Figure 7-2 Parse of "face-2.7a - to turn the face or body in a specified direction" using grammar of figure 7-1.
Figure 7-3 Parse of "loft-.0a - to strike or throw a ball so that it rises high in the air" based upon grammar of Figure 7-1.
7.2 Morphological Parsing to Verb Normal Form (VNF)

abatis - a defensive barrier of felled trees with sharpened branches turned outward.

This definition is an excellent example of how much information can be contained within one noun phrase. To completely represent the content of this definition it is necessary to do more than simply "parse" it. One must undo the morphological transformations as well. A parsing of this phrase into semantic relations might resemble the following:

(BARRIER DET A
  NBR S
  MOD DEFENSIVE
  SOURCE (TREE NBR PL
           MOD FELLED)
  HASPART (BRANCH NBR PL
            MOD SHARPENED
            THM* (TURN MANNER OUTWARD)))

To see what a more complete representation should result in consider the following:

defensive = (DEFEND INST ABATIS THM1 X THM2/from Y)
i.e. "abatis defends x from y"

barrier = (BAR INST ABATIS THM1 Y THM2/from Z)
i.e. "abatis bars y from z"

defensive barrier =
  (ENABLE ARG1 (BAR INST ABATIS THM1 Y THM2/from Z)
   ARG2 (DEFEND INST ABATIS THM1 X THM2/from Y))
or "factoring" INST ABATIS out,

  (ENABLE INST ABATIS ARG1 (BAR THM1 Y THM2/from Z)
   ARG2 (DEFEND THM1 X THM2/from Y))
i.e. "abatis barring y from z defends x from y."

Continuing with "of felled trees" we find "of" to be all that remains of another event, the "making" of the abatis, i.e.,
of = (MAKE AGT X SOURCE W THM ABATIS)

felled trees = (FELL AGT X THM TREES)

of felled trees = (MAKE AGT X1 SOURCE (TREES THM* (FELL AGT X2)))

defensive barrier of felled trees =

(MAKE AGT X1
 SOURCE (TREES THM* (FELL AGT X2))
 THM (ABATIS INST*
 (ENABLE ARG1 (BAR THM1 Y THM2/from Z)
  ARG2 (DEFEND THM1 X3 THM2/from Y))))

with = (TREES HASPART Z)

sharpened branches = (SHARPEN AGT X THM BRANCHES)

turned outward = (TURN AGT X PATH OUTWARD)

sharpened branches turned outward =

(TURN AGT X1 THM (BRANCHES THM* (SHARPEN AGT X2)) PATH OUTWARD)

with sharpened branches turned outward =

(TREES HASPART (BRANCHES THM* (SHARPEN AGT X1)
 THM* (TURN AGT X2 PATH OUTWARD)))

defensive barrier of felled trees

with sharpened branches turned outward =

(MAKE AGT X1
 SOURCE (TREES THM* (FELL AGT X2)
 HASPART (BRANCHES THM* (SHARPEN AGT X3)
 THM* (TURN AGT X4 PATH OUTWARD)))

THM (ABATIS INST* (ENABLE ARG1 (BAR THM1 Y THM2/from Z)
 ARG2 (DEFEND THM1 X5 THM2/from Y))))
Displaying these in a chronological order we have:

At t0 to t1,

\[(\text{GROW T} \equiv \text{1 TREES T} \equiv \text{M2 BRANCHES}) \implies (\text{HASPART TREE BRANCHES})\]

What is implied here is not that all trees have branches, which might very well be a property of trees in general, only that the trees which are under consideration here acquired branches as a result of growing them. "Branch" itself might be taken as a verb, which is the origin of the theme case argument "branches", i.e. "Branches branch from trees." I have also not explicitly dealt with the question of quantification, but what would also have to be represented here is that each tree has its own branches, rather than either one tree having all the branches or all trees sharing the same branches. These last possibilities might require pragmatic knowledge of plants to resolve.

At t2,

\[(\text{FELL AGT X} \equiv \text{1 TREES})\]

At t3,

\[(\text{SHARPEN AGT X} \equiv \text{2 BRANCHES}) \implies (\text{BRANCHES MOD SHARPENED})\]

At t4,

\[(\text{TURNS AGT X} \equiv \text{3 BRANCHES PATH OUTWARD})\]

which satisfies the creation criterion for an abatis. i.e. "defensive barrier" is actually an intended function rather than an integral property of an abatis.

At t5,

\[(\text{BAR INST ABATIS THM Y})\]

thus,

\[(\text{DEFEND INST ABATIS THM X GOAL/FROM Y})\].
Thus we have a complex parsing process and a subsequent temporal ordering resulting in five events being involved in one noun phrase definition taken from the MPD. One advantage of using the MPD can now be demonstrated. Definitions in the Pocket Dictionary are closely related to their counterparts in the two larger Merriam-Webster dictionaries. Thus, if we decide to, we can elaborate upon the "abatis" definition by examining The Seventh Collegiate's definition,

abatis - a defense formed of felled trees the sharpened ends of whose branches face the enemy

or continue upward to the unabridged Third International's definition,

abatis - a defensive obstacle usu. formed by felled trees whose butts are secured towards the place defended with the often sharpened branches directed outwards against the enemy but sometimes made of live small trees bent down and often reinforced with barbed wire

This ability to consult a more detailed definition which can clearly be associated with the version in the Pocket Dictionary, and typically will include an example sentence for each sense meaning, permits the resolution of semantic problems that might otherwise prevent the Pocket Dictionary from being usable as a semantic data source.

7.3 Lexical Disambiguation by Computer

Lexical disambiguation may be defined as the process of determining which of a fixed set of sense meanings is assignable to a given lexical item in a given context. A simple example of this task, proposed by Bar-Hillel [1964], would be to be able to determine the correct sense of "pen" in the sentence "the pig is in the pen". If this task were undertaken in the context of the senses offered in the Pocket Dictionary, it would be to determine that "pen" meant "an enclosure for animals" rather than "a writing instrument". Automatic lexical disambiguation would thus be the process of performing such a task by means of a computer.

In addition to the necessary property of being able to tell which sense or senses from a fixed set are assignable to a lexical item in context, it would be desirable for all assignable sense meanings to be ranked in terms of their likelihood of assignment. All of these disambiguation tasks can be greatly facilitated by the use of dictionary definitions and in particular the hierarchical structure of the dictionary.
7.3.1 Automatic Disambiguation via Co-Occurrence of Words in Dictionary Definitions

The indexing and use of co-occurrences is traditionally a technique of information science used to process enormous volumes of text such as the titles of documents in a library collection. Within artificial intelligence such relations have not been extensively explored because AI has primarily dealt with small problems and domains in which the investigators have hand-coded all the knowledge the "intelligent" system will use. When one moves out of this area of hand-made tools one must resort to more automatic techniques such as those of information science. This however does not mean that one must stay confined to the concepts of statistical relatedness -- and here is where I believe AI and information science can combine to form a stronger investigative paradigm. Using the results of a co-occurrence system one can follow paths in a real network, that of dictionary definitions, and then name the arcs traversed to explain the co-occurrence relations with a cognitive AI basis. Thereafter one may implement computational rules and procedures to traverse similarly named arcs to solve analogous problems.

Within dictionary definitions words are not necessarily related because they are spelled the same. The meaning of a word extracted from context requires the addition of a disambiguation sense-number for reliable propagation. Since the only words which are unambiguous in the definitions of the current "processed" definitions are the kernel terms, there are typically several contending senses for each remaining spelling-form in a definition. Using the disambiguated kernel terms as the basis for traversing paths between definitions one can achieve a first order approximation to assuring that the co-occurring words one encounters will be in the same domain and hence reliably represent the same concept. This is perhaps clearer when discussed in the context of two examples.

