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COMPUTER UNDERSTANDING OF METAPHORICALLY USED VERBS

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Summary

A major problem confronting computer programs driven by natural-l ngu ge input consists of the interpretation of linguistic expressions for which the intended literal meaning is not explicitly given by the lexical components of the expression. An example is the "extended use" of the verb 'leap' in 'the country leapt to prosperity'. Such extended usages--whether quasi-as imilated or original--can be considered metaphorical to the extent that they are based on analogies. This paper establishes a framework for interpreting metaphorical expres ions by analysis of underlying abstract components--such as "transition" and "intensity" for the above example. This is in contrast to previous approaches which rely on a number of word senses intended to represent metaphorical usages directly.

An experimental program finds literal interpretations for input representing a simple sentence in which the "verbal concept" (action, state or attribute) is used metaphorically. This input has the general configuration 'SUBJECT VERB OBJECT SOURCE/GOAL' or 'SUBJECT PREDICATE-ADJECTIVE'. The interpretations are given in the form of primitive English paraphrases. These paraphrases, which are intended merely to illustrate the information which can be extracted from metaphorical input, are based on

semantic representations which are convertible to structures specified by Schank's conceptual dependency theory. The interpretation of metaphorically used verbs thus represents a particular case of the general tasks of disambiguation and interpretation encountered by the conceptual dependency parser.

The approximation to the literal meaning of a metaphorical verb is achieved through reference to semantic descriptions based primarily on a small number of conceptual features and abstract structures. These descriptors are specified for classes of those concepts which are expressed in English by nouns, verbs, adjectives and prepositional phrases. The complete set of values for the descriptors or verbal concepts is represented as a multi-dimensional matrix containing the defined concepts. This matrix, which is only partially described in this paper, exhibits relationships and analogies which underlie metaphorically used verbs.

The relative independence and abstract character of the basic semantic descriptors render the system easily extensible to further capabilities, such as more conclusive interpretations or the treatment of more challenging expressions. The emphasis on systematic descriptions and primitive concepts to produce simple paraphrases is viewed as reflecting human understanding of novel linguistic expressions and providing a model to explore questions related to such understanding.

Contents

1. Approach

Metaphorical usages have often been regarded as "special cases" to which the particular language analysis method under discussion did not apply. This paper presents a method for computer understanding of a class of phrases in which the verb is used "metaphorically", but which ignores the distinction between "extended" and "assimil ted" usages. This approach provides flexibility in handling previously unseen usages. The assumption underlying this approach is that analogies are involved in language understanding to a greater extent than speakers consciously realize.

1.1. Analogies

Analogies are the means by which we substitute, extend or borrow concepts. In the use of an analogy, a word is borrowed from its usual context to express some component of meaning shared by the concept underlying the borrowed word in its literal sense and the concept which the borrowed word is to represent. This results in an extended or metaphorical use or the word. The system to be described is intended to show the analogy comprehension necessary for the interpretation of metaphorical usages of verbs.

The problem of determining the meaning of a metaphorical expression is one of knowing the critical similarities and differences which a borrowed sense of a word has with respect

to the original sense. In some cases an essentially metaphorical usage ceases to be thought of as borrowed, and acquires an idiomatic sense of its own. However, if the similarities and differences which enter into metaphorical usages can be identified, we can still handle such an expression as we do those expressions which are generally viewed as metaphorical. Consider the examples

1) The House Killed the bill

2) I see what you mean

Here the first example appears to be metaphorical, the second not. A language analyzer prepared to handle only non-metaphorical input might achieve the correct interpretation of 'I see' in the sense of 'I understand'. However, it would succeed only if 'see' were listed in the dictionary as equivalent to 'understand' in one sense. Such a solution ignores the capabilities which humans have for correctly interpreting such sentences without having learned this synonymity. A parser which lacks this ability, i.e. to interpret without relying on ad hoc aids, will not have the flexibility required to approach similar problems in which such aids are missing due to the prejudices of the person who defines verbs for the lexicon.

