MODELING DICTIONARY DATA

by

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ABSTRACT

Forms and structures of definitions in Merriam-Webster's dictionaries are presented to derive models of sense selection contexts, sense meanings, and hierarchical relations among verbs. The sense meaning model is presented as a case-role semantics accompanied by time-ordered sets of assertions marked for truth value. Systematic extraction of these types of models from dictionary data is argued to be an encouraging line of research.

I think we are all agreed that since about 1968 we have had some very interesting natural language processing systems that have very limited but powerful capabilities within those limitations. The critical thing that has been going on in these is to choose a microworld as Ralph Grishman suggested [reference to preceding talk] where there is very little that in fact can be said, and then you are able to manage the semantics.

Now the situation of trying to understand text is quite different. You know, examples of those microworlds are The Woods Airline Guide [2], and the lunar rocks data base [3], the Winograd hand-and-blocks [4], and the Heidorn trucks at a gas depot [5], and Schank's John and Mary -- with John's attitude towards Mary. [laughter] And there are others. I think that in text processing we are nowhere near in such good shape. I have seen interesting experiments by Sager about 3 years ago [6] in terms of getting some semantic structure out of documents and I recall early work by Harris [7], to get kernel sentences out of documents. And most recently we have some work by Charniak on children's stories [8] in which the great contribution was, I think, to show how incredibly difficult it is to solve the problem of reference even there, in order to find the antecedent for a pronoun, 'it'. There are a couple of examples where you have to have the full strength of some kind of a problem solving/theorem prover system.

Most recently, a paper that hasn't gotten around very much, is a very ambitious effort by Roger Schank [9] on setting up discourse structure for paragraphs. That paper will probably be circulating pretty widely by Spring. In that, he very ambitiously takes the folk tale from Eskimo literature - several paragraph stories - about 5 I think - and he makes a causal chain of the relationships among the deep conceptual dependency structures that he derives. It's easily criticizable. There are many things where each of us would differ on whether that is the path or exactly what is going on. But I admire it very much because it is a very ambitious attempt to deal with a fairly large piece of text. The point is we don't have models for dealing with large amounts of text, or even with several paragraphs of text. We don't really know how to handle the semantics of text discourse.

The basic problems are: How do you use sentences to understand following sentences? How do you solve problems of reference? And what is an adequate lexical structure to do this? What is an adequate semantic structure to represent the resulting meanings? That whole family of questions is seeking answers.

We are very much concerned in my group at Texas to study all these things. We have one student (we haven't got very much budget for this) but one student is working on discourse analysis; a dissertation by Hendrix [10] is about finished on modelling techniques -- an approach toward representing meanings as set-theoretic expressions. It takes semantic nets right down to the abstract algebraic description of what the meaning of sentences is.

And what I will talk about today is Robert Amsler's studies of the Merriam-Webster dictionaries.

With that introduction, let me shift to the business of computational lexicology. I think 'lexicology' is a fine enough word. It is in contrast to lexicography -- studying how to put together meanings to make a dictionary is lexicography. Lexicology is, as best I understand it, the study of how the meanings are organized; what is the hierarchical structure; how much in the way of loops and things of this type occur; and how can you take and transform from this list, 150,000 entries, alphabetically organized, into some organization that is computationally more significant. That, essentially, is the study. The desired outcome is to transform the dictionary into data that is reasonably computable; and hopefully to get semantic models out with considerably less difficulty than is currently the case.

Now I want to talk about the kinds of semantic models. There are really three kinds of data that we are able to get, from the English lexicon. One is a model for the meaning of a word. And I will show examples of what I mean by model shortly. The next is a model that for each sense meaning of a word can detect the context patterns that will select that sense rather than some other. The third thing of course is we want to organize the whole set of words that use that word in its definition. Now these things will, I hope, become clearer in a little bit.

First, to the dictionary. I think we know from a linguistic point of view that the proper source of semantic information is a large corpus of ordinary usage of the language -- a very large corpus; the Brown-Kucera corpus [11] is one example; perhaps larger ones are needed. In about 1966, while I was still at System Development Corporation, with John Olney, John put in a proposal to NIH to keypunch Webster's Collegiate Dictionary. He managed to get the grant, and it cost about $35,000 and about two years to get the thing keypunched with great accuracy -- 1 error in a thousand strokes, or something of this level was the quality control on it. And he incidentally keypunched Webster's Pocket Dictionary [12]. Now the mass of data here is quite significant. The Webster's Collegiate currently resides on eight tapes. Now several years later and we could probably get that on 2 or 3 tapes of high density form. The pocket dictionary fits comfortably on one tape, but it pretty much fills it up. Whenever one does some computation with these data bases it is likely to be very expensive. So I have really spent a great deal of time over the past 5 years at Texas discouraging people from running these tapes through the computer unless they had a really strong hypothesis and a well-formulated plan.

Now, why this particular lexicon? I think somewhere we are aware of the fact, for example, that Random House also has a keypunched version of a rather large dictionary [13]. And some work has been done on that too. John Olney liked the Webster's dictionary because he went up and visited the people in Springfield: Gove was editor at that time: and John was very much impressed by the way that they went about making their dictionary. What they have done, is to accumulate citations for perhaps fifty or one hundred years, and they have room after room of files filled with citations of usages of words. So there is the corpus on which that dictionary is based. Now many not-so-careful dictionary makers don't do that. You know their offices are typically -- a dozen filing cabinets and a large shelf of dictionaries [laughter] and they sort of rewrite the definitions from one dictionary on an intuitive basis or something into another form. Well Merriam-Webster's is a much more careful operation. People collect these citations and the process of making a dictionary from the citations is as follows:

Let us suppose that for the word 'move' you might have a thousand citations. And so you start putting them into heaps of similiar usages. You sort them out into pile and pile, pile, pile: and then you decide how to describe each pile. OK, the resulting description is a sense meaning for one usage of the word 'move'. Well, in Webster's Third International [14], in addition to presenting that description, a usage example is also included. And in the Collegiate it is very frequently the case that with the sense meaning there will be an example.

So what I am suggesting is that the Merriam-Webster's dictionaries are in fact based on a large corpus of English usages that are carefully collected. Now I suppose the weakness here is that it is all written usages, I imagine, I am not sure -- rather than spoken language. When a sense description is compiled with a typical usage example one is not quite sure how typical that example is and not quite sure how free it is from particular biases of a particular lexicographer who is liable to be an English teacher brought in every few years to go through the massive effort of producing a new edition of the dictionary. I think there is a new one due out in 1976, a Fourth International. Well, I am not too close to that, but linguistic quality is the reason that John Olney chose the Merriam-Webster's dictionary as a data base that was suitable for keypunching.