Consider the definition of "abalone",

abalone-.0a - a large edible sea mollusk-.0a with an ear-shaped shell

The disambiguated kernel term of this definition (i.e., "mollusk-.0a") and its definition are first looked up and listed as known data.

mollusk-.0a - any of a large group-1.0a of mostly shelled and aquatic invertebrate animals-1.2a/1 including snails, clams, and squids

Next, the possible senses of each of the other content words involved in the definition of "abalone" are also looked up and a search for matching spellings in their definitions is performed.
large-.1a - having more than usual power, capacity or scope
large-.2a - exceeding most other things of like kind in quantity or size
edible-.0a - fit or safe to be eaten
sea-.1a - a large body-.4a of salt water-.1a/
sea-.2a - OCEAN
sea-.3a - rough water-.1a
sea-.3b - a heavy wave-.2.1a
sea-.4a - something-.0a like or likened to a large body of water
ear-.1a - the organ-.2a of hearing
ear-.1b - the outer part-.1a of this in a vertebrate
ear-.2a - something-.0a resembling a mammal's ear in shape or position
ear-.3a - sympathetic attention-.2a
shape-.2.1a - APPEARANCE
shape-.2.2a - surface configuration-.0a
shape-.2.2b - FORM
shape-.2.3a - bodily contour-.2a apart from the head and face
shape-.2.3b - FIGURE
shape-.2.4a - PHANTOM
shape-.2.5a - CONDITION <he's in pretty good shape>
shell-.1.1a - a hard or tough outer covering of an animal (as a beetle, turtle or mollusk) or of an egg or a seed fruit (as a nut)
shell-.1.1b - something-.0a that resembles a shell <a pastry shell>
shell-.1.2a - a case-.2.1a holding an explosive and designed to be fired from a cannon
shell-.1.2b - a case-.2.1a holding the charge of powder and shot or bullet for small-arms
shell-.1.3a - a light narrow racing boat-.0a propelled by oarsmen

It should be mentioned here that because at this stage I have no information about which of these senses is appropriate in this context I must list all of the senses. The task of determining which of the above senses are (and are not) appropriate constitutes a longer range goal for the dictionary.

In the case of "shell", which has several rather distinctive meanings relating to "biological organisms", "ammunitions", and "racing boats", the need for disambiguation becomes acute. Also in this case, the dictionary definition itself provides the clue needed to distinguish "abalone" as having a "shell" of the biological organism type.
This is done by noting that "shell-1.1a" contains the word "mollusk" in its definition. Since "mollusk" is unambiguously "mollusk-.0a", there is circumstantial evidence for a computer co-occurrence program and positive proof for a human for the disambiguation of "shell" to "shell-1.1a." I regard this as more than pure chance, for there are reasons that some sense of "shell" should mention "mollusk" in its definition. The dictionary deals with a concept's defining traits and words co-occurring in definitions are likely to be parts of each other's semantic domains. This contrasts with co-occurrence in ordinary descriptive text, where words may be present for numerous other reasons unrelated to their definitions.

For the second example I will choose a more complex disambiguating context. Consider the definition of "abatis":

abatis-.0a - a defensive barrier-.0a of felled trees with sharpened branches turned outward.

The work done in building the noun taxonomy has given the disambiguation of "barrier" as the kernel term of the definition, but nothing is known of the senses of "defensive", "felled", "trees", "sharpened", "branches" and "outward". Despite the fact that these words appear unambiguous to the knowledgeable speaker of English, they cannot be so readily dismissed computationally. This reflects the psychological bias that humans bring with them when reading textual material, i.e., they do not see ambiguity because they have drawn upon their immense background of knowledge to eliminate the ambiguity almost as soon as they read the text.

Thus, "defensive" relating to "the answer made by the defendant in a legal action" or, "an argument in support or justification" is not considered by the human reader; nor is "felled" meaning "to sew (a seam) by folding one raw edge under the other" considered. "Tree" in the sense of "a piece of wood adapted to a particular use <a shoe tree>" or, "something in the form of or felt to resemble a tree <a genealogical tree>" is not considered. Nor are any of the numerous alternative senses of "sharp", such as "irritable", "higher than the true pitch", "involving an abrupt or extreme change", "clear, distinct". "Branch" as "a division of a family descended from a particular ancestor" or "a discrete unit or element of a complex system (as of knowledge, people, or business)" is not considered; and "turn" as "to revolve mentally", "to shape by means of a lathe", "to gain by passing in trade <turn a profit>", etc., are not considered; "outward" alone, of the above words in the definition of "abatis", has a single sense meaning, "toward the outside".

Some of the above senses could be eliminated by using standard selectional features of "human", "abstract vs. concrete", etc., and these could be made available with further augmentation of the dictionary; but many other senses cannot be so resolved. What is most interesting, however, is that once again co-occurrence would appear to offer some help
in disambiguation of definitions such as that of "abatis".

If one considers the definitions of "tree", "branch" and "fell" the following interesting phenomenon appears:

\textbf{tree-1.1a} – a woody perennial plant-2.1a usu. with a single main stem and a head of branches and leaves at the top.

\textbf{branch-1.1a} – a natural subdivision\textbackslash Rv.0a (as a bough or twig) of a plant stem.

\textbf{fell-2.1a} – to cut-1.3a, beat-1.1a, or knock-1.1a down <fell trees>

No other sense of "tree" uses the spelling-forms "plant", "stem" or "branches" in its definition; no other sense of "fell" uses "trees" in its definition; and only one other sense of "branch" uses "plant" and "stem" in its definition, that of,

\textbf{branch-1.2a} – a division-.2a (as of an antler or a river) related to a whole like a plant branch to its stem.

Thus the structure of figure 7-4 exists.

\begin{center}
\includegraphics{figure7-4.png}
\end{center}

\textbf{Figure 7-4 Co-Occurrence Relations Disambiguating "abatis" Definition Words}
This implies that "tree-1.1a" has a co-occurrence relationship with both "branch-1.1a" or "branch-1.2a" and that "fell-2.1a" has a co-occurrence relationship with "tree". Thus "fell" in the definition of "abatis" is disambiguated to "fell-2.1a" by the co-occurrence of "trees" in its example usage; "trees" in the definition of "abatis" is disambiguated to "tree-1.1a" by the co-occurrence of "plant" and "stem" in its definition and that of "branches"; and "branch" is disambiguated to either "branch-1.1a" or "branch-1.2a" by the same co-occurrence relationships.

The procedures followed may be enumerated as in figure 7-5.
Technique V

Steps: (1) For each word in the text determine its part of speech.

(2) For each noun, verb, or adjective determine from its dictionary taxonomy the ISA link for each sense.

(3) For each sense, add to the ISA link all content words in the definition of that sense.

(4) Intersect the sets of words formed for each sense in steps 2–3 above with the sets of words formed for the other words in the text.

(5) For all non-null intersections formed create a set containing the disambiguated words in that intersection.

(6) Repeat steps 1–5 for each ISA link found in 2, keeping the intersections found in ranked order of occurrence until either:

(a) a root node is reached for a sense

or

(b) all words in the text have been disambiguated taking the additional words accompanying each successively more general ISA link and adding them to that sense’s intersection set.

(7) When no further connections can be formed take the ranked set of connections and substitute the disambiguated senses for the undisambiguated words of the text.

Figure 7-5 Co-Occurrence Disambiguation of Words in a Text
7.3.2 Automatic Disambiguation via Natural Language Meta-Rules

The phenomenon of co-occurring spelling-forms clarifying which sense of a word is being used in a definition occurs again and again in the dictionary. It is not, however, an infallible disambiguation technique. It is basically just statistical evidence of a deeper cognitive basis for disambiguation. The number of cases in which definitions without previously disambiguated content words will reliably yield disambiguations solely via co-occurrence relationships may be only a fraction of the existing vocabulary (though totaling several thousand words). But, when considering the magnitude of the task of disambiguating the text of the entire dictionary, co-occurrence disambiguation "guesses" would probably prove very useful in an interactive disambiguation environment, much the way current interactive computer spelling correctors provide a powerful aid to text users seeking a correct spelling of a word from their list of "guesses" and their stored lexicon of forms.

The co-occurrence phenomenon does suggest that a true natural language processing technique could be developed by determining the cognitive basis for each of the co-occurrence disambiguations and then modeling that basis with disambiguation meta-rules, or statements about how to use the arcs of a very large taxonomic semantic network to arrive at disambiguations.

For instance, in the "abalone" example of section 7.3.1 it can be seen that a part/whole relationship exists between "shell-1.1a" and "abalone-.0a" by virtue of the part/whole relationship between "mollusk-.0a" and "shell-1.1a" and the transitivity of the ISA relationship between "abalone-.0a" and "mollusk-.0a". This is illustrated in the figure 7-6.

```
MOLLUSK-.0A ---/ISPART/--- SHELL-1.1A
  \   |
   \  ISA
    \|
   ABALONE-.0A ---/HASPART/--- SHELL-?
```

Figure 7-6 Part/Whole Relationship between Abalone-.0a and Shell-1.1a
Using this diagram I can state a simple "meta-rule" for disambiguating "shell?", namely:

\[
\begin{align*}
\text{If} & \quad (Y \neq \text{ISPART X} \neq) \\
\text{and} & \quad (Z \neq \text{ISA X} \neq) \\
\text{and} & \quad (Z \neq \text{HASPART Y}) \\
\text{then} & \quad (Y \text{ is disambiguated to } Y \neq)
\end{align*}
\]

Likewise in the "abatis" example, "branch" and "tree" have a part/whole relationship (and interestingly enough in two senses of each, hence the minor ambiguity of "branch" remaining unresolved); "tree-1.1a" and "plant-.0a" have an ISA relationship; "branch-1.1a" and "stem" have a prototypical example relationship; and "fell" and "tree" have a case-argument relationship, with "tree" as the prototypical theme (direct object) of a "felling" event. This may be illustrated as in figure 7-7.

\[
\begin{align*}
\text{PLANT-.0A} & \iff \text{ISPART} \iff \text{BRANCH-1.1A} \iff \text{TYPICAL} \iff \text{STEM} \\
\text{/IS/A/} & \iff \\
\text{/TYPICAL} & \iff \\
\text{THEME/} & \iff \\
\text{FELL-2.1A}
\end{align*}
\]

**Figure 7-7 Relationships of FELL-2.1A, TREE-1.1A, PLANT-.0A and BRANCH-1.1A derived from definitions related to "abatis".**

Thus for "abalone" the relationships of SIZE "large", ATTRIBUTE "edible", HABITAT "sea", and HASPART "shell" could be added when the definition was disambiguated. For "abatis" the relationships of ATTRIBUTE "defensive", HASPART "trees" (with "trees" HASPART "branches") would likewise be added.