In this sense, we should be able to understand metaphorical sentences on the basis of an analogy to the ordinary or literal sense of the words involved. The examples

1) The idea of growing their own radishes was born ,

2) He hid his embarrassment about the honey pot

3) He relinquished his hopes

4) Her painting said something to me

are all metaphorical in different ways with respect to the ordinary sense of the verb: the literal effect of 'hide' is visual; that of 'relinquish' has to do with control of a physical concept; that of 'say' has to do with linguistically expressed information. But in each case there is an analogy between the ordinary and the metaphorical usage of the verb. The analogy consists of the similarity of the "effects" which occur in the non-metaphorical and metaphorical usages:

1) The idea (= to grow their own radishes) was born

The baby (= Percy) was born

Effect = A new idea (baby) can be related to

2) He hid his embarrassment about the honey pot

He hid the honey pot

Effect = Others are not visually aware of his embarrassment (honey pot)

3) He relinquished his hopes

He relinquished the presidency

Effect = He no longer has a certain attribute

4) Her painting said something to me

Her book said something to me

She said something to me

Effect = I have a new mental concept to consider

Information derived from such metaphorical expressions should at least include analogous effects of this kind, which represent the "result" component of the meaning of the expression. (A related problem of extracting conceptual inferences is discussed by Schank and Rieger (8).)

This task requires a verb description system which categorizes verbs by two criteria:

1) the identification of an underlying structural component which is similar for verbs which are used analogously in linguistic expressions, and
2) the identification of a certain level at which the verb applies, such as "physical".

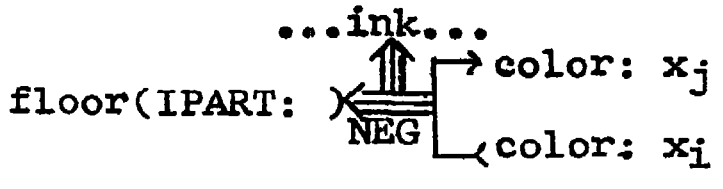
Each verb will thus be classified, not in terms of a single category, but in terms of two types of variables having values according to these two criteria. Thus levels and structure-concepts must be determined which can be used as a basic form of description of verbs in the dictionary.

1.2. Conceptual dependency interpretations

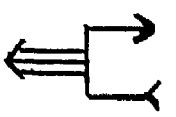
In addition to such verb descriptions, which serve the analysis task, the form of "target" representations, i.e. of the literal interpretations must be considered. The basic assumption underlying a choice of representation is that a "translation" from a metaphorical to a corresponding literal expression cannot be achieved by manipulation of components

at any syntactic level. What is needed is an "interlingua", which deals with relationships between concepts at the cognitive level. The conceptual representations which apply to this interlingua are not dependent on the original lexical form (or language) of the input, and can be used to generate paraphrases of the input into the same or other languages, given the concept-to-syntax mapping rules for that language. The choice of a form of conceptual representation must be guided by the extent to which it shows relationships between concepts at the cognitive level. The conceptual dependency theory of Schank (6-9) provides such a representation in terms of predicative and qualifying dependencies between conceptual categories and is assumed as the context of the method presented here.

In a dependency, according to this theory, a concept of one conceptual category is dependent on, qualifies directly or serves to describe a concept of another conceptual category according to rules of conceivability. These unambiguous, language-free dependencies are word-independent, although the concept symbols on occasion map directly into some lexical term expressing these concepts. The nature of conceptual dependency representations, as well as their suitability for metaphor analyses, can be conveyed by a simple example. 'The ink stained the floor' can be represented conceptually as



. The significance of this

representation lies not in the particular notation adopted, but in the components of meaning which it reveals. The dots (... ...) indicate that the ink is not necessarily the agent, but is merely somehow involved in the action. The "causation arrow" () indicates a causal relationship as opposed to the example 'the ink hit the floor'. The  notation indicates a change of state of 'floor', or more specifically, an Inalienable PART of the floor. The 'NEGative' notation is a "connotation" (5) which is secondary to the purely objective representation of 'stain'.