Now we have been poking around with dictionaries for quite some time, and they are really hard to work with. I might add by the way there are about 20 copies of these tapes around the country in various research groups, and not too much has been done in the seven years that that corpus has been available. The reason is because it is/very very difficult and expensive to work with it, and very hard to know what you are doing while you work with it. And I am sad to say you may get that idea very clearly by the time this lecture is finished.

Now let me show you some of the things that emerge from Amsler's work on this dictionary. One of the first things that we have all noticed in the dictionary is that there appear to be hierarchical properties. Words are defined in terms of other words. And there is a tendency to go up the tree to an increasingly more abstract word. So 'march' might be defined in terms of 'walk' and 'walk' eventually gets up to 'move'. Figure 1 is an example of that. 'Retort' is defined "to answer sharply". And 'answer' is defined in its turn "to write or speak in response". 'write' is "to communicate in print" and to speak is "to communicate by voice." Finally, "to communicate" goes to "to make known" so we notice that the hierarchy is quite regular and we can now define "to retort" as "to make known by voice, in response, sharply."

Now what has been done? Well, we have taken advantage of the lexicographer's rather careful behavior to define a word in terms of a superclass word, a higher, more abstract term, while carefully setting out differentia as modifying phrases. So "to retort" is "to answer sharply." "to answer" is "to write or speak in response." So we are able in this hierarchy simply to lift up the differentia and to define everything in terms of the top-level verb. Well this is rather interesting. Many of us are aware of Schank's assertion that fourteen primitive verbs will account for all of the verb usages in English [15]. I doubt the number fourteen. On the other hand, it is fairly clear that a single primitive accounts for hundreds of verbs.

insert Figure 1 here

In these studies, we first looked at some 600 verbs of communication. In order to do that we inverted the dictionary so that for each word that occurred in a definition we had an entry; and associated with that entry were the definitions that it had occurred within. So by inverting the dictionary file we were able to sort things and discover just how words go up the tree — and sometimes around in circles. In the 600 verbs of communication there are 3 senses of meaning for communication and we haven't studied them in exhaustive enough detail to be absolutely sure, but it is my impression that 2 or 3 models of 'make known', i.e. 'communicate', will account for some 600 verb meanings by following this pattern of carrying up the differentia.

Most recently, Amsler has studied 200 verbs of motion; and the way he got these was a little bit simpler. The communication verbs are a deep hierarchy. On the verbs of motion, he simply took from the inverted file all of the verbs that use the word 'to move' as the defining kernel, — i.e. as the superclass; and those go up to what appear to be some 5 or 6 sense meanings of 'move.' I will show you these sense meanings shortly.

Figure 1.

Using a Hierarchy of Verbs

RETORT	-	TO ANSWER SHARPLY
ANSWER	-	TO WRITE OR SPEAK IN RESPONSE
WRITE	-	COMMUNICATE IN PRINT
SPEAK	-	COMMUNICATE BY VOICE
COMMUNICATE	-	MAKE KNOWN

TO RETORT ⇒ MAKE KNOWN, BY VOICE, IN RESPONSE, SHARPLY

⇒ MAKE KNOWN, IN PRINT, IN RESPONSE, SHARPLY

The point of the hierarchy of verbs, particularly with reference to collecting semantic information, is: how can we sort the material that occurs in a good dictionary so that conceivably we can make models for 20, 50 or 100 units of meaning, and classify everything that is defined in terms of those words underneath them. There will be a great savings computationally if we are able to do this.

Let's see what I mean by a model. Let's consider a sentence, "John wired a greeting to Mary." We are still in the verbs of communication here. "to wire" is "to telegraph". "to telegraph" is to communicate, instrument telegraph, medium telegram. Now the representation of meaning that I found quite useful for answering questions is the semantic net structures that I have talked about many times but the notation is simpler now. In Figure 2 C2 is a token of 'communicate'; the verb used was 'wire'. The tense is past, Actant or Agent - John, Theme - a greeting. Source - John. Goal - Mary. Instrument - telegraph. Medium - telegram. That is what we can get out of a shallow level analysis of the sentence "John wired a greeting to Mary". Now that is just the first stage. I am not quite sure of terminology yet, but I think of that as a shallow semantic analysis or a shallow semantic structure. I used to call it a deep case structure but it is really not very deep at all. Those of you who are acquainted with the dependency structure can see that this head verb is simply in a flat tree dominating all of these arguments. Now the structure is really quite syntactic although it has semantic aspects. I also assume, by the way, that we have selected the particular sense meanings of these words.

insert Figure 2 here

Now we want more. First of all, associated with the definition of 'wire' are things that will take it up to 'communicate', and add arguments to the meaning of communicate. But now associated with communicate also in addition to the syntactic data that is needed to sort out its arguments will be a set of assertions. If somebody is to communicate something it is an event that occurs in time. So at the initial time, t1, the agent or actant knows the theme. John knows the greeting he sends. I think 'know' will be a primitive.

At t2 he sends the medium which in this case is the telegram. It might have been a letter. It might have been anything that carries information in regard to a communicate verb. At time t3 it is possible the goal person will receive that telegram; at time t4 it is possible that the goal person will know the message. So the final values of each assertion are: true, true, true, possible, possible. It is also the case that John, the agent, wanted the goal person to know the message and he wanted this at least from t1 to t3 when he sent it. Now that is a fair but not absolutely necessary type of inference. So what we are doing is to associate with 'communicate' a set of assertions defined over the argument

Figure 2.

A Communication and Some of its Meaning

<u>JOHN WIRED A GREETING TO MARY</u>

To Wire ⟹ To Telegraph

To Telegraph ⟹ To Communicate, Inst: Telegraph, Med: Telegram

```
(C1 TOK  COMMUNICATE, VB  WIRE, TENSE  PAST,
    A JOHN, TH  GREETING, S  JOHN, G MARY,
    INST  TELEGRAPH, MED  TELEGRAM)
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```
COMMUNICATE: ASSERT  (( KNOW   A   TH   T1   TN   T)
                      ( SEND   A   MED  T2   T3   T)
                      ( GET    G   MED  T3   T4   P)
                      ( KNOW   G   TH   T4   TU   P)
                      ( WANT   A   ( KNOW   G   TH) T1   T3   T))
```

Instantiation:

```
(( KNOW   JOHN   GREETING   T1   TN   T)
 ( WANT   JOHN   ( KNOW   MARY   GREETING) T1   T3   T)
 ( SEND   JOHN   TELEGRAM   T2   T3   T)
 ( GET    MARY   TELEGRAM   T3   T4   P)
 ( KNOW   MARY   GREETING   T4   TU   P))
```

variables. And when these are applied to the particular usage we discover that John knows the greeting at time t1 to tn, which means that he knew the greeting all along, and John wanted Mary to know the greeting from t1 at least until he sent it, and John sent the telegram from time interval t2 - t3; it is possible that Mary got the telegram during time t3 - t4; and it is possible that Mary knows the greeting at some time t4 to tu'. It is also important to point out that t1 is before t2, t2 is before t3, etc., and tu is before now, are all assertions that hold. So what is going on here? This is really what we mean by a model. We mean that the assertions that are explicitly made in the sentence are one part of the model of the meaning of that sentence and the assertions that are implied in the setence are another part of the model. So the lexical structure that we seek would make those explicitly available. Now we know from the work of Charniak and Schank's students, Riesbeck[16], Rieger[17], and Goldman[18] that these things are definitely going to be useful in discourse analysis, although I confess I don't know how to do discourse analysis with this type of assertion yet. That is another line of research we are very much concerned with.