The reason for this relationship network is that I expect to be able to write meta-rules for successful disambiguation which will wholly encompass the statistical co-occurrence phenomenon that performs disambiguation. Stated in other terms, this means that I believe every
successful co-occurrence disambiguation has an underlying rule-based statement that will potentially be more powerful and more accurate in performing automatic disambiguation than the observed co-occurrence relationship itself.

Further, the development of a rule-based disambiguation program offers the additional benefit of an explanation to accompany each disambiguation. Thus, the proposed disambiguation procedure would perform a disambiguation-finding and disambiguation-explaining process within the existing structure of the lexicon.

7.3.3 Lexical Disambiguation in Non-Dictionary Text

Although the dictionary constitutes a form of natural language somewhat different from that of other types of prose, its definitions are reasonable targets for extended efforts at disambiguation because they constitute a body of knowledge which itself may help to disambiguate ordinary text. If the text of the dictionary were being disambiguated it would also be useful as a "boot-strap" to the completion of its own disambiguation. This is so because every definition which is completely disambiguated may then be used as the basis of accurate co-occurrence relationships between word senses rather than word spelling-forms. Thus, for example, once the definition of "abalone" were completely disambiguated, there would be a definite link between "sea-la" and "shell-l.1a". Likewise, in the case of "abatis", the disambiguation of its definition would provide positive knowledge that "tree-l.1a", "fell-2.1a", and "branch-l.1a" co-occur, indicating that the reciprocal problem of which sense of "tree" occurs in the definition of "fell-2.1a" would not exist when that definition was reached.

Thus, dictionary definitions can assist in the further disambiguation of their own text. It therefore is reasonable to expect that a fully disambiguated dictionary could form the basis for a disambiguation procedure useful on any text. Numerous examples of this could be provided, but the classic one proposed by Bar-Hillel, namely the sense of "pen" in the sentence, "The pig is in the pen", was selected for illustration here because it cannot be disambiguated by any syntactic information present in the sentence.

Disambiguation in this instance can be performed by knowledge of the meanings of the words "pig" and "pen". Such knowledge is contained in the definitions of the words "pig" and "pen" as presented in the dictionary after these definitions are fully disambiguated.

In order to illustrate the computational procedure I intend to develop, it is useful to first describe in words what I believe would have to occur for the definitions in the MPD to produce the desired disambiguation. It is important here to note that I am insisting on solely using the existing text of the dictionary. I cannot add words or
alter the contents of the definitions, because in a real-world situation I would not have known beforehand that the system would be asked to disambiguate these words. Hence if this example works it would have worked without my having intervened to pre-arrange the information such that the program would then have conveniently found it. This is a significant departure from most of natural language processing, and I think a considerable improvement in generality.

The judgement of native listeners that the sentence "the pig is in the pen" is unambiguous (it actually has several ranked interpretations), is based upon the most likely interpretation of "pig" being "a swine", and "pen" as being "a small enclosure for animals". The reason this joint interpretation "makes sense" is that a "pig" is immediately accepted as being an "animal" and the appropriateness of the "pen" is recognizable by its "for animals" defining phrase.

How would this recognition occur computationally? First, the noun taxonomy would be employed to transitively connect "pig" to "swine", "mammal", and then "animal". Let me refer to such an upward taxonomic path as a "trace". Next, the same procedure would be applied to "pen". The traces associated with "pen" involve, for the dictionary, two alternatives, one being a path through "enclosure" to "thing"; the other, through "writing instrument", and "instrument" to "thing". Neither trace for "pen" would yield the necessary connection to "animal" however, as the "animal" portion of the appropriate definition of "pen" is not part of the taxonomy. Thus, a connection between "pen" and "animal" is required. This is provided if I include the words accompanying the kernel of the definition as part of the context acquired while traversing the taxonomy. Thus, because "for animals" is part of the full definition of "pen", the term "animals" (or its easily derived singular, "animal") is included in what I may call the "trace context". The intersection of the words of the definitions in the trace contexts of "pig", "swine", "mammal", "animal"; and "pen", "enclosure(animal)"; "thing" thus yields "animal" as a connecting link (figure 7-8).

```
enclosure(animal)
   ↑      ↑
   pen  mammal
   ↓      ↓
    swine
    ↓
     pig
```

Figure 7-8 Taxonomic Relations between "pen" and "pig"
Now that this simple view of what is being sought in the dictionary has been stated, I will show what complicates the process (and would be required for it to actually be performed by a computer). First, while the "naive listener" above might only have two senses of "pen" the dictionary actually has four:

pen-1.1A - a small enclosure for animals
pen-1.2A - a small place of confinement or storage
pen-3.1A - an instrument with a split point to hold ink used for writing
pen-3.1B - a fluid-using writing instrument

What is more surprising is that "pig" has five senses even in a pocket dictionary, namely:

pig-.1A - SWINE
pig-.1B - a young swine
pig-.2A - PORK
pig-.3A - one resembling a pig (as in dirtiness or greed)
pig-.4A - a casting of metal (as iron or lead) run directly from a smelting furnace into a mold

The existence of these senses means that far more than the simple ambiguity perceived by naive speakers would be considered, which is not necessarily a handicap in light of the other possible contexts. For example, if I chose "pig-.4A", then I am likely to want "pen-.2A". What is desired is a set of ranked alternatives from which a selection might be made on the basis of other higher-order context variables. If one were discussing the operation of a steel mill, then "iron" would already be highly likely to provide a context for "pig-.4A" being selected.

The most common interpretation of "pen" would be as "pen-1.1A", "a small enclosure for animals", with "pig" being either "pig-.1A" or "pig-.1B". This interpretation is capable of automatic computational selection because of the linkages between "pig-.1A" (or "pig-.1B"), "animal(s)" and "pen-1.1A".

To see how this computation would be performed it is necessary to examine the appropriate data in the noun taxonomy. Extracting from this data a "trace" of taxonomically linked noun kernels for each sense of "pig" one gets the tree-like structures of figure 7-9.
Figure 7-9 All Noun Taxonomies of PIG and PEN

If ISA+ is the transitive ISA relationship, then X ISA+ Z implies that for some set of nodes,

\{Y_1, Y_2, Y_3, ... Y_{n-1}, Y_n\}

there is a set of ISA arcs such that,

X ISA Y_1
Y_1 ISA Y_2
Y_2 ISA Y_3

... 
Y_{n-1} ISA Y_n
Y_n ISA Z

is true.
I may then define a transitive THEME relationship, THEME+, as implying that if X THEME+ Y, then either,

\[(X \text{ THEME } Y)\]

or

\[(X \text{ THEME } W) \text{ and } (Y \text{ ISA+ } W)\].

If "pen-1.1A - a small enclosure for animals" is analyzed into a Verb Normal Form (section 7.2), i.e., the "enclosure" kernel noun is transformed into an instrument argument to an "enclose" (vb.) event, then it may be represented as:

\[
\begin{align*}
\text{If} & \quad (X \text{ SIZE SMALL}) \\
\text{and} & \quad (X \text{ INST* } (\text{ENCLOSE THEME } (\text{ANIMAL NBR PL}))) \\
\text{then} & \quad (X \text{ ISA PEN-1.1A})
\end{align*}
\]

If now an inference rule for the verb "enclose" is added introducing the preposition "in", i.e.,

\[
\text{If } (\text{ENCLOSE INST Y THEME } Z) \text{ then } (Z \text{ IN } Y)
\]

Then a rule for determining that "pen" in "the pig is in the pen" is "pen-1.1a" may be stated as:

\[
\begin{align*}
\text{If} & \quad (Z \text{ ISA+ ANIMAL-.0A}) \\
\text{and} & \quad (Z \text{ IN } Y) \text{ equivalent to } (\text{ENCLOSE INST Y THEME+ } Z) \\
\text{and} & \quad (Y \text{ ISA+ PEN}) \\
\text{then} & \quad \text{PEN is disambiguated to PEN-1.1A}
\end{align*}
\]

There are two senses of PIG which will satisfy the value of Z in the above rule, namely "pig-.1a - SWINE" and "pig-.1b - a young swine".