If it is assumed that the use of metaphor relies on some similarity of semantic components between an ordinary and an extended sense, it can be seen that a representation of this type, reflecting a conceptually-oriented semantic theory, is adequate to the task at hand. By reference to the abstract components of causation, change of state, part vs. whole and negativeness revealed by the above conceptual structure for 'stain', a paraphrase for the metaphorical 'his business activities stained his reputation' is easily approximated: 'his activities caused a negative change in (part of) his reputation'. There is no dependence on complex transformations or multiple word senses, which might in fact fail in the case of novel forms of expression, such as more "creative" metaphor.

The components of conceptual dependency representation can be briefly described as follows. The conceptual categories

between which the various conceptual dependencies exist are ACT, PP ("picture producer") and PA ("picture assister"). At the syntactic level, these categories are sometimes expressed in the English language by verbs, nouns and adjectives respectively. However, such correspondence does not always occur. For example, many nouns can be expressed directly in terms of verbal or attributive concepts ('the state of...', 'that which...'). Such nouns would not be mapped directly into PPs.

The dependencies which hold between the specified categories at the cognitive level must ultimately be given by a "conceptual grammar" which reflects their conceivability and therefore their comprehensibility. Such a grammar, independent of actual word-construct usage, would include information such as what kind of concepts can be related by a specification of position in time. Our concern here, however, will be mainly with the lower-level and more detailed information contained in a "conceptualization", or simple conceptual structure.

The general conceptual dependency format which has been established for the conceptualizations which will be referred to takes one of the following forms (semantic terms which are irrelevant to the metaphor problem, such as tense, will be ignored):

PP (object) ⟸ <relation> ⟹ PP (object)

e.g. ink ⟸ ON ⟹ floor

The ink is on the floor
The ink is in contact with the floor

PP (object) ⟸⟹ PA (attribute)

e.g. ink ⟸⟹ COLOR: black

The ink is black
The ink has a black color

PP ⟸ <attribute-value (new)>, <attribute-value (old)> (change of state)

e.g. ink ⟸ COLOR: black, COLOR: ?

The ink turned black
The ink changed to a black color

PP (actor) ⟸⟹ ACT (action) ⟵ PP (object) ⟵ <goal>, <source>

(continued) ⟵ I ⟵ <instrumental conceptualization>

e.g. John ⟸⟹ ATRANS ⟵ CONTROL:ink — R → Mary, John

(cont.) ⟵ I ⟵ John ⟸⟹ PTRANS ⟵ ink ⟵ D → Mary(IPART:hand), John(IPART:hand)

John gave Mary the ink by handing it to her
John handed Mary the ink

or John ⟸⟹ MTRANS ⟵ ink ⇕ ? — CP(Mary), CP(John)

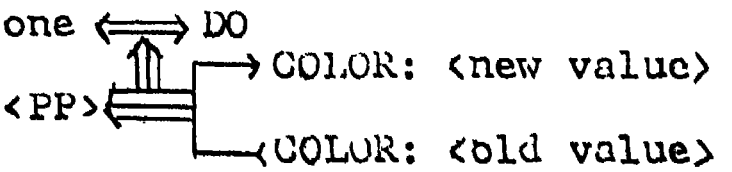
John communicated the ink story to Mary
Mary heard about the ink from John

The actual relevance and character of some of the components of the latter type depends on which ACT is present. The list of ACTs is:

MOVE	GRASP	PTRANS
PROPEL	SPEAK	MTRANS
INGEST	ATTEND	ATRANS
EXPEL	MBUILD	

The source-goal component is irrelevant to the ACT GRASP, for example. For PTRANS (physical transition), the object, source and goal must be specified and are physical. For MTRANS (mental transition), the object is itself a conceptualization and the source and goal are the mental processors of human or at least animate beings: Conscious Processor, Long Term Memory and Immediate Memory. For ATRANS (abstract transition) the object is a form of control and the source and goal are animate beings. Each of these three forms of transition involves a type of "conceptual case": PTRANS takes the Directive or locative case ($\overset{D}{\leftarrow}$), and MTRANS and ATRANS the Recipient or possessive case ($\overset{R}{\leftarrow}$). The object which is dependent on an ACT in that it is "acted upon" is in the Objective case ($\overset{O}{\leftarrow}$ PP (object)).

