group is really little more than a form word."

Grammatically, we note that some, dozens, twelve, and piece can stand alone as stereotyping pronouns, so that suppressing them as suggested by Jespersen and Sweet is unattractive. The expression some men can be accented as some men, corresponding to the pronoun use in some, or some men corresponding to the determiner use in some man. In written form it is ambiguous. Since the quantifier meaning subsumes the determiner meaning, we will choose this to represent the ambiguous written form.

Each, every, and all deal with sets. We follow Vendler in his distinctions between them. Briefly, all suggests a collective sense but does not suggest a specific set as do each and every. Each and every suggest a distributed sense, with each suggesting one-by-one. Compare

> The number of all those blocks is 17.
> The number of each of those blocks is 17.
>
> All of the members rose when the president entered.
> Each of the members rose when the president entered.

Even though every suggests a distributed sense, it sets up a collective referent.

> I gave every boy a cookie.
> *He thanked me.

They thanked me.

27. The Simple Sentence

There is a tendency to equate sentence with nexus, but this is wrong. Zandvoort (1966) explains the accepted notion of a sentence:

> "An oral or written communication is made up of one or more units, each of which contains a complete utterance formed according to a definite pattern. Such units are called SENTENCES"
>
> "A sentence may consist of one or more words. Examples of one-word sentences are such exclamations as Thanks! - Brother! - Good! - What! (445) - Fire! - Rain!; imperatives such as Stop! - Look! (cf. a closely similar use of adjectives and adverbs like Quick! or Quickly! - Steadly!); and vocatives such as Mother! - Jack!...
>
> Other, non-exclamatory (or not necessarily exclamatory) examples are Yes. - No. - True (as a formula of concession). - Perhaps. - Certainly. - Impossible. - Tired? - Hungry? - Rain? - What? (= What did you say?)."
>
> Most sentences of more than one word consist of two nuclei, one indicating the person or thing about whom or which a statement is made (or a question asked), the other containing the statement or the question asked.
>
> The word (or words) indicating the person or thing referred to is (are) called the SUBJECT of the sentence; that (those) containing the statement (or the question) the PREDICATE."

In the following sentences the subject is underlined.

Nothing doing.
He a gentleman!
I see.
You don't say so.
Twenty people were killed.
The dogs barked furiously.
My sister married young.
John and Mary have gone.
After some time they saw a light.
There was no wind.
To advance was difficult, to retreat impossible.
Who saw the victim last?
Where is the station?
Has she been ill?
Does your brother play tennis?
Will waiting do him any good?

28. Use of Information in a Sentence

In the sentence The oldest dress is blue we break the words down into those used to identify, the oldest dress, and those used to describe, is blue. Here we would naturally equate the description is blue with new information given to the listener by the speaker. In general, however, one cannot equate new information with the description. This is made obvious by one word sentences like Thanks! The word Thanks is used to locate the concept THANKS in the listener's memory. This concept is not further specialized, modified, or described in any way. The new information for the listener is that this concept has been designated by the speaker at this particular moment. A speaker can emphasize certain words in a sentence to indicate which part of a sentence is to be interpreted as new information.

John ran to the store.
John ran to the store.
John ran to the store
John ran to the store.

With this in mind let us redraw Figure 3 as Figure 18.