This rule for disambiguating "pig" in "the pig is in the pen" is of course very limited in its range of application, requiring constants such as ANIMAL-.0A, ENCLOSE, and PEN in its statement. However, from collections of such rules one might determine more extensive "meta-rules" which would have only variables or variables with feature restrictions in their statements.
CHAPTER VIII  CONCLUSIONS

This dissertation has shown that the machine-readable text of an ordinary dictionary can be computationally analyzed to provide a wide variety of syntactic and semantic information about a language. Specifically:

1) A concordance of dictionary definition texts can be used as data in a componential analysis of the case argument patterns of high-level verbs and nouns.

2) The structure of dictionary definitions provides a basis for constructing taxonomies of both verbs and nouns, but requires semantic disambiguation of the "genus" terms of each definition when alternate senses exist.

3) Taxonomies created by computationally connecting the paired main entries and semantically disambiguated genus terms of definitions form "tangled hierarchies" [Fahlman 1975; 1977] or semi-lattices. These taxonomies are rooted in clusters of circular definitions or semantic relations to other nodes (word-senses) in the taxonomy. They are acyclic except for these primitive root clusters. The existence of these terminating clusters causes the dictionary to be a forest of tangled trees rather than a single tangled tree.

4) Two common types of terminating relations are those defining nodes of the ISA-hierarchy as nodes in the part-whole hierarchy (e.g. leaf IS-PART plant), and those defining nouns as the case arguments of verbs (e.g. vehicle INSTRUMENT-OF carry; worker AGENT-OF work; etc.)

5) Numerous statistics provided by counting the frequencies of definitions by parts-of-speech, numbers of senses, sizes of defined vs. defining vocabulary, frequency of disambiguated genus terms, and the sizes and depths of computationally grown tangled trees provide new information for future research and further semantic hypotheses about the language.

These reveal, for instance, that basically nouns, verbs and adjectives account for 98% of all definitions, with nouns overwhelmingly superior in numbers to verbs or adjectives. There are approximately 3 times as many nouns as there are verbs or adjectives.

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6) The dictionary, being a closed definitional system, uses circularity in definitions when primitive concepts are being defined. Knowing this one can thus use the circularity of sets of high-level definitions to identify, describe, and study the semantically primitive concepts of the language.

7) Using knowledge of the structure of the dictionary gained through study of concordances and augmented by human identification and disambiguation of definition genus terms, a complete taxonomy of the noun and verb definitions of the Merriam-Webster Pocket Dictionary (27,000 nodes for nouns; 12,000 nodes for verbs) was computationally constructed. This tool provides the capability for numerous further studies of semantic domains and language primitives. Extraction tasks for componential analyses which required months of hand-labor at the beginning of this project can now be performed in hours.

8) Interactions between the ISA-hierarchy and the part/whole hierarchy can be used as the basis for inductive reasoning and analogy discovery (e.g. LEAF:PLANT::FROND:FERN).

9) A large number of defining words, termed "partitives" and "collectives", exist in an ISA-hierarchy (e.g. the terms under GROUP) as well as being used to define words via quantificational relationships to other words.

10) A preliminary phrase-structure grammar for verb definitions shows dictionary defining syntax to be dominated by the conjunctions AND and OR and highly structured to use parallel constructions involving these conjunctions. Such grammars may automatically identify the genus terms of definitions.

11) A deep semantic analysis technique (parsing to verb normal form (VNP)) involving morphologically decomposing nouns and other syntactic forms into their underlying verbs and supplying deleted verbs is proposed. Using this technique it is believed that a greatly enriched knowledge base representing the content of definitions (and text) can be produced from the elliptical form of such text.

12) The controlled use of co-occurrence of words within taxonomically linked definition texts is proposed as a potentially useful technique for the discovery of underlying semantic bases for lexical disambiguation. Capable of automatic computation, the technique provides ranked candidate disambiguations of numerous other words in the dictionary. It is minimally seen as a useful augmentation of human disambiguation decision-making for definitions and believed to be a valuable tool for discovering cognitively-based semantic "meta-rules" which could be computationally stated and applied to perform fully-automatic lexical disambiguation.
## APPENDIX I

**Rules for Plural-to-Singular Suffix-Analysis Based Upon The Merriam-Webster Third International Dictionary**

<table>
<thead>
<tr>
<th>Rule</th>
<th>Examples and Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SES -2 * IS *</td>
<td>theses, analyses, crises</td>
</tr>
<tr>
<td>SEZ -2 *</td>
<td>buzzes</td>
</tr>
<tr>
<td>SEX -2 * IS *</td>
<td>axes → ax / axes → axis</td>
</tr>
<tr>
<td>SEH C -2 *</td>
<td>torches</td>
</tr>
<tr>
<td>SEH S -2 *</td>
<td>dashes</td>
</tr>
<tr>
<td>SEI -2 Y *</td>
<td>armies, soliloquies, skies</td>
</tr>
<tr>
<td>SEV -3 P * E *</td>
<td>leaves / knives</td>
</tr>
<tr>
<td>SEG -3 X *</td>
<td>larynges → larynx, spinges → sphinx</td>
</tr>
<tr>
<td>SEC I -3 X *</td>
<td>matrices</td>
</tr>
<tr>
<td>SEC I -4 E X *</td>
<td>indices</td>
</tr>
<tr>
<td>SECU -3 X *</td>
<td>cruciess</td>
</tr>
<tr>
<td>SED -3 S *</td>
<td>aphides, probosides, ephemerides</td>
</tr>
<tr>
<td>SE -2 *</td>
<td>+es</td>
</tr>
<tr>
<td>SIE -3 IS *</td>
<td>necropoleis → necropolis</td>
</tr>
<tr>
<td>S -1 *</td>
<td>+s</td>
</tr>
<tr>
<td>NEX -2 *</td>
<td>oxen</td>
</tr>
<tr>
<td>NEM -2 AN *</td>
<td>men, women, Englishmen</td>
</tr>
<tr>
<td>MI -2 *</td>
<td>cherubim, seraphim</td>
</tr>
<tr>
<td>EA -1 *</td>
<td>formulae</td>
</tr>
<tr>
<td>ECI -3 OUSE *</td>
<td>mice, lice</td>
</tr>
<tr>
<td>ESEE -4 OOSE *</td>
<td>geese → goose</td>
</tr>
<tr>
<td>IGR -1 *</td>
<td>monsignori → monsignor</td>
</tr>
<tr>
<td>I0 -1 IS *</td>
<td>logoi → logos</td>
</tr>
<tr>
<td>I -1 US *</td>
<td>foci → focus, radii → radius</td>
</tr>
<tr>
<td>ARO E -3 U R *</td>
<td>femora → femur</td>
</tr>
<tr>
<td>ARO -3 US *</td>
<td>corpora → corpus</td>
</tr>
<tr>
<td>AREM -1 ON *</td>
<td>ephemera → ephemeron</td>
</tr>
<tr>
<td>ARE -3 US *</td>
<td>genera → genus</td>
</tr>
<tr>
<td>ANI -3 EN *</td>
<td>nomina → nomen, gravamina → gravamem</td>
</tr>
<tr>
<td>AN -1 ON *</td>
<td>phenomena</td>
</tr>
<tr>
<td>ATAM -2 * TON *</td>
<td>schemata → schema vs. automata → automaton</td>
</tr>
<tr>
<td>AIL -1 ON *</td>
<td>ganglia</td>
</tr>
<tr>
<td>AIM -1 U M *</td>
<td>emporia → emporium</td>
</tr>
<tr>
<td>X -1 *</td>
<td>beaux → beau, adieux → adieu</td>
</tr>
</tbody>
</table>
Example: KNIVES

Using the rule: S E V -3 F * E *.

We would first match S E and V to the last three letters of KNIVES, starting from the end. Next we would remove (-3) three letters, leaving KNI. Then we would add an F, yielding KNIF and look this word up (unsuccessfully). Then we would add an E, forming KNIFE, looking this word up successfully.