When we analyze a mass of verbs one of the things that we are attempting to do is to discover the case arguments that go along with each. For the verbs of communication (see Figure 3), there are: agent - which is an animate organism; theme - contents of the communication; source - the person or system that sends it; goal - the receiver; manner - for example, sharply, harshly; instrument - telephone, telegraph, voice; depth and length - long, short; frequency - repeatedly; intensity - loudly; and medium - the form of the communication.

insert Figure 3 here

I think that is enough for communication verbs, as a notion to get started with. Figure 4 is an example of the data that has been put together -- This is one page from the 200 verbs of motion, and what has gone on here, is shown for example in 'paddle 2.1'; moves; theme - the hands and feet; path - about; medium - presumably water or something of this sort; So what is done is to take the verbs and using an ordinary editor program go through with as little change in the definition as possible, and mark the category of each distinguishing argument for the usage. In fact, it takes a lot of sorting in heaps before one can get categories organized and then one begins to edit the definitions to get them into uniform structure.

insert Figure 4 here

Figure 3.

Arguments of Communication Verbs

AGENT - Person or Animate

THEME - Contents of Communication

SOURCE - Place or Person

GOAL - Person

MANNER - e.g. Sharply, Harshly

INSTRUMENT - e.g. Telephone

DEPTH/LENGTH - e.g. Long ... Descant

FREQUENCY - e.g. Repeatedly ... Nag

INTENSITY - e.g. Loudly ... Bellow

MEDIUM - e.g. Form of Communication - Letter, Telegram

Figure 4.