There are a number of other conceptual connectives and modifiers which apply to such conceptualizations. These can be referred to in (6). The most important of these as concerns the representation of the concepts considered in this paper is the element of causation: ⟨causing conceptualization⟩ ⇑ ⟨caused conceptualization⟩

This component underlies verbs such as 'make' () and 'color' ().

Differentiated types of causation and the conditions for their applicability are given in (6). Intended causation or purpose will be designated in the present work as 

2. Characterization of Verbal Concepts

It is proposed that verbs be represented as entries in a multi-dimensional matrix which shows the similarities and differences mentioned. As a characterization of "all" verbal concepts is desired, regardless of whether these are realized lexically as verbs, adjectives or prepositional relations, such concepts will be referred to as 'VERBs', as opposed to the lexical 'verbs'. The column headings of this matrix give the characteristic "structures" of the VERBs, either explicitly or as configurations of features, and the row headings are "levels", "planes" or "frameworks" of the VERBs. Each entry then represents a "category" of verbs which satisfy column- and row- (and further dimension-) values. Conceptual ACTs as introduced in the previous section are also subject to definition in terms of this matrix. ACTs are considered to be sufficient as a basis for describing all actions underlying language, regardless of how this action is expressed in a particular language. For instance, the ACT 'MTRANS' underlies the verbs 'tell',

'forget' and other verbs of mental transition. It is these primitive concepts rather than any specific lexical verb which will be retrieved from the matrix as output of an operational metaphor routine.

2.1. Levels

The four levels postulated for verbal concepts are:

PHYSICAL (e.g. 'touch')

MENTAL (e.g. 'think')

SENSORY (e.g. 'see')

CONTROL (e.g. 'donate')

The PHYSICAL level includes verbs which predicate the existence, attributes or associations of objects with spatial (material) aspects.

The MENTAL level is distinct in that "objects" on this level are representations of objects, or of other representations in a recursive manner. It is thus the level through which thought and communication take place. Verbs of thought have been analyzed in (8). Since MENTAL objects are not real-world objects or situations, but rather pointers to such objects, they cannot be conceptually dependent on non-MENTAL concepts other than (usually human) mental processors.

The SENSORY level includes VERBs of perception, or the reception of "images". Concepts on this level provide the link from the physical world to the consciousness of a language user as well as to other animate beings. SENSORY concepts could be analyzed in PHYSICAL (spatial and temporal) terms. However, this kind of detail seems to have little relevance to the linguistic problems under consideration.

The CONTROL level refers to relationships which express possession or control by an animate being. An object on this level is a form of control, or a "potential for action". CONTROL VERBs basically consist of conditions attached to the actions of an animate being and are sometimes expressed lexically through modal auxiliaries, for example as 'can', 'may' or 'must'. Possession defined as a CONTROL relationship is thus distinguished from purely PHYSICAL or locative relationships. The verb 'have (a physical object)', for example, is defined in terms of the CONTROL level rather than the PHYSICAL level.

Each of these levels has a few sublevels (e.g. SENSORY: eye, ear) which are sometimes specifically referenced in metaphorical extensions. These are described in (5).

2.2. States

Given the matrix format of the verb descriptors, the specified levels (row components) can best be clarified

by consideration of the "simplest" structure (column component) as it applies on each level. This structure is referred to as a STATE or as a STATIC structure, and represents in general terms "existence, with or without an attribute, and with or without association with another object". STATEs are presented here in two forms which represent the '+' and '-' values of one of the "features" (Section 2.4) which further differentiate VERBs. These two feature values are termed "actual" and "potential", according to whether the given STATE has the feature value '-HYPothetical' or '+HYPothetical'. STATEs in these two forms represent primitive concepts to which further features can be applied to obtain more complex VERBs. An explanation of verb entries which are examples for the two forms at various levels should give some idea of the scope and basis of the verb analysis. Space considerations limit the discussion to two levels.