With this same rule,

LEAVES ==> LEA +F ==> LEAF (lookup successful).
APPENDIX II

DEFINITIONS OF "MOVE" VERBS

AGITATE 1.1 - MOVE WITH AN IRREGULAR RAPID MOTION
APPROACH 1.1 - MOVE NEARER TO
ASCEND 1.1 - MOVE UPWARD ; /MOUNT/, /CLIMB/
BARGE 2.2 - MOVE OR THRUST ONESELF CLUMSILY OR RUDELY
BLOW 1.1 - MOVE FORCIBLY
BLUNDER 1.1 - TO MOVE CLUMSILY OR UNSTEADILY
BOB 1.1 - MOVE UP AND DOWN JERKILY OR REPEATEDLY
BOLT 1.1 - MOVE SUDDENLY ( AS IN FRIGHT OR HURRY ) ; /START/, /DASH/
BULLDOZE 1.1 - TO MOVE , CLEAR , GOUGE OUT , OR LEVEL OFF WITH A
   TRACTOR-DRIVEN MACHINE ( BULLDOZER )
BUMP 1.1 - TO MOVE OR ALTER BY BUMPING
BUSTLE 1.1 - TO MOVE OR WORK IN A BRISK FUSSY WAY
CARRY 1.1 - MOVE WHILE SUPPORTING : /TRANSPORT/, /CONVEY/, /TAKE/
CHUG 1 - TO MOVE OR GO WITH CHUGS < A LOCOMOTIVE CHUGGING ALONG >
CIRCLE 2.2 - TO MOVE OR REVOLVE AROUND ; <ALSO> : TO MOVE IN A CIRCLE
CIRCULATE 1.1 - TO MOVE OR CAUSE TO MOVE IN A CIRCLE, CIRCUIT, OR ORBIT
COAST 2.2 - TO MOVE ( AS DOWNHILL ON A SLED OR AS ON A BICYCLE WHILE NOT
   PEDALING) WITHOUT EFFORT
CRAWL 1.1 - TO MOVE SLOWLY BY DRAWING THE BODY LONG THE GROUND
DANCE 2 - TO MOVE QUICKLY UP AND DOWN OR ABOUT
DANDLE 1 - TO MOVE UP AND DOWN IN ONE´S ARMS OR ON ONE´S KNEE IN
   AFFECTIONATE PLAY
DASH 7 - TO MOVE WITH SUDDEN SPEED
DELAY 3 - TO MOVE OR ACT SLOWLY
DIVERGE 1 - TO MOVE OR EXTEND IN DIFFERENT DIRECTIONS FROM A COMMON
   POINT
DODGE 1 - TO MOVE SUDDENLY ASIDE
DRAG 2 - TO MOVE WITH PAINFUL SLOWNESS OR DIFFICULTY
DRAW 1.3A - TO MOVE OR GO STEADILY OR GRADUALLY < NIGHT DRAWS NEAR >
DROP 9 - TO MOVE DOWNWARD OR WITH A CURRENT
EDGE 2 - TO MOVE OR FORCE GRADUALLY < EDGE INTO A CROWD >
FALL 1.12 - TO MOVE OR EXTEND IN A DOWNWARD DIRECTION
FALTER 1 - TO MOVE UNSTEADILY : /STUMBLE/, /TOTTER/
FAN 2 - TO MOVE (AIR) WITH OR AS IF WITH A FAN
FIDDLE 2 - MOVE THE HANDS OR FINGERS RESTLESSLY
FIDGET 2.1 - TO MOVE OR CAUSE TO MOVE OR ACT RESTLESSLY OR NERVOUSLY
FLAP 3 - TO MOVE ( AS WINGS ) WITH A BEATING MOTION
FLING 1 - TO MOVE HASTILY , BRUSQUELY , OR VIOLENTLY
FLIRT 1 - TO MOVE ERRATICALLY : /FLIT/
FLOAT 2 - TO MOVE GENTLY OR THROUGH A FLUID
FLOUNCE 1 - TO MOVE WITH EXAGGERATED JERK MOUNTS
FLUCTUATE 1 - TO MOVE UP AND DOWN OR BACK AND FORTH LIKE A WAVE
FLUTTER 2 - TO MOVE WITH QUICK WAVING OR FLAPPING MOUNTS