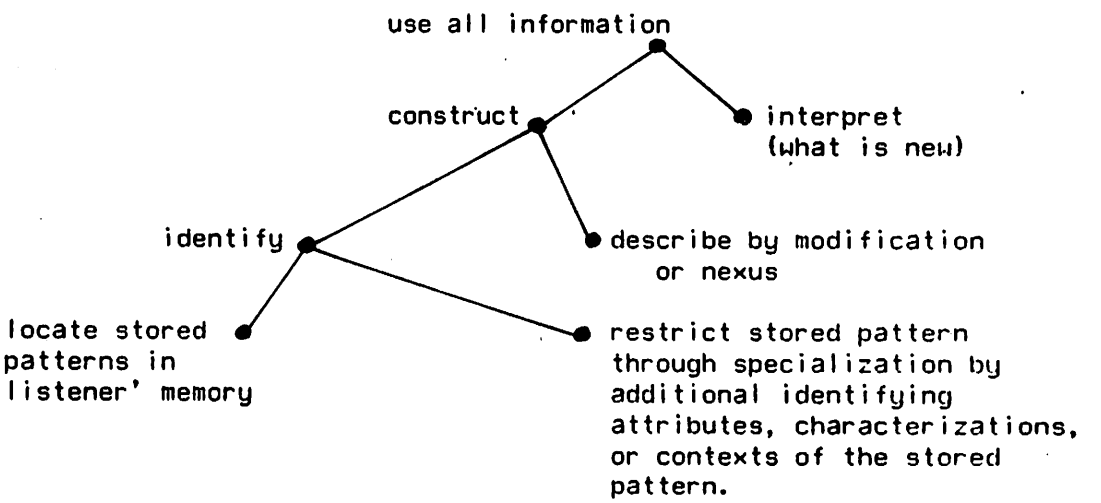


Figure 18

The Zandvoort examples show that a sentence can take a number of

different forms. As we develop more rules of grammar the reader will be able to see in detail how the steps in Figure 18 are carried out for each of these forms. At this point it is important to distinguish these distinct steps in order to understand our approach. For example, we will treat the sentence

How are you?

in the same way we have dealt with fire plug. The entire sentence can be used to locate an already existing concept in the listener's memory. No restriction or description is done. When the listener interprets this concept he sees that he knows it as a greeting which in most contexts does not call for a detailed answer of how he feels.

Such a sentence would commonly be called idiomatic. Our contention is that if idiomatic is taken to mean already stored in memory with special knowledge attached to it, then idiomatic phrases are more prevalent than is generally thought. If idiomatic means already stored in memory, then perhaps the bulk of commonly used phrases are idiomatic.

29. Lambda Binding and Lambda Abstraction

Church's lambda notation is widely used to construct predicates and functions out of combinations or variations of other predicates and functions. In McCarthy's (1960) adaptation of this notation, the notation (LAMBDA (X Y)(EQUAL (HEIGHT X) Y)) would mean the predicate of the two arguments X and Y which is true only when the HEIGHT of X is EQUAL to Y, HEIGHT and EQUAL being previously defined.

Suppose we are given any nexus such as elephants love peanuts. We can create a predicate of one argument from this using the lambda notation, e.g. (LAMBDA (X) elephants love X), which is a predicate of one argument, X, true only when elephants love X. Any concept in the nexus could be selected for replacement by a variable. We could have

(LAMBDA (X) X love peanuts)
(LAMBDA (X) elephants X peanuts)
(LAMBDA (X) elephants love X).

This process of variablization and lambda binding is known as lambda abstraction. Something like lambda abstraction appears to be a fundamental grammatical process. We take this process to underlie the so-called wh-movement that occurs in direct questions, indirect questions, and relative clauses. Examples of these three forms are (Baker 1970):

What did Albert buy?	(direct question)
Alice didn't know what Albert bought.	(indirect question)
Alice didn't wash what Albert bought.	(relative clause)

The distinction between the last two is seen in the two readings of

I know what he knows.

In the indirect question reading this means "If he knows X, then I know he knows X." In the relative reading it means "If he knows X then I know X."

Baker points out that these forms behave differently in other ways

Alice didn't know what was given to whom.
*Alice didn't wash what was given to whom.

Alice didn't know what else Albert bought.
*Alice didn't wash what else Albert bought.

Alice didn't know what it was that Albert bought.
*Alice didn't wash what it was that Albert bought.

Let us informally apply lambda abstraction to each of the three wh-forms.

What did Albert buy.
What Y such that (LAMBDA (X) Albert bought X) is true of Y.

Alice didn't know what Albert bought.
Alice didn't know what Y such that
(LAMBDA (X) Albert bought X) is true of Y.

Alice didn't wash what Albert bought.
Alice didn't wash Y such that
(LAMBDA (X) Albert bought X) is true of Y.

In our terms, in each case something is characterized as being the

object in the nexus Albert bought X. Wh-movement is similar to slot shift. It differs in that wh-movement always moves something out of a nexus and can come up through any number of embedded nexuses, e.g.

I know the girl Mary told Sam to keep Bob playing with.

Also, wh-movement does not add a characterization to an existing slot, rather, it creates a characterization which can be used in place of a noun.

Lambda notation is used in the programming language LISP. A form such as (MOTHER (FATHER X)) is lambda bound to create a function (LAMBDA (X) (MOTHER (FATHER X))). The lambda binding determines the scope of the bound variable, X.

In this conception, a variable is meaningful only within the expression defined by the scope of its associated lambda. The lambda notation indicates the expression with respect to which a variable is meaningful.