If other feature values are ignored for the moment, -/+HYPothetical STATEs can be thought of as the first two columns of the matrix. At the MENTAL level we have:

	ACTUAL	POTENTIAL
<u>Perception</u>		
O-Predication:		
R	think	SUBJ: believe OBJ: know
O	be in CP	be in LTM-P
VAL		TV=+: be true

cont.	ACTUAL	POTENTIAL
O-Presupposition:		
R	enjoy	SUBJ: like OBJ: appreciate
O	be in CP	please
VAL	AV=+: "be fun"	AV=+: be nice
Volition		
R		will
O		be in LTM-V
VAL		DV=+: be good (to do)

The MENTAL level is divided into two sublevels to correspond with the faculties of perception and volition. Perception in turn has two forms--the predication of the existence of the Object, and the valued perception of a presupposed Object. Only the former type is examined here.

It is first noted that this and each sublevel allows for an R-, O- and VAL-form of a VERB. O = Object, R = Recipient or experiencer ("location", "source" or "goal" of O), and VAL = VALue of O. The labels R, O and VAL indicate whether the lexical entry which maps into the slots headed by these labels expresses a verbal concept from the point of view of R or O, or expresses a value of O. Syntactically, the "point of view" of R or O is reflected by a verb having a noun with "role" R or O respectively as syntactic subject. For example, the R-role 'see' corresponds to the O-role

'appear'. If no verb for a given slot comes to mind, a phrase is given which simply reflects the conceptual representation of this STATE. Thus the O-role entry corresponding to 'believe' is 'O(=proposition) be in Long Term Memory'. The value imposed by 'believe' on the Object, which for this sublevel is a Truth Value (TV), is positive ('+').

Verbs or predicate adjectives in the 'VAL' row express a possible value of the Object as opposed to the relationship of the Object to an R which is given by O-role verbs. Although the verbs and adjectives given as examples all presume a positive value of O, other degrees of positiveness on the value scale could underlie other verbs or adjectives. For instance, 'be indifferent to' means that the Object lies midway between the '+' and '-' Attitude or Aesthetic value for the experiencer.

Since a MENTAL STATE expresses an attitude towards a MENTAL object which may or may not correspond with that of "outside observers", verbs may express either a 'SUBJective' or an 'OBJective' MENTAL STATE, as shown. That is, a speaker says 'he knows that...' to mean 'he believes that..., and it is true'.

The difference between the ACTUAL and POTENTIAL columns can best be explained in terms of the present example. Generally, 'actual' refers to the fact that the relationship underlying the verb is presently "in operation", "realized"

or "expressed". 'Potential' denotes that the object can be retrieved in order to create an 'actual' relationship. Thus 'think' in the sense of mental activity ('think about') involves an "active" object and says something about the present state of the thinking person, but 'believe' or 'know' represents a "stored" rather than an active object. This difference is expressed through representation of R as CP (Conscious Processor) and LTM for 'think' and 'believe' respectively. There is no value assigned to O for this sense of 'think', since a truth value is not assigned to a MENTAL object except in the process of forming a belief or making an assumption.

The SENSORY level can be illustrated briefly by reference to the representation of conceptual attributes in terms of this level. 'Beautiful' is defined by primitive components on the 'visual' sublevel: 'SENSORY (eye) VAL: AV=+' or, 'a visually perceived, aesthetically positive attribute of an object'.

All three non-PHYSICAL levels involve objects O which are non-material, i.e. not PPs. Rather the object is a form of information, image or control for the MENTAL, SENSORY and CONTROL levels respectively. All of these objects, which might be thought of conceptually as verbal or attributive concepts, have a "relationship" only to a true experiencer, i.e. an animate R. At the PHYSICAL level, on the other hand,

R need not be animate. The PHYSICAL level reflects only the physical aspect of the relationship expressed by a VERB; R may happen to be animate, but the animate aspect is irrelevant to this level. This means that 'have' in the sense 'John has the newspaper' is assigned to the CONTROL level rather than to the PHYSICAL. However, a PHYSICAL relationship, as expressed by 'John has the newspaper on his head' or '...in front of him', could be derived as an inference of the CONTROL-level 'have'.