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FLUTTER 4 - TO MOVE ABOUT OR BEHAVE IN AN AGITATED AIMLESS MANNER
FLY 1 - TO MOVE IN OR PASS THROUGH THE AIR WITH WINGS
FLY 2 - TO MOVE THROUGH THE AIR OR BEFORE THE WIND
FLY 6 - TO MOVE OR PASS SWIFTLY
FORGE 1 - TO MOVE AHEAD STEADILY BUT GRADUALLY
FREEWHEEL 1 - TO MOVE, LIVE, OR DRIFT ALONG FREELY OR IRRESPONSIBLY
FUNNEL 2 - TO MOVE TO A CENTRAL POINT OR INTO A CENTRAL CHANNEL
GLIDE 1 - TO MOVE SMOOTHLY AND EFFORTLESSLY
GO 1.1A - TO MOVE ON A COURSE: /PROCEED/
GRAVITATE 1 - TO MOVE OR TEND TO MOVE UNDER THE INFLUENCE OF GRAVITATION
GRAVITATE 2 - TO MOVE TOWARD SOMETHING
GRIND 6 - TO MOVE WITH DIFFICULTY OR FRICTION
HASTEN 2 - TO MOVE OR ACT QUICKLY: /HURRY/
HIKE 1 - TO MOVE OR RAISE WITH A SUDDEN EFFORT
HITCH 1 - TO MOVE BY JERKS
HOP 1 - TO MOVE BY QUICK SPRINGY LEAPS
HOVER 1 - /FLUTTER/; <ALSO>: TO MOVE TO AND FRO
HURL 1 - TO MOVE OR CAUSE TO MOVE VIGOROUSLY
HURRY 3 - TO MOVE OR ACT WITH HASTE
HURTLÉ 1 - TO MOVE WITH A RUSHING SOUND
INCH 2.1B - TO MOVE SLOWLY <CAR S INCHING ALONG THE SLIPPERY ROAD>
JERK 2 - TO MOVE IN SHORT ABRUPT MOTIONS
JIGGLE 1 - TO MOVE WITH QUICK LITTLE JERKS
JOLT 1 - TO MOVE WITH A SUDDEN JERKY MOTION
Kedge 1 - TO MOVE A SHIP BY HAULING ON A LINE ATTACHED TO A SMALL ANCHOR DROPPED AT THE DISTANCE AND IN THE DIRECTION DESIRED
LASH 1 - TO MOVE VIGOROUSLY
LABOR 2 - TO MOVE WITH GREAT EFFORT
LUMBER 1 - TO MOVE HEAVILY OR CLUMSILY
LURK 1 - TO MOVE FURTIVELY: /SNEAK/
MARCH 1 - TO MOVE ALONG IN OR AS IF IN MILITARY FORMATION
MIGRATE 1 - TO MOVE FROM ONE COUNTRY, PLACE, OR LOCALITY TO ANOTHER
MILL 2 - TO MOVE IN A CIRCLE OR IN AN EDDYING MASS
NOD 2 - TO MOVE UP AND DOWN <THE TULIPS NODDED IN THE BREEZE>
NOSE 2 - TO PUSH OR MOVE WITH THE NOSE
NOSE 6 - TO MOVE AHEAD SLOWLY <THE SHIP NOSED INTO HER BERTH>
PADDLE 2.1 - TO MOVE THE HANDS AND FEET ABOUT IN SHALLOW WATER
PADDLE 2.1.1 TO- TO MOVE ON OR THROUGH WATER BY OR AS IF BY USING A PADDLE
PASS 1.3 - TO MOVE PAST, BEYOND, OR OVER
PLAY 2.2 - TO MOVE AIMLESSLY ABOUT: /TRIFLE/ <PLAYS WITH A RING NERVously>
PLAY 2.6 - TO MOVE OR OPERATE IN A BRISK, IRREGULAR, OR ALTERNATING MANNER <A FLASHLIGHT PLAYED OVER THE WALL>
POUND 4 - TO MOVE OR MOVE ALONG HEAVILY
PROGRESS 1 - TO MOVE FORWARD: /PROCEED/
PUTTER 1 - TO MOVE OR ACT AIMLESSLY OR IDLY
RATTLE 2 - TO MOVE WITH A CLATTERING SOUND <RATTLE DOWN THE ROAD>
RECEDE 1 - TO MOVE BACK OR AWAY: /WITHDRAW/
RECIPROCATE 1 - TO MOVE BACKWARD AND FORWARD ALTERNATELY <A RECIPROCATING MECHANICAL PART>
REMOVE 1.1 - TO MOVE FROM ONE PLACE TO ANOTHER : /TRANSFER/
REMOVE 1.2 - TO MOVE BY LIFTING OR TAKING OFF OR AWAY
REVOLVE 12 - TO MOVE OR CAUSE TO MOVE IN AN ORBIT ; <ALSO> : /ROTATE/
RIDE 2 - TO FLOAT OR MOVE ON WATER < RIDE AT ANCHOR > ; <ALSO> : TO MOVE LIKE A FLOATING OBJECT
RING 2.2 - TO MOVE IN A RING OR SPIRALLY
RISE 7 - TO MOVE UPWARD : /ASCEND/
ROCK 1 - TO MOVE BACK AND FORTH IN OR AS IF IN A CRADLE
ROLL 1 - TO MOVE BY TURNING OVER AND OVER
ROLL 2 - TO MOVE ON WHEELS
ROLL 3 - TO MOVE ONWARD AS IF BY COMPLETING A REVOLUTION < YEARS ROLLED BY >
RUN 15 - TO MOVE IN SCHOOLS ESP. TO A SPAWNING GROUND < SHAD ARE RUNNING >
RUN 7 - TO MOVE ON OR AS IF ON WHEELS : PASS FREELY
RUSH 1 - TO MOVE FORWARD OR ACT WITH TOO GREAT HASTE OR EAGERNESS OR WITHOUT PREPARATION
SCOUR 1 - TO MOVE RAPIDLY THROUGH : /RUSH/
SCREW 3 - TO MOVE OR CAUSE TO MOVE SPIRALLY ; <ALSO> : TO CLOSE OR SET IN POSITION BY SUCH AN ACTION
SCUD 1 - TO MOVE SPEEDILY
SHAKE 1 - TO MOVE OR CAUSE TO MOVE JERKILY OR IRREGULARLY : /QUIVER/ < THE EXPLOSION SHOOK THE HOUSE >
SHUFFLE 3 - TO MOVE WITH A SLIDING OR DRAGGING GAIT
SHUTTLE 1 - TO MOVE BACK AND FORTH RAPIDLY OR FREQUENTLY
SIDLE 1 - TO MOVE SIDEWAYS OR SIDE FOREMOST
SKIP 1 - TO MOVE WITH LEAPS AND BOUNDS
SKULK 1 - TO MOVE FURTIVELY : /SNEAK/ , /LURK/
SLIDE 1 - TO MOVE OR CAUSE TO MOVE SMOOTHLY ALONG A SURFACE
SLINK 1 - TO MOVE STEALTHILY OR FURTIVELY
SMACK 1 - TO MOVE ( THE THE LIPS ) SO AS TO MAKE A SHARP NOISE
SMASH 2 - TO MOVE FORWARD WITH FORCE AND SHATTERING EFFECT
SNEAK 1 - TO MOVE, ACT , OT TAKE IN A FURTIVE MANNER
SPIN 6 - TO MOVE RAPIDLY ALONG
SPIRAL 1 - TO MOVE IN A SPIRAL COURSE
SPRING 1 - TO MOVE SUDDENLY UPWARD OR FORWARD : /LEAP/ , /BOUND/
SPRING 3 - TO MOVE QUICKLY BY ELASTIC FORCE
SQUELCH 2 - TO MOVE IN SOFT MUD
STEAM 3 - TO MOVE BY OR AS IF BY THE AGENCY OF STEAM
SURGE 2 - TO MOVE IN WAVES
SWASH 1 - TO MOVE ABOUT WITH A SPLASHING SOUND : /SPLASH/
Sweep 4 - TO MOVE OVER WITH SPEED AND FORCE < THE TIDE SWEPT OVER THE SHORE >
Sweep 6 - TO MOVE OR EXTEND IN A WIDE CURVE
SERVE 1 - TO MOVE ABRUPTLY ASIDE FROM A STRAIGHT LINE OR COURSE
SWING 1 - TO MOVE RAPIDLY IN AN ARC
SWING 5 - TO MOVE OR TURN ON A HINGE OR PIVOT
TEAR5 5 - TO MOVE OR ACT WITH VIOLENCE, HASTE OR FORCE
TEETER 1 - TO MOVE UNSTEADILY : /Wobble/
THRASH 3 - TO MOVE ABOUT VIOLENTLY : TOSS ABOUT
THROW 1.7A - TO MOVE ( A LEVER ) SO AS TO CONNECT ( AS A CLUTCH OR SWITCH )
THUD 1 - TO MOVE OR STRIKE SO AS TO MAKE A THUD
TILT 1 - TO MOVE OR SHIFT SO AS TO INCLINE : /TIP/
TOSS 4 - TO MOVE RESTLESSLY OR TURBULENTLY < TOSSES ON THE WAVES >
TRAVEL 2 - TO MOVE AS IF BY TRAVELING (I.E. TRAVEL 1 - TO GO ON A TRIP OR TOUR) : /PASS/
TRAVEL 5 - TO MOVE FROM POINT TO POINT < LIGHT WAVES TRAVEL VERY FAST >
TREAD 2 - TO MOVE ON FOOT : /WALK/ ; <ALSO> : /DANCE/
TREMBLE 2 - TO MOVE, SOUND, PASS, OR COME TO PASS AS IF SHAKEN OR TREMULOUS
TRIP 1 - TO MOVE WITH QUICK LIGHT STEPS
TROOP 1 - TO MOVE OR GATHER IN CROWDS OR GROUPS
TUG 3 - TO MOVE BY PULLING HARD : /HAUL/
TURN 1.1A - TO MOVE OR CAUSE TO MOVE AROUND AN AXIS OR CENTER :
/ROTATE/ , /REVOLVE/ < TURN A WHEEL >
TWITCH 1 - TO MOVE OR PULL WITH A SUDDEN MOTION : /JERK/
TWITCH 2 - TO MOVE JERKILY : /QUIVER/
UNSETTLE 1 - TO MOVE OR LOOSEN FROM A SETTLED POSITION : /DISPLACE/, /DISTURB/
UP 3.3A - TO MOVE OR CAUSE TO MOVE UPWARD : /ASCEND/
VERGE 3.2 - TO MOVE OR INCLINE IN A PARTICULAR DIRECTION
WADE 2 - TO MOVE OR GO WITH DIFFICULTY OR LABOR AND OFTEN WITH
DETERMINED VIGOR < WADE THROUGH A DULL BOOK >
WAGGLE 1 - TO MOVE BACKWARD AND FORWARD OR FROM SIDE TO SIDE : /WAG/
WALK 1 - TO MOVE OR CAUSE TO MOVE ALONG ON FOOT USU. AT A NATURAL
UNHURRIED GAIT < WALK TO TOWN > < WALK A HORSE >
WALTZ 2 - TO MOVE OR ADVANCE EASILY, SUCCESSFULLY, OR CONSPICUOUSLY < HE
WALTZED THROUGH CUSTOMS >
WANDER 1 - TO MOVE ABOUT AIMLESSLY OR WITHOUT A FIXED COURSE OR GOAL :
/RAMBLE/
WARP 3 - TO MOVE ( A SHIP ) BY HAULING ON A LINE ATTACHED TO SOME FIXED
OBJECT ( AS A BUOY, ANCHOR, OR DOCK)
WASH 6 - TO MOVE OR REMOVE BY OR AS IF BY THE ACTION OF WATER
WAVE 4 - TO MOVE BEFORE THE WIND WITH A WAVELIKE MOTION < FIELDS OF
WAVING GRAIN >
WHIP 10 - TO MOVE NIMBLY OR BRISKLY ; <ALSO> : TO THRASH ABOUT LIKE A
WHIPLASH
WHIP 1 - TO MOVE, SNATCH, OR JERK QUICKLY OR FORCEFULLY
< WHIP OUT A GUN >
WHIRL 1 - TO MOVE OR DRIVE IN A CIRCLE OR SIMILAR CURVE ESP. WITH FORCE
OR SPEED
WHIRL 4 - TO PASS, MOVE, OR GO QUICKLY
WHIRL 1 - TO MOVE, FLY, OR REVOLVE WITH A WHIZZING SOUND : /WHIZ/
WHISH 1 - TO MOVE WITH A WHIZZING OR SWISHING SOUND
WHISK 1 - TO MOVE NIMBLY AND QUICKLY
WHISK 2 - TO MOVE OR CONVEY BRISKLY < WHISK OUT A KNIFE > < WHISKED THE
CHILDREN OFF TO BED >
WIGGLE 1 - TO MOVE TO AND FRO WITH QUICK JERKY OR SHAKING MOVEMENTS :
/JIGGLE/
WIND 4.2 - TO MOVE OR LIE SO AS TO ENCIRCLE
WOBBLE 1 - TO MOVE OR CAUSE TO MOVE WITH AN IRREGULAR ROCKING OR
SIDE-TO-SIDE MOTION
WORK 3.19A - TO MOVE SLIGHTLY IN RELATION TO ANOTHER PART
WORM 1 - TO MOVE OR CAUSE TO MOVE OR PROCEED SLOWLY AND DEVIously
WREATHE 1.2B - TO MOVE OR EXTEND IN CIRCLES OR SPIRALS
WRENCH 1 - TO MOVE WITH A VIOLENT TWIST
WIGGLE 1C - TO MOVE OR ADVANCE BY TWISTING AND TURNING < A SNAKE
Wriggled along the path >
Writhe 1 - TO MOVE OR PROCEED WITH TWISTS AND TURNS < Writhe in Pain >
ZIP 1.1 - TO MOVE OR ACT WITH SPEED OR VIGOR
ZOOM 1 - TO MOVE WITH A LOUD HUM OR BUZZ
### APPENDIX III