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HURRY 3 - MOVE OR ACT (SPEED: WITH HASTE)
HURTLE 1 - MOVE WITH (SOUND: A RUSHING SOUND)(SPEED: RUSH)
INCH 2.1B - MOVE (SPEED: SLOWLY) <CARS INCHING ALONG THE SLIPPERY ROAD>
JERK 2 - MOVE IN (SUB-ACTS:  (DISTANCE: SHORT)(ACCELERATION: ABRUPT) MOTIONS)
JIGGLE 1 - MOVE WITH (SPEED: QUICK)(DISTANCE: LITTLE)(STEADINESS/SUB-ACTS: JERKS)
JOLT 1 - MOVE WITH A (ACCELERATION: SUDDEN)(STEADINESS: JERKY) MOTION
KEDGE 1 - MOVE (THEME: A SHIP) BY (SUB-ACT; HAULING ON (INSTRUMENT; A LINE ATTACHED TO A SMALL ANCHOR DROPPED AT THE DISTANCE ...
KEDGE 1 ... AND IN THE DIRECTION DESIRED)(NON-MOVERS: <2+>))
LASH 1.1 - MOVE (EMOTIVE/FORCE: VIGOROUSLY)
LABOR 2 - MOVE WITH (EMOTIVE/FORCE: GREAT EFFORT)
LUMBER 1 - MOVE (FORCE/EMOTIVE: HEAVILY) OR (EMOTIVE: CLUMSILY)
LURK 1 - MOVE (EMOTIVE: FURTIVELY) ; /SNEAK/
MARCH 1 - MOVE (PATH: ALONG) IN OR (EMOTIVE: AS IF IN MILITARY FORMATION)
MIGRATE 1 - MOVE FROM (SOURCE: ONE COUNTRY, PLACE, OR LOCALITY) TO (GOAL: ANOTHER COUNTRY, PLACE OR LOCALITY)
MILL 2 - MOVE (PATH: IN A CIRCLE) OR (MEDIUM: IN AN EDDYING MASS)
NOD 2 - MOVE (PATH: UP A DOWN) <THE TULIPS NODDED IN THE BREEZE>
NOSE 2 - TO PUSH OR MOVE WITH (INSTRUMENT; THE NOSE)
NOSE 6 - MOVE (PATH: AHEAD)(SPEED: SLOWLY) <THE SHIP NOSED INTO HER BERTH>
PADDLE 2.1 - MOVE (THEME: THE HANDS A FEET)(PATH; ABOUT) IN (MEDIUM; SHALLOW WATER)
PADDLE 2.1 - MOVE (PATH: ON) OR (PATH: THROUGH)(MEDIUM: WATER) BY USING (INSTRUMENT: A PADDLE) OR (MANNER: AS IF BY USING A PADDLE)
PASS 1.3 - MOVE (PATH: PAST),(PATH: BEYOND), OR (PATH: OVER)(NON-MOVERS: <1+>)
PLAY 2.2 - MOVE (MOTIVE; AIMLESSLY)(PATH: ABOUT) ; /TRIFLE/ <PLAYS WITH A RING NERVOUSLY>
PLAY 2.6 - MOVE OR OPERATE IN A (SPEED: BRISK),(PATH/STEADINESS/FREQUENCY: IRREGULAR), OR (STEADINESS/FREQUENCY: ALTERNATING) MANNER
POUND 4 - MOVE OR MOVE (PATH; ALONG) (FORCE/EMOTIVE: HEAVILY)
PROGRESS 1 - MOVE (PATH: FORWARD) ; /PROCEED/
PUTTER 1 - MOVE OR ACT (MOTIVE: AIMLESSLY) OR (MOTIVE: IDLY)
RATTLE 2 - MOVE WITH (SOUND: A CLATTERING SOUND) <RATTLE DOWN THE ROAD>
RECEDE 1 - MOVE (PATH: BACK) OR (PATH: AWAY) ; /WITHDRAW/
RECIPROCATE 1 - MOVE (PATH; BACKWARD A FORWARD) (STEADINESS/FREQUENCY; ALTERNATELY) <A RECIPROCATING MECHANICAL PART>
REMOVE 1.1 - MOVE FROM (SOURCE: ONE PLACE) TO (GOAL: ANOTHER PLACE) ; /TRANSFER/
REMOVE 1.2 - MOVE BY (SUB-ACT; LIFTING) OR (SUB-ACT: TAKING (PATH; OFF) OR (PATH; AWAY)(NON-MOVERS; <1+>))
REVOLVE 12 - MOVE OR CAUSE TO MOVE (PATH: IN AN ORBIT) ; <ALSO> ; /ROTATE/
RIDE 2 - TO FLOAT OR MOVE (PATH: ON (MEDIUM; WATER)) <RIDE AT ANCHOR> ; <ALSO> ; TO MOVE (MANNER; LIKE A FLOATING OBJECT)
RING 2.2 - MOVE (PATH: IN A RING) OR (PATH: SPIRALLY)
RISE 7 - MOVE (PATH: UPWARD) ; /ASCEND/
ROCK 1 - MOVE (PATH: BACK A FORTH) IN (INSTRUMENT: CRADLE) OR (PATH; AS IF IN A CRADLE)
ROLL 1 - MOVE BY (SUB-ACT: TURNING (PATH: OVER A OVER))
ROLL 2 - MOVE ON (INSTRUMENT: WHEELS)
ROLL 3 - MOVE (PATH: ONWARD AS IF BY COMPLETING A REVOLUTION) <YEARS ROLLED BY>
RUN 15 - MOVE IN (QUANTITY: SCHOOLS) ESP. TO (GOAL; A SPAWNING GROUND) <SHAD ARE RUNNING>
RUN 7 - MOVE ON (INSTRUMENT; WHEELS) OR (FORCE/RESISTANCE; AS IF ON WHEELS) ; PASS (RESISTANCE: FREELY)
RUSH 1 - MOVE (PATH: FORWARD) OR ACT (EMOTIVE: WITH TOO GREAT HASTE OR EAGERNESS OR WITHOUT PREPARATION)
SCOUR 1 - MOVE (SPEED: RAPIDLY)(PATH; THROUGH) ; /RUSH/
SCREW 3 - MOVE OR CAUSE TO MOVE (PATH: SPIRALLY)
SCUD 1 - MOVE (SPEED; SPEEDILY)
SHAKE  1 - MOVE OR CAUSE TO MOVE (STEADINESS: JERKILY) OR (PATH/STEADINESS/FREQUENCY; IRREGULARLY); /QUIVER/
SHUFFLE 3 - MOVE WITH A (SPEED/RESISTANCE: SLIDING GAIT) OR (SPEED/RESISTANCE: DRAGGING GAIT)
SHUTTLE 1 - MOVE (PATH; BACK A FORTH)(SPEED; RAPIDLY) OR (FREQUENCY; FREQUENTLY)
SIDLE 1 - MOVE (PATH; SIDEWAYS) OR (ORIENTATION; SIDE FOREMOST)
SKIP 1 - MOVE WITH (SUB-ACTS: LEAPS A BOUNDS)
SKULK 1 - MOVE (EMOTIVE: FURTIVELY) ; /SNEAK/ , /LURK/
SLIDE 1 - MOVE OR CAUSE TO MOVE (RESISTANCE: SMOOTHLY)(PATH: ALONG A SURFACE)
SLINK 1 :- MOVE (EMOTIVE: STEALTHILY) OR (EMOTIVE: FURTIVELY)
SMACK 1 - MOVE (THEME: THE LIPS)(MOTIVE/SOUND: SO AS TO MAKE A SHARP NOISE)
SMASH 2 - MOVE (PATH: FORWARD) WITH (FORCE: FORCE)  ^ (SUB-ACT: SHATTERING EFFECT)
SNEAK 1 - MOVE, ACT , OT TAKE IN A (EMOTIVE; FURTIVE) MANNER
SPIN 6 - MOVE (SPEED: RAPIDLY)(PATH: ALONG)
SPIRAL 1 - MOVE (PATH: IN A SPIRAL COURSE)
SPRING 1 - MOVE (ACCELERATION; SUDDENLY)(PATH: UPWARD) OR (PATH; FORWARD) ; /LEAP/ , /BOUND/
SPRING 3 - MOVE (SPEED: QUICKLY) BY (INSTRUMENT; ELASTIC (FORCE: FORCE))
SQUELCH  2 - MOVE IN (MEDIUM: SOFT MUD)
STEAM 3 - MOVE BY (INSTRUMENT: THE AGENCY OF STEAM) OR (MANNER: AS IF BY THE AGENCY OF STEAM)
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We are developing methodology - so we are working with the pocket dictionary; and it is quite clear that the pocket dictionary has abbreviated many, many meanings to the point where they are not useful. I think "scud - to move speedily" is a good case in point. 'March' is defined without even using the notion that it is on foot. Abbreviated definitions are fine for some purposes, but the Collegiate is much better for model making and of course the Third International is, as far as we can detect without looking at it exhaustively, quite good.

We also use the dictionary to develop context patterns that will identify the sense meanings for each word. Figure 5, for example, is an analysis of 'move' from the Third International which includes sentence examples.

Has a physical object changed location?
Yes, Has a physical object changed ownership or status?
Yes, e.g. The Christmas items were moving rapidly.
We just moved to town.
Has the physical object changed ownership or status, No.
Move 1 - e.g. The cars moved down the road.
The chess master moved the chess piece.

That one was puzzling for a while [laughter]

Has a part of the physical object changed location. Yes.
Move 2 - e.g. The trees moved gently in the breeze.
He moved restlessly in his sleep.
He pressed the button and the machine began moving.
And so on.

Here is a continuation of that chart.

Has the rate at which something was happening changed? Yes.
e.g. The plot moved quickly. The melody moves upward.
Has some action which is a part of the plan or procedure been proposed or performed? So we get into Move 6.
Move for a recess.
Revolutionaries must make their moves carefully.
Moves in social circles.
Has someone's emotional state changed?
Move to tears.