Representative verb forms for STATEs at the PHYSICAL level follow:

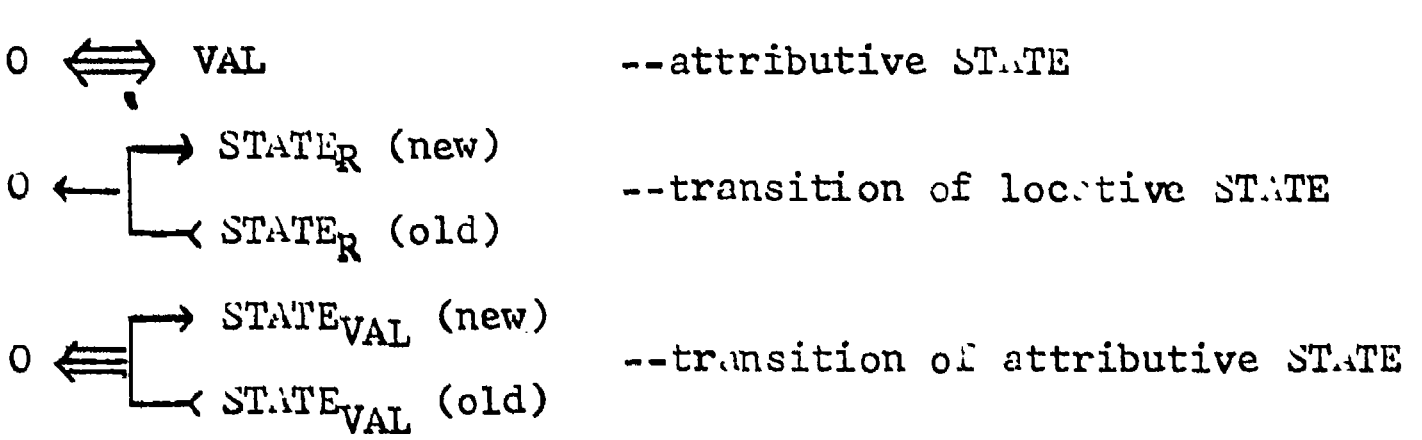
	ACTUAL	POTENTIAL
R	have as part	
	contain	
	have on	
O	be connected to	
	be in	
	be on	
	be at	be near
VAL	be	almost be
	be ⟨PA-value⟩	
	e.g. be red	

The R- and O-VERBs correspond to relations between PPs identified in (5) (IN, ON, AT, PROX), whereas the VAL VERBs are conceptual attributes--PA dependencies on PPs.

The ACTUAL/ POTENTIAL distinction as described above does not strictly apply to the PHYSICAL level, for in one sense all PHYSICAL relationships are "actual". However, an analogy suggested by this analysis in comparison with the other levels is discussed in (5).

2.3. Structures

Structures reflect abstractions of verbal concepts, i.e. elements of conceptual states or actions which humans recognize independently of whether any matter or object involved is visible. A VERB structure consists of an "effect component" and, if the concept of change is implied in the VERB, a "cause component". If both a cause and an effect component are present, they are connected by a causal link-- ⇑ --as for 'achieve', or a "tried" (Section 2.4) causal link-- ⇞ --as for 'practice (for)'. Effect structures take one of the following forms:



STATEs, which underlie verbs such as 'think', 'watch', 'control', 'have' and 'be', have been introduced above. In the verb definitions to follow, STATEs are represented mnemonically as '(0 AT R)' and '(0 BE)' or '(0 BE <VAL>:)'.

The transition-arrow should reflect the assumption that language-users usually focus on a certain aspect of the change quality, e.g. 'start state' or 'stop state', even though stopping one state always means starting another.