**SAMPLE OF MPD PART-OF-SPEECH CATEGORY CONTENTS**

Full List of Main Entry Non-LY Adverbs

<table>
<thead>
<tr>
<th>aback</th>
<th>evermore</th>
<th>passim</th>
</tr>
</thead>
<tbody>
<tr>
<td>abaft</td>
<td>everywhere</td>
<td>pell-mell</td>
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behindhand
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betwixt
beyond
bias
by
cantabile
cap-a-pie
catercorner
clockwise
collect
con
con brio
contrariwise
counter
counterclockwise
crescendo
crisscross
crosswise
darkling
dead
depth
double
doubtless
down
late
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lengthwise
less
lickety-split
lief
likewise
literatim
little
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loose
malapropos
manyfold
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new
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nix
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nonetheless
north
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notwithstanding
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noway
nowhere
nowhere near
nowise
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o'er
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offshore
offstage
oft
throughout
thus
thwart
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to
today
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tomorrow
tonight
too
topsy-turvy
to wit
true
twice
ultra vires
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unawares
under
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underground
underhand
underneath
undersea
under way
up
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uppermost
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upstage
upstairs
upstream
uptown
upward
upwards of
upwind
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**Full List of Main Entry -LY Adverbs**

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**Full List of Main Entry Pronouns**

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Full List of Main Entry Interjections

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<th>Adios</th>
<th>Fore</th>
<th>Lo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahey</td>
<td>Gesundheit</td>
<td>Priethee</td>
</tr>
</tbody>
</table>
alleluia hail roger
aloha hallelujah viva
amen hollo why
auf wiedersehen hosanna zounds
eureka hurrah
fie huzzah

Full List of Main Entry Suffixes

-able -er -ize
-ade -ery -less
-age -es -let
-al -ess -like
-ally -est -ly
-an -eth -ment
-ance -ful -most
-ancy -fy -ness
-ant -hood -or
-ar -ic -ous
-ard -ical -ry
-ary -ify -s
-ate -ing -ship
-cy -ish -some
-dom -ism -th
-ed -ist -ty
-en -istic -ward
-ence -ite -ways
-ency -ity -y
-ent -ive

Full List of Main Entry Prefixes

anti- over- sub-
in- re- super-
non- semi- un-

Partial Listings of Multi-Part-of-Speech Category Contents

Category: "pure" NOUN Frequency: 12466

aardvark, abacus, abalone, abatement, abatis, abattoir, abbacy, abbrev, abbey, abbe, abbot, abbreviation, abdomen, abecedarian, zucchett, zwieback, zwinglian, zygote, zymase
Category: "pure" VERB  
Frequency: 2779
abase, abash, abate, abbreviate, abdicate, abduct, abet, abhor, abide, abjure, ablate, abnegate, abolish, abominate, abound,  
wreathe, wring, write, writhe, yean, yearn

Category: "pure" ADJECTIVE  
Frequency: 3805
abandoned, abhorrent, abject, ablative, ablaze, able-bodied, able, abloom, abominable, aboriginal, abrupt, absentminded, absorbent,  
youngish, youthful, yummy, zealous, zippy, zonal

Category: NOUN-VERB  
Frequency: 1941
abandon, abuse, accent, accord, account, addict, address,  
adventure, affiliate, affix, age, aid, aim, air, alarm, alibi,  
yank, yap, yawn, yell, yield, yoke, zero, zip, zone

Category: NOUN-ADJECTIVE  
Frequency: 458
accidental, accordion, acid, adamant, adept, adhesive, adjuvant, adult, aerial, affirmative, agape, alien, ambulatory, ancient,  
woolen, working, worthy, yea, young, zany

Category: "pure" ADVERB  
Frequency: 332
aback, abeam, abed, aborning, aboveboard, abreast, abroad,  
accelerando, accordingly, adrift, ad infinitum, ad interim, ad lib,  
whither, wholly, willy-nilly, withal, wrongly

Category: NOUN-VERB-ADJECTIVE  
Frequency: 166
abstract, ace, advance, aggregate, alert, alternate, arch, average, base, bay, black, blanket, blank, blind, bluff, bound, brave,  
wholesale, wildcat, winter, wood, work, yellow

Category: VERB-ADJECTIVE  
Frequency: 87
absent, alight, animate, appropriate, approximate, articulate, awake, bandy, bare, blunt, busy, callous, clean, complete,  
tame, tarry, thin, truncate, utter, warm, weary
Category: "pure" PREPOSITION

according to, afoot of, against, ahead of, alongside of, amid, among, amant, apropos of, aside from, as for, as of, as regards, as

          to, toward, unto, upon, versus, via, with

Category: ADJECTIVE-ADVERB

alike, amiss, apropos, away, backward, deadly, doubtless, downright, early, else, fain, farther, farthest, far, headlong,

          upward, very, whilom, wide, yearly, yonder, yon

Category: "pure" PRONOUN

anybody, anyone, anything, everybody, everyone, everything, herself, hers, he, himself, him, idem, itself, I, me, myself, no

          whosoever, whoso, who, yourself, yours, you

Category: NOUN-ADVERB

adagio, alias, allegro, andante, aside, aye, forte, hereafter, here, horseback, incognito, largo, meantime, meanwhile, midway, may, outdoors, peradventure, percent, pro, seaward, solo, tandem, tete-a-tete, today, tonight, whereabouts, wherefore, yesterday, yes

Category: "pure" CONJUNCTION

albeit, although, and/or, and, as if, as long as, as soon as, as though, because, if, inasmuch as, insofar as, lest, nor, or, supposing, than, unless, whenever, whensoever, whereas, whatever, whereat, whereof, wheresoever, whereto, whether, whilst, whithersoever

Category: NOUN-ADJECTIVE-ADVERB

dead, deep, due, east, enough, extra, fair, first, high, ill, inland, least, little, north, no, overhead, quarterly, short, south, straight, then underground, upstairs, west, wild, worse

Category: NOUN-ADJECTIVE-VERB-ADVERB

back, best, better, counter, double, fast, fine, flat, flush, forward, foul, full, last, long, plumb, plump, right, sharp, still, thwart, true, well, worst, wrong, zigzag
Category: ADVERB-PREPOSITION  
Frequency: 23
abaat, aboard, about, above, across, alongside, along, around, aslant, astraddle, athwart, below, beneath, besides, beside, between, beyond, by, throughout, to, underneath, within, without

Category: "pure" INTERJECTION  
Frequency: 19
adios, ahoy, alleluia, aloha, amen, auf wiedersehen, eureka, fie, gesundheit, hallelujah, hollo, hosanna, hurrah, huzzah, lo, prithee, roger, viva, zounds

The remaining parts of speech are all mixed categories with frequency less than ten. They include the following:

Category: ADJECTIVE-PRONOUN  
Frequency: 9
another, her, his, other, some, whatever, whichever, which, whose

Category: NOUN-VERB-ADVERB  
Frequency: 8
bang, bias, collect, con, crisscross, fleet, nix, tiptoe

Category: ADJECTIVE-ADVERB-PRONOUN  
Frequency: 8
all, any, each, none, same, such, this, what

Category: ADJECTIVE-ADVERB-PREPOSITION  
Frequency: 7
next, nigh, off, on, over, through, under

Category: ADVERB-CONJUNCTION  
Frequency: 6
howbeit, however, though, whereupon, wherever, yet

Category: VERB-ADJECTIVE-ADVERB  
Frequency: 5
even, free, further, loose, pretty

Category: NOUN-PREPOSITION  
Frequency: 5
at, failing, midst, vice, worth

Category: NOUN-ADJECTIVE-ADVERB-PREPOSITION  
Frequency: 5
astride, in, less, opposite, outside
<table>
<thead>
<tr>
<th>Category: ADJECTIVE-PREPOSITION</th>
<th>Frequency: 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>behind, pending, unlike, wanting</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: NOUN-ADJECTIVE-PREPOSITION</th>
<th>Frequency: 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>following, minus, past, plus</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: ADVERB-PREPOSITION-CONJUNCTION</th>
<th>Frequency: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>before, notwithstanding, since</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: NOUN-VERB-PREPOSITION</th>
<th>Frequency: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>bar, pace, till</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: ADJECTIVE-PRONOUN-CONJUNCTION</th>
<th>Frequency: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>both, either, neither</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: PREPOSITION-CONJUNCTION</th>
<th>Frequency: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>but, for, until</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: NOUN-VERB-ADJECTIVE-ADVERB-PREPOSITION</th>
<th>Frequency: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>down, out, up</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: NOUN-PRONOUN</th>
<th>Frequency: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>it, nobody, somebody</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: NOUN-ADJECTIVE-PRONOUN</th>
<th>Frequency: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>few, many, one</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: VERB-ADVERB</th>
<th>Frequency: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>OK, upstage</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: NOUN-ADVERB-PREPOSITION</th>
<th>Frequency: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>inside, vis-a-vis</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: NOUN-ADVERB-PRONOUN-CONJUNCTION</th>
<th>Frequency: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>when, where</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category: NOUN-PRONOUN-ADVERB</th>
<th>Frequency: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>nothing, there</td>
<td></td>
</tr>
</tbody>
</table>
All of the remaining categories have a single occurrence and shall hence be only listed with POS categories and the word.