insert Figures 5a,5b,5c here

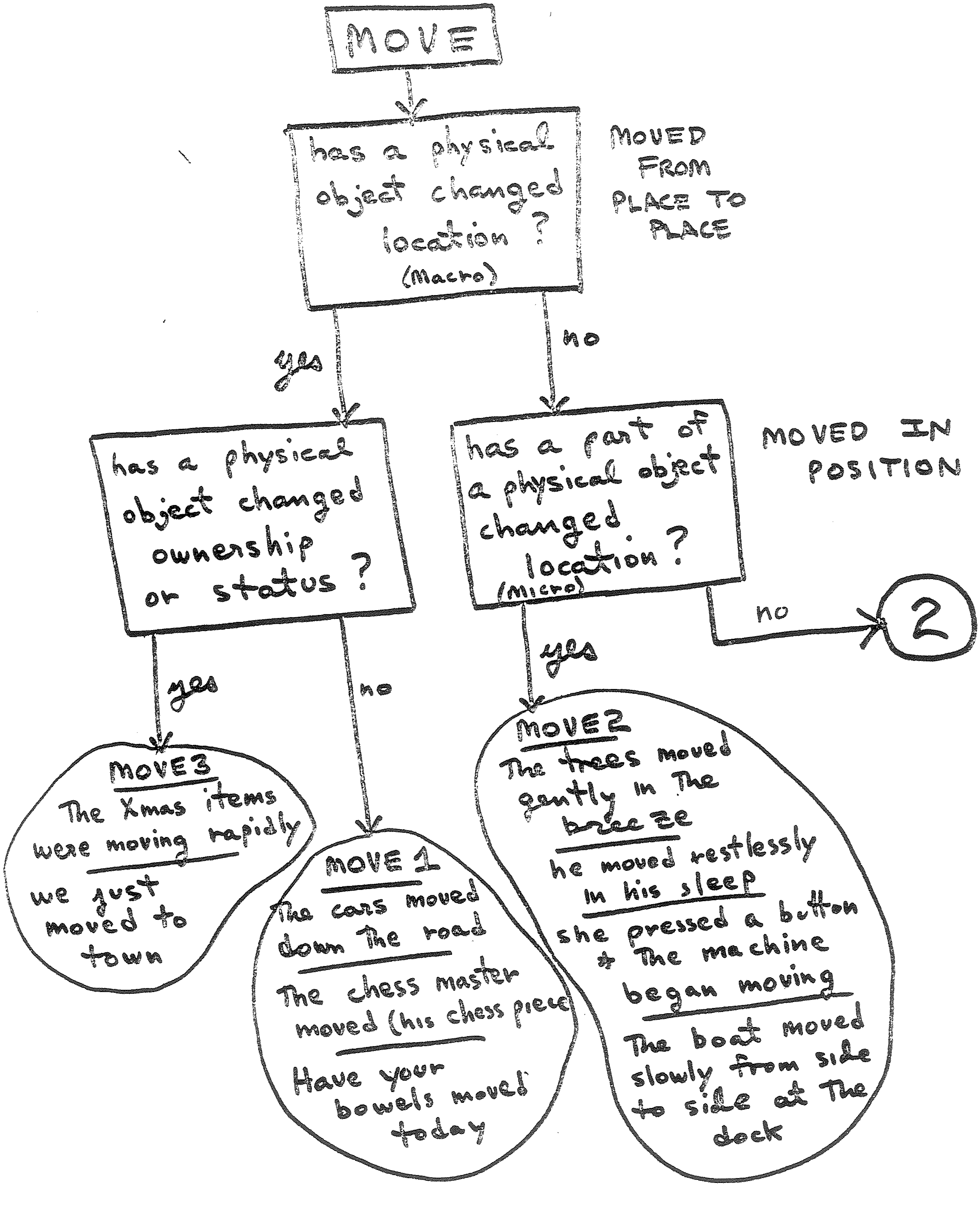
MOVE
has a physical object changed location ? (Macro)
MOVED FROM PLACE TO PLACE
yes
no
has a physical object changed ownership or status ?
has a part of a physical object changed location ? (Micro)
MOVED IN POSITION
no
2
yes
yes
no
MOVE3
The Xmas items were moving rapidly
we just moved to town
MOVE 1
The cars moved down The road
The chess master moved (his chess piece
Have your bowels moved today
MOVE2
The trees moved gently in The breeze
he moved restlessly in his sleep
she pressed a button & The machine began moving
The boat moved slowly from side to side at The dock

Fig 5a

MOVE$_{4,5,6}$

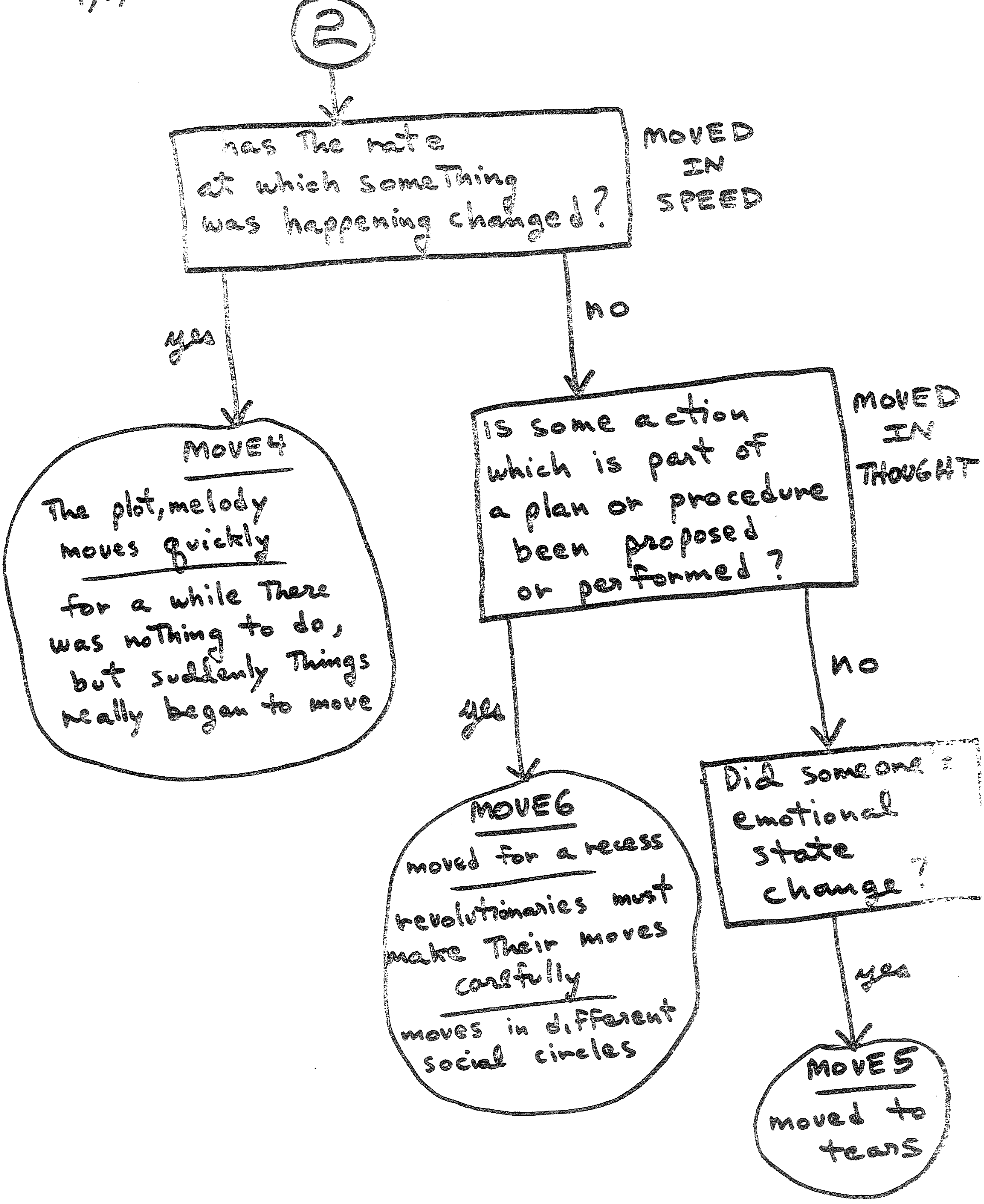
2
has The rate at which someThing was happening changed?
MOVED IN SPEED
yes
no
MOVE4
The plot, melody moves quickly
for a while There was noThing to do, but suddenly Things really began to move
Is some action which is part of a plan or procedure been proposed or performed?
MOVED IN THOUGHT
yes
no
MOVE6
moved for a recess
revolutionaries must make Their moves carefully
moves in different social circles
Did someone's emotional state change?
yes
MOVE5
moved to tears