Instead of using the lambda notation we will indicate the expression for which a variable is defined by making the variable an aspect of the expression. In our view, there is no structural difference between a variable and other aspects. Calling an aspect a variable means only that it is to be used for the traditional purposes of variables. By merely treating any aspect as a variable we achieve the effect of lambda abstraction.

30. Sentence Generation

Over the past two decades much insight into sentence structure has been gained by investigating algorithms which would in theory generate all syntactically correct sentences and no others. The pioneer and leader in this work is Noam Chomsky.

Chomsky's generation algorithms have been based on a three phase process:

a) Generation of basic sentence structures by a context free grammar.

b) Lexical insertion; replacement of abstract symbols in the basic sentence structures with words.

c) String transformation operations on the base sentence structures, e.g., the passive transformation.

A sentence matching the pattern of a string transformation may be rewritten as specified by that transformation. Transformations interchange, add, and delete string segments. The transformations are ordered and the order of the transformations affects what sentences are generated. All the transformations are tested against a subordinate clause before any of them are tested against the clause containing it. Some transformations apply only to the top level clause.

The ordered list of transformations given in Akmajian and Heny (1975), an elementary book on transformational grammar, is given below.

1. Dative Movement (Optional)
2. Equi NP Deletion (Equi) (Obligatory)
3. Raising to Object (Obligatory)
4. Raising to Subject (Obligatory)
5. For Deletion (Obligatory)
6. Passive (Optional)
7. Agent Deletion (Optional)
8. Reflexivization (Obligatory)
9. Extraposition (Optional)
10. It Deletion (Obligatory)
11. Number Agreement (Obligatory)
12. There Insertion (Optional)
13. Tag Formation (Optional) (LC)
14. Negative Placement (Obligatory)
15. Contraction (Optional)
16. Subject-Auxilliary Inversion (Obligatory) (LC)
17. WH Fronting (Obligatory)
18. Affix Hopping (Obligatory)
19. Do Support (Obligatory)

Many other transformations as well as alternative formulations of these have been proposed. Nevertheless, the phenomena dealt with by these nineteen transformations will provide sufficient basis for an overview of our approach to sentence generation.

While some of the transformations are mutually independent, others work in concert. Descriptions of the transformations follow, those that combine to produce an effect are described together.

Dative Movement

This moves prepositional objects into indirect object position.

The following three transformational pairs are used to generate subject and object complements.

Raising to Subject, For Deletion

It for John to be at the party seems.

becomes by raising to subject

John seems for to be at the party.

which becomes by for deletion

John seems to be at the party.

Raising to Object, For Deletion

John believes it for Bill to be a criminal.

becomes by raising to object

John believes Bill for to be a criminal.

becomes by for deletion

John believes Bill to be a criminal.

Equi NP Deletion, For Deletion

I prefer for I to go.

becomes by equi NP deletion

I prefer for to go.

becomes by for deletion

I prefer to go.

I force you you to go.

becomes by equi NP deletion

I force you to go.

Passive, Agent deletion

Passive moves the direct or indirect object into subject position and the old subject after by. Optionally, Agent deletion deletes the by phrase.

Reflexivization

This replaces repetitions of the subject which occur in the predicate adjuncts by a pronoun involving self.

John cut John

becomes

John cut himself

The constraints on this process are not fully understood.

Extraposition, It Deletion

It that you are here is good.

becomes by it deletion

That you are here is good.

or becomes by extraposition

It is good that you are here.

Number Agreement

This copies the person-number from the subject to the verb.

There Insertion

A cookie is in the box.

becomes by there insertion

There is a cookie in the box.

Tag Formation, Negative Placement

Used to generate tag questions of the form

You are good, are you not.
You are not good, are you.
You are good, aren't you.

Contraction

Contracts not into n't

Subject-Auxilliary Inversion

You did go?

becomes by subject-auxilliary inversion

Did you go?

WH Fronting

This we described in the section on lambda abstraction.

Affix Hopping

This is used to specify what verb forms the auxilliaries may be followed by.

I have -en be -ing go.

becomes

I have be -en go -ing.

Do Support

I ran?

becomes by subject auxilliary inversion

-ed I run?

becomes by do support

Did I run?

We have given a very sketchy description of these rules. For a full discussion the reader is referred to Akmajien and Heny.

In place of these rules we propose the following series of ordered steps:

1. Nexus Formation
2. Reflexivization
3. Conjunction
4. Extraposition
5. Wh- fronting
6. Sentence Pronominalization (LC)
7. Minor-movement (LC)

A single step may correspond to several rules but is internally consistent

with respect to the type of computations required. The steps, then, would be logical program modules.