ADJECTIVE-ADVERB-CONJUNCTION.........................only
ADJECTIVE-ADVERB-PREPOSITION-CONJUNCTION........after
ADJECTIVE-ADVERB-PRONOUN-CONJUNCTION...............that
ADVERB-DEFINITE+ARTICLE..............................the
ADVERB-PREPOSITION-PRONOUN-CONJUNCTION...........as
ADVERB-PRONOUN-CONJUNCTION........................so
ADVERB-PRONOUN.........................................somewhat
NOUN-ADJECTIVE-ADVERB-INTERJECTION...............fore
NOUN-ADVERB-CONJUNCTION..............................while
NOUN-ADVERB-INTERJECTION..............................why
NOUN-INDEFINITE+ARTICLE..............................a
NOUN-VERB-ADJECTIVE-PREPOSITION-CONJUNCTION.....like
NOUN-VERB-ADJECTIVE-PREPOSITION......................round
NOUN-VERB-CONJUNCTION..............................while
NOUN-VERB-INTERJECTION...............................hail
NOUN-VERB-PREPOSITION-CONJUNCTION..................save
NOUN-VERB-PRONOUN.....................................mine
PRONOUN-DEFINITE+ARTICLE.............................ye
VERB-ADJECTIVE-ADVERB-PREPOSITION..................near
VERB-ADJECTIVE-PRONOUN...............................own
VERB-PREPOSITION-CONJUNCTION.......................except
APPENDIX IV

DISAMBIGUATION PROTOCOL TRANSCRIPT

Transcribed Tape Recorded Protocol of the Disambiguation Procedure

This session was recorded on April 26, 1979, well after the completion of the actual disambiguation phase. Thus, this present task provides both data on intuitive criteria as well as a consistency comparison with the scores assigned to the kernel terms in the actual procedure. The disambiguator, GAH, was provided a blank coding form consisting of noun main entries with sense definitions and kernel candidate terms beginning with the letter M; as well as a copy of the MPD for reference. Presented here are excerpts of the session, for the kernel candidate term MARK. Also present at the session was project supervisor RA.

The text is extracted verbatim from the transcribed tape recording with <,> text added to show what portion of the coding form or dictionary was being examined. Centered text segments contained within ==='s are boundaries of extracts. [,]’s contain scores entered during the session, separated by a semicolon from the original score entered several months ago. Horizontal spacing is indicative of short pauses, vertical spacing represents longer pauses. The ... segments do not represent omitted material, but are used for speech which trailed off into a pause. {,}’s represent non-text exclamations. Asterisks within <,>’s mark where material was obscured on the coding form.

=== BEGINNING OF KERNEL CANDIDATE TERM "MARK" ===

<PATHFINDER .OB........ = MARK............. ONE THAT EXPLORES UNTRAVELED REGIONS TO MARK OUT A NEW ROUTE>

GAH: pathfinder - the one that explores untraveled regions to mark out a new route

verb
[ X ; X ]

<PERIOD 1.3A.......... = MARK............. A PUNCTUATION MARK $161$1 USED ESP. TO MARK THE END OF A DECLARATIVE SENTENCE OR A* *ABBREVIATION>

a punctuation mark , period

[Note: $161$1 is a symbol code for a non-ASCII character]
<1 mark <n> 1 : TARGET; also : GOAL, OBJECT 2 : something (as a line or fixed object) designed to record position; also : the starting line or position in a track event 3 : BUTT 4 : the question under discussion 5 : NORM <not up to the -> 6 : a visible sign : INDICATION; also : CHARACTERISTIC 7 : a written or printed symbol 8 : GRADE < a 9 of B++> 9 : IMPORTANCE, DISTINCTION 10 : a lasting impression>

OooK
[Clears throat] Target
something designed to record, position the starting line

question, norm, a visible sign, indication or characteristic a written or printed symbol here we go, that's probably it grade, importance, distinction a lasting impression

OK, it's 1.7A
{tch}
[ 1.7A ; 1.7A ]

<POINT 1.7A............. = MARK............. A PUNCTUATION MARK ; ESP>

point

a punctuation mark ... the same thing
[ 1.7A ; 1.7A ]

<POINT 1.8A............. = MARK............. A DECIMAL MARK>

point a decimal mark

is a written symbol
[ 1.7A ; 1.7A ]

<POST 1.2A............. = MARK............. A POLE OR STAKE SET UP AS A MARK OR INDICATOR>

post - a poll or stake set up As a mark OK, this is set up As a visible sign

that's 1.6 A
slash plus since it is not in the kernel
[ 1.6A/+ ; X ]

<POSTMARK .OB........... = MARK............... THE MARK CANCELING THE
POSTAGE STAMP>

postmark - the mark canceling the postage stamp
{tch} well, now this is very interesting
{tch} postmark is a visible sign
it is also a printed sym... no its not a symbol

something designed to record position no
no
a visible sign
{tch} {sigh} {tch-tch tch-tch}
well, it's not the same kind of visible sign that
a pole or stake is

{?? Oh ??}, but I'd still 1.6A
{tch}, alright
[ 1.6A (later changed to 1.7A - see ahead) ; 1.7A ]

<PRICK 1.1A............ = MARK............... A Mark or small wound made by
a pointed instrument>

prick - a mark or small wound
not a target, not designed to record, not the starting line
not the butt, not a question under discussion or a norm

again this is a visible sign
[ 1.6A ; 1.6A ]

<PRINT 1.1A............. = MARK............... A mark made by pressure>

print - a mark made, by pressure
{tch} a visible sign
[ 1.6A ; 1.6A ]

<PROFESSIONALISM .1A.. = MARK............... The conduct, aims, or
qualities that characterize or mark a profession or a prof*
*ional person>

professionalism - the conduct, aims or qualities that characterize or mark,
verb,
[ x ; x ]

<QUESTION MARK .0A..... = MARK............. A PUNCTUATION MARK $18$1 USED
ESP. AT THE END OF A SENTENCE
TO INDICATE A DIRECT QUESTION>

a question-mark, a punctuation mark is 1.7 A
[ 1.7A ; 1.7A ]

<SCAR .0A............. = MARK............. A MARK LEFT AFTER INJURED
TISSUE HAS HEALED>

scar - a mark left after injured tissue has healed

Ah HA - a visible sign? Yes
[ 1.6A ; 1.6A ]

<SCRATCH 2.1A........... = MARK............. A MARK MADE AS OR AS IF BY
SCRATCHING ; ALSO>

scratch - a mark made by or as if by scratching

a visible sign
[ 1.6A ; 1.6A ]

<SEAL 3.3A.............. = MARK............. A MARK ACCEPTABLE AS HAVING
THE LEGAL EFFECT OF AN
OFFICIAL SEAL>

seal - a mark acceptable as having the legal effect of an
official seal

a mark?

I think that this is a written or printed symbol

yes
[ 1.7A ; 1.7A ]

{tch}
which makes me want to go back and reconsider postmark
again

and I'm going to change that one
to 7A as a written symbol
[ erases 6 in score for MARK in POSTMARK .0B
and enters 7 in its place]

<SEMICOLON .0A........ = MARK............. A PUNCTUATION MARK $167\$1
USED ESP. IN A COORDESP.
INATESP. ING FUNCTION BETW*
MAJOR SENTENCE ELEMENTS>

{tch} semicolon, a punctuation mark   is 1.7A
[ 1.7A ; 1.7A ]

<STAMP 2.2A.............. = MARK............. THE MARK MADE BY STAMPING ;
ALSO>

stamp - the mark made by stamping      1.7A
[ 1.7A ; 1.7A ]

=== END OF SESSION ===
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Salton, G. and Lesk, M.F. (1971). "Information analysis and