Fig 5 6

FIGURE 5C.

MOVE CONTEXT PATTERNS

SENSE	AGENT	THEME	FROM SOURCE	TO GOAL	LOC	E.G.
MOVE1	*	PHYS-OBJ	Loc1	Loc2	MEDIUM	TRAVEL,MARCH
MOVE2	*	PHYS-OBJ PART			Loc1	AGITATE,FIDGET
MOVE3	⟨ANIMATE⟩	"CENTER OF ACTIVITY"	Loc1	Loc2		MIGRATE1
MOVE4		"PLOT, MELODY"	STATE1	STATE2		
MOVE5		EMOTIONAL STATE	STATE1	STATE2		TOUCH,PERSUADE,STIR2
MOVE6	⟨HUMAN⟩	"STATEMENT, RESOLVE"		STATE1		"MAKE A MOTION"

So there are six senses of 'move' that Amsler distinguished by studyinc the Third International. Now what does that mean computationally? In ficure 5a we have move 1, 2, 3, 4, 5, 6. We have the basic, most important, arguments that usually occur. And here the agent must be human. Move 6, is to make a motion or resolution. So we must check the theme to make sure that it has some kind of a marker equivalent to 'statement' or 'resolve', a 'resolution' or something of this sort; and of course we will check the agent to determine that it is human. Emotional state, move 5; e.g. "the novel moved me to tears"; the criterion is that the Theme be a person and the Goal an emotional state. In terms of our experience with microworld modeling, it is usually sufficient to mark the nouns with particular semantic features in this kind of an area. But will that approach work all across the language? Semantic features are probably not sufficient, so after defining the criteria for selecting the particular senses of meaning; How does one mark the appropriate information on the nouns and distinguish the types of sentences that can be arguments for that sense? -- Well, we have learned a lot in terms of microworld models. And I think this will solve eventually.

In studying the verbs of motion Figure 6 is our current set of argument classifications: agent, theme, source, goal, instrument, path, medium, speed, acceleration, steadiness, continuity, force, resistance, and orientation. Now Amsler is making quite a detailed study of these arguments because he is still exploring the possibility that he will be able to take the definitions and push them onto a display scope and draw particular kinds of squiggles to represent in real time the meaning of the motion verb. Whether he will be able to do that or not remains to be seen. It is clear and easy for some things and not for others. Notice manner, of course, is liable to be an attitude, and 'thud' is "to move with a heavy sound". If one wants to make pictures of meanings, one needs more than a tempero-spacial frame of reference; one must also pick up the connotative, emotional frame of reference. In the 200 or so move verbs, there are at least a dozen that have sound and probably a couple dozen that have connotative things going on. In 'lurk', for example, 'slyly' is one of the connotations that goes along with it. So it is rather hard to draw pictures of all of the move verbs.

insert Figure 6 here

Figure 7 is an example of how we expect to use the move verb. "Arnold marched the army slowly through the countryside from New York to Montreal." First we give the shallow semantics of the sentence. C1 is a move. C1 represents this whole proposition, this whole idea. There is a moving going on. The verb that was used is "to march". Now I saved the verb because I just don't want to fuss around like Goldman does trying to find my way back to the

FIGURE 6.

ARGUMENTS OF MOTION VERBS

AGENT

THEME - (OBJECT MOVED)

SOURCE - FROM

GOAL - TO

INSTRUMENT - (USED FOR MOVING)

PATH - (COURSE OR PATH-OF-MOTION)

MEDIUM -

SPEED - (E.G. FAST, SLOW)

ACCELERATION - (E.G. SUDDEN)

STEADINESS - (E.G. STEADY, WITH JERKS)

CONTINUITY - (E.G. FREQUENTLY)

FORCE - (E.G. FORCEFULLY, SLIGHTLY)

RESISTANCE - (E.G. WITH FRICTION, AS IF ON WHEELS)

ORIENTATION - (SIDE FOREMOST - SIDLE)

surface representation. Some of you have read Goldman's excellent thesis[18] in terms of how you go from Schank's very deep conceptual dependency structure back into making sentences but in some cases one can save a lot of trouble by carrying the verb along, and not get into that. The tense - past; the agent - Arnold; the theme - C2 is a token of an army; now in fact, one needs tokens for all words but I am not showing the complete computational representation; I am trying to communicate it. I had to put a token for 'army' because there is a difference between what amies do in general and what this army did. So: 'move', by marching, in the past, done by Arnold, from New York, to Montreal, through the countryside, in military formation, speed - slowly. Now using the type of modelling that we discussed in the verbs of communication, the assertions associated with 'move' translate into this time-ordered series of assertions: - that it is probably true that Arnold was at New York from t1 to t-delta. It is true that the army was at New York t1 to t-delta. It is probably true that Arnold was in the countryside from t-delta to tn. It is true that the army was there. It is probably true that Arnold was in Montreal from tn to tu and it is true that the army was in Montreal from tn to tu. And t1 is before t-delta; t-delta is before tn; tn is before tu and tu is before now; are all true. So we have got time going on. Now 'slowly' is translated into "greater the move rate of armies than the move rate of C2"; C2 was the token of the army; it was a particular instantiation of the concept 'army' that occurred in this context. And "in military formation" during the whole period is a reasonable inference to make. Now I don't want to make this sound very cut-and-dried because there are a lot of other inferences that might be made. Notice, nobody said the army was on foot. And yet marched implied that it was. And nobody said that the army was tired when they got to Montreal. I don't know whether they were or weren't. But probably it is the case that you would want to make that inference to understand "Why did they sleep for 24 hours thereafter?" Well you need to make the possible inference that if the distance is from New York to Montreal and if one walks or if on foot, well then one will probably be tired. And if tired, one will want to sleep for a long time.

insert Figure 7 here

I feel pretty good about how we are able to do things with verbs and I feel very hopeful that we can develop a methodology for sorting the dictionary to get this kind of information in fairly large quantities. With a generous sponsor some day we might just go at it and see how many primitives we in fact need for a particular purpose. The purpose is obviously important in terms of how you classify things.