Let us discuss each step in turn.

Nexus Formation

A nexus A/B is grammatical if A is a grammatical subject of B or B is a grammatical characterization of A. In addition, if the nexus (D*A C)/B is grammatical and if D can be inferred from C and B, then the nexus C/B is grammatical. For example,

The price of that watch is ten dollars.

makes grammatical

That watch is ten dollars.

During nexus formation the phenomena described by Dative Movement, Raising to Subject, Raising to Object, For Deletion, Equi NP Deletion, Passive, and Agent Deletion occur. We anticipate that a fact would be explicitly represented in the semantic model by a nexus. Inflection by TENSE., PRO., and determiners as well as modification by disjuncts such as surprisingly is done only when a nexus is to be turned into a sentence.

We have an instance of the passive whenever the second participle is chosen as the predicate of a nexus. Since the nexus is formed directly in the passive there is no issue of agent deletion.

Dative movement is determined by the selection of slot characterizations when forming the predicate. The same is true of raising to object.

Raising to subject does not exist in our formulation using inflections.

Reflexivization

This operation is similar to the standard transformational formulation. We know that this must come before conjunction because one cannot combine

I gave John a present.
John gave John a present.

to form

John and I gave John a present.

Lees and Klima (1963) point out that

They found a smokescreen around them.
They threw a smokescreen around themselves.

differ in that found takes a nexus as object (and thus them does not refer to the subject of the nexus containing it) whereas threw takes a standard object.

Apparently reflexives involving the dative such as

He showed the girls pictures of themselves.
He showed the girls pictures of himself.
He gave Mary a car to drive herself around in.

are not well understood.

Conjunction

Two nexuses can be combined into one. Simple cases are clear, but this phenomena is not completely understood. Of course, conjunction of concepts is also possible during nexus generation or concept formation.

Extraposition

The first two steps (nexus formation and reflexivization) do not involve the notion of left and right. The last five steps, conjunction, extraposition, WH-fronting, sentence pronominalization, and minor movement, do involve this notion. Their purpose is apparently to exploit time sequential processing of the sentence by

the listener so as to convey emphasis and to reduce the listener's processing load.

Our version of extraposition accounts for Extraposition, It Deletion, and There Insertion.

We insert it when the extraposed item is moved but otherwise endorse the standard extraposition transformation. There insertion we view as one of several processes which move an adjunct to the front of a sentence.

There is a cookie in the box.
There comes a time to quit.
Well do I remember the day.
Out they rushed.
Many a time has he given me good advice.
Many a rabbit had he snared, without the game-keeper noticing it.
Dates I could never remember.

WH- Fronting

This is described in the section on lambda abstraction. There we indicated that a sentence like

What animals did he bite?

is formed by WH-fronting the object of bite. That is, the concept which describes the object of the nexus he did bite what animals is made an aspect with genus what animals and specializer the nexus. The nexus is treated as subordinate so that the sentence consists of the phrase what animals qualified by the nexus of which it is an aspect. This is to be contrasted with the sentence

He bit what animals?

in which the nexus is a main clause.

Sentence Pronominalization

Some pronouns refer to elements in other sentences. These can be inserted during nexus formation. The rule for insertion of

pronouns at this step has been discussed by Langacker (1969). He suggests that A may be used to pronominalize P unless (1) P precedes A; and (2) either (a) the nexus immediately containing P also contains A; or (b) A and P are elements of separate conjoined structures. This rule allows

The woman who will marry him will visit Ralph tomorrow.
The woman who will marry Ralph will visit him tomorrow.

while disallowing

*He is much more intelligent than Ralph looks.

Minor Movement

Here we include Tag Formation, Contraction, Subject-Auxilliary Inversion, and Do Support. Examples of minor movement are

Bob picked up John.
Bob picked John up.

What dog he could have?
What dog could he have?

We have enough of that paint we used last year to finish.
We have enough to finish of that paint we used last year.

31. Final Remarks

The constructs specialization, modification, nexus, naming, productivity, and slot shift are really quite simple and can be quickly defined. However, the worth of any such constructs lies in their explanatory power and the leverage they give in thinking about difficult linguistic problems. We have attempted to provide sufficient scope and depth so that the reader can appreciate the power of our theory. Because of the resulting length of our presentation, we have omitted discussion of the many interesting alternative formulations we tried along the way. We can't then, hope to convince the reader that there aren't equally good alternative choices for notation, etc. We do hope, however, that he is convinced that our formulation is superior to those previously proposed.

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