I don't know very much about nouns. We have struggled with nouns. They also occur in hierarchies in the lexicon. One

Figure 7.

A Move Model

Arnold Marched The Army Slowly Through The Countryside From New York To Montreal.

```
(C1  TOK  Move, VB March, Tense Past, A Arnold,
     TH (C2  TOK  Army), MED  Countryside, S New-York,
     G  Montreal, MAN  (in Military Formation), SPEED  Slowly)

((ATP  Arnold  New-York  T1  T-DELTA)
 (AT   Army    New-York  T1  T-DELTA)
 (ATP  Arnold  Countryside  T-DELTA  TN)
 (AT   Army    Countryside  T-DELTA  TN)
 (ATP  Arnold  Montreal   TN  TU)
 (AT   Army    Montreal   TN  TU)
 (GR   (Moverate Army)(Moverate C2))
 (IN   Army  Military-Formation T1 TN)
 (Before  T1  T-DELTA)
 (Before  T-DELTA TN)
 (Before  TN  TU)
 (Before  TU  NOW) )
```

interesting fact is that the top of any noun hierarchy appears to be an argument position in a verb. Once again, I haven't seen a hundred nouns so I am not quite sure that this is always the case. But in the few nouns that we have looked at and taken up the hierarchy, we eventually reach an argument position. For example, 'message' is eventually defined at the top as 'that which is communicated.' So it is an argument; it is defined as the theme of a basic verb. Now a book (see figure 8) is all kinds of things. It is print on pages of a given size. A handbook is a concise book for memoranda or notes. A hardback is a book bound with hard covers. A paperback is paper-covered. A primer is a book that is used to teach children to read and so on. So summarized in a network are all the things the dictionary describes about 'book'. This doesn't focus on the hierarchical structure; this just shows the main senses in which the word book can be used.

insert Figure 8 here

To put it all together, as far as we know, we are going to end up handling nouns the same way we handled verbs. That is, a noun is going to be something that has a set of arguments. It'll be defined in terms of the top level, a high level word, with particular differentiating arguments from the meaning of that high level word. And it too will be a predication like a verb. Except of course it will fit into the argument position of the verb. So the conclusion here is that I am talking about a good deal of work that is in progress and I am not quite sure what the outcomes of it will be. I think at this time it is really quite hopeful, because it seems to be a fairly clear path to developing a methodology for extracting from these large, large sources, carefully put together of semantic information, that which we can use for question-answering machines -- machines that will eventually read text -- I still hope.

APPLAUSE! ! !

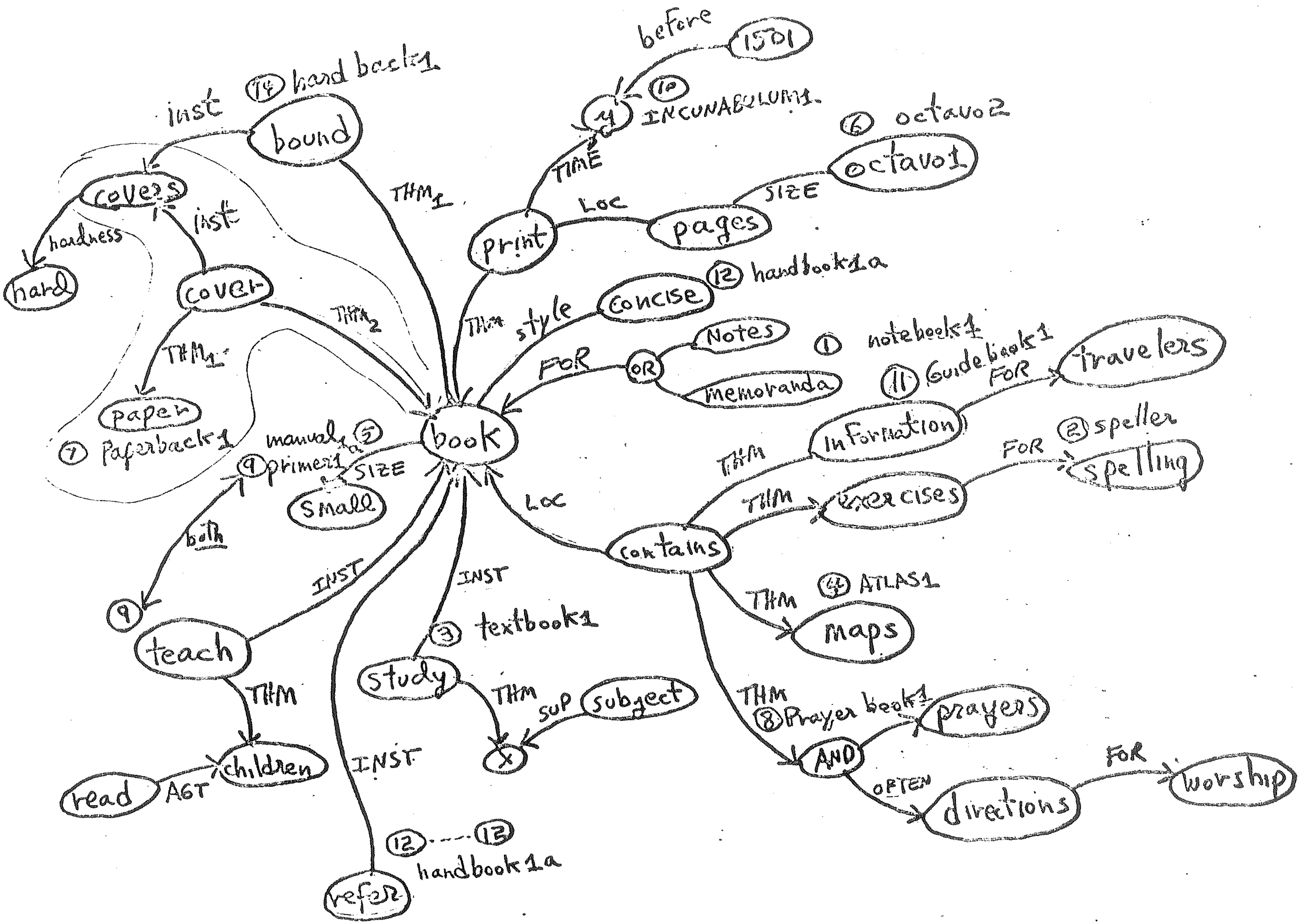

Fig. 8 "Book" Definitions

Questions

Hobbs Concerning the decomposition of verbs, I guess the original motivation for Ogden's construction of Basic English [19] was reducing 1800 English verbs to 14 or so?

Is his work useful at all to you?

Simmons I've looked at that again and again and again; it has not yet been useful to me. I am not sure whether that is his fault or my fault. But I haven't yet been able to get use outof it.

Hobbs Concerning the nouns, is a reasonable way of looking at nouns to simply say, items in an index, or entries in an index, which point to a large number of facts? What you have to attempt is to organize these facts into various clusters of facts which are arranged in some sort of hierarchical kind of order according to the task that you are doing?

Simmons Sure, but isn't that the same thing that we are up against with verbs? We want to take the verb and transform it into a set of assertions, a set of facts. Similiarly we want to take the noun and transform it into a set of assertions, but sort of pick up the first level implications of its meaning. The critical question to me is how you use those sets of assertions to understand text. That is the problem of deep discourse analysis.

Martin And the first thing that is interesting to me is what a similiar path we have been down. I feel like I have done exactly what you have done except I had to do it by hand. I didn't have a dictionary. I pored over the dictionary at night, and my people have been poring over the dictionary. And just from hearing you talk I know that people here can't get an idea of how well this works. But this works actually quite well. It is very informative. And because I have done the same thing I can ask certain questions where I did things differently from you and I have wondered why. For one thing, in the case of 'book' - in the case of verbs too, I brought everything to a single level. Rather than saying there is a book and we know certain things about that; and then there is a handbook under that and there are certain things we know about that which are not true of books; it seems to be at the same level and the same thing with the verbs. Rather than saying there are certain things about 'march' which have nothing to do with 'move', but yet they take some general properties from move; you have brought it all back to the same level; and that is one thing that I have done differently. I wondered why you did it that way. Do you see what I am saying? You tend to translate 'march' into 'move' plus a lot of arguments rather than put things directly on 'march' and then also know that it points up to 'move' and some of the properties come from there and some are directly on it.

Simmons Yes. I am working on a hypothesis that we can describe the verbal meanings of English in something considerably less than the 20,000 verbs that English has. So I really want to be able to put the bulk of my effort on a few verbs and put the distinguishing features on the lower level verbs like 'march', and 'walk', and so on; and carry the distinguishing features up to the primitive model. I would like to have fifty verb models, if that is enough, and carry the distinguishing features up as added assertions. So that every word that is a descendent of one of these higher order verbs will have as true the assertions of the higher order verb plus its own distinguishing features.

Martin Yes. That forces you to be able to do it in terms of models and features; that never allows you the out of saying that in fact I would be better off just to put a more or less description; but a much more ambitious way of trying to solve this whole problem.

Simmons I think the difference, of course, is that you have a problem and an application directly under your fingers. You konw the pragmatics of what you are doing. We are in the more theoretical range of trying to see what we can do with the lexicon; and a general theme of how we are going to use models, rather than a particular application at this time. I think that would account for the differences.

Grishman I would like to hold off on questions now, if I may. [due to schedule]

References

Grishman,R.,Sager,N.,Raze,C. and Bookchin,B., "The Linguistic String Parser." AFIPS, Conference Proceedings Vol. 42: AFIPS Press, Muntvale,N.J. 1973, pp. 427-434.

[2] Woods,William., "Procedural Semantics for a Question-Answering Machine," Fall Joint Computer Conference, ;Proceedings 1968, pp.457-471.

[3] Woods,W.A.;Kaplan,R.M.;Nash-Webber,B. "The Lunar Sciences Natural Language Information System: Final Report. BBN Report No. 2378, BBN Cambridge, Mass. June,1972.

[4] Winograd,Terry. Understanding Natural Language. New York: Academic Press, 1972.

[5] Heidorn,George E. "Natural Language Inputs to a Simulation Programming System." NPS-55HD, Naval Post Graduate School, Monterey, Calif. 1972.

[6] Sager,Naomi, et.al., "An Application of Syntactic Analysis to Information Retrieval," String Program Reports No. 6, N.Y.U., Linguistic String Program, April,1970.

[7] Harris,Zellig S., "Decomposition Lattices," T.D.A.P. no. 70, U. of Pa., Linguistics Dept., 1967.

[8] Charniak,Eugene C., "Toward a Model of Children's Story Comprehension." AI TR-266, MIT, Cambridge,Mass., 1972.

[9] Schank,Roger C., "Understanding Paragraphs," Instituto per gli Studi Semantici e Cognitivi, Castagnola, Switzerland, 1974. (order from: Centro di Documentazione della Fondazione Dalle Molle per gli studi linguistici e di comunicazione internationale, Villa Barbariga, 30039 San Pietro di Stra/ Italy.) see also [20].

[10] Hendrix,G., "Preliminary Constructs for the Mathematical Modelling of English Meanings." University of Texas, Department of Computer Sciences, Working Draft, April 1975. (not for distribution).

[11] Kucera,H. and Francis,N., Computational Analysis of Present-Day American English., Brown University Press., 1967.

[12] Olney,J.;Revard,C.;Ziff,P., "Toward the Development of Computational Aids for Obtaining a Formal Semantic Description of English," SDC document SP-2766/001/00, Oct., 1968.

[13] Inquiries regarding the availability of the Random-House Dictionary of the English Language tapes should be directed to Mr. Laurence Urdang, managing editor, Random House,Inc., 501 Madison Avenue, New York 22, New York.

[14] Gove,Philip B. (ed.) Webster's Third New International Dictionary (unabridged). G.&C. Merriam Co., Publishers., Springfield, Mass. 1971

[15] Schank,Roger C., "The Fourteen Primitive Actions and their Inferences," Stanford Artificial Intelligence Laboratory, AIM-183, March,1973.

[16] Riesbeck, C. "Computer Analysis of Natural Language in Context," Ph.D. Thesis, CS Department, Stanford, 1973.

[17] Rieger,C. "Conceptual Memory," Ph.D. Thesis, CS Department, Stanford, 1973.

[18] Goldman,N., "The Generation of English Sentences from a Deep Conceptual Base," Ph.D. Thesis, Computer Science Departement, Stanford Univ.,Calif., 1973.

[19] Ogden,C.K., The System of Basic English., Harcourt,Brace, and Co., N.Y. , 1934.

[20] Schank,Roger C. (ed.), Conceptual Information Processing, North-Holland Publishing Co., 1975 (inspress).