Thus there are three types of change-of-state effects:

a)	TRANSITION	(complete)	(TR)
b)	start TRANSITION	(leave STATE)	(TR-L)
c)	finish TRANSITION	(enter STATE)	(TR-E)

These structures underlie verbs such as a) 'give', 'pass to'; b) 'forget', 'lose'; and c) 'enter', 'join'.

2.4. Features

Features might be thought of either 1) as <u>each</u> providing an additional dimension of the matrix in terms of its set of values or 2) as applying to structures in various combinations of values to form <u>configurations</u> of feature values. In the latter case, the configurations provide the values (columns) of one (horizontal) dimension. In either case, the values of the following binary features indicate whether a certain conceptual element is present in a VERB. The above structures implicitly presume a negative value for all features except CONTINuous, which is positive (c.f. Fillmore's '-Momentary' (1)). Explicitly stated feature values expand the information given by these structures in a VERB description. The features, with '+' and '-' examples, are:

+/-	AGENTive	e.g.	break (vases)/(vases) break
	HYPothetical		believe/contemplate
	SHARED		agree/believe
	CONTINuous		live/die
	REPeated		beat/hit
	VOLitional (voluntary)		look/see
	TRY (tried without implied success)		offer/give

The AGENTive feature has particular significance in that it is related to the role specification of the verb as described in section 2.2. The syntactic subject of a +AGENT verb has role AGENT and the object role R or O. The feature itself is defined in a restrictive sense; +/-AGENT refers to whether an agent which is external, i.e. other than R or O, is involved. Thus 'tell' and 'give' are +AGENT (one who tells = AGENT; recipient of information = R; information received = O), but 'recall' (in the sense of 'remember') and 'take' are -AGENT (one who recalls = one who "receives" = R; information "received" = O).

3. Characterization of NOMINALs

In order to know when verb substitutions along a vertical dimension of the matrix can be made "meaningfully", we need a description system for "NOMINALs", i.e. concepts that serve as "objects" at one of the above levels, which governs possibilities of dependencies of these NOMINALs on the VERBs. Furthermore, in order to allow more flexibility in handling the inherently vague problem of what is meaningful, it is useful to refer to a two-level hierarchy of "degree of restrictiveness" in judging whether such dependencies represent metaphorical phrases. In the verb definitions, this information is given in terms of specifications on the

NOMINALs which appear in the dictionary definition of the verb. The two degrees of restriction are marked 'B (Broad)' and 'N (Narrow)'; the specifications themselves consist of either specific NOMINALs or features of NOMINALs. These descriptors are illustrated in Sections 4 and 5.

3.1. Features

A feature-oriented system of description for NOMINALs is described in (5). Here the defining elements of NOMINALs are presented without elaboration, merely to show the terms in which NOMINAL dependencies on verb 1 concepts are specified. A configuration of levels for NOMINALs has been devised which is not identical to but is related to that established for VERBs: MENTAL, SENSORY, CONTROL, ACTIVE, MATERIAL, TIME, SPACE. However, for this limited discussion, VERB levels will be assumed for NOMINALs, with 'PHYSICAL' corresponding to 'MATERIAL'.

The features are presented in three groups, although this division is not significant to the implementation of the theory. The first group expresses topological or basic physical properties:

+/-	PART	roof, step / house, proof
	SHAPE	rainbow, idea / fog, geography
	CONTAIN	shoe / pencil
	FIXED	field, tree / bird, ball
	1-DIMENSIONAL	fence, streak / ball, flash
	2-DIMENSIONAL	ocean, table / pole, statue
	FLUID	"plural" concept, river, (some) time / ice, moment

It might be seen by the examples given that these features are considered as abstract properties which are extended to levels other than the PHYSICAL.

The second group consists of:

+/- HUMAN
ANIMATE

+HUMAN will be considered to imply +ANIMATE.

The third group focuses on the "meaning" of a concept rather than on an, objective properties:

+/- MANMADE key, motor, story / boy, stone
DYNAMIC boy, motor, story / key, stone

The DYNAMIC feature refers not to the presence or absence of moving parts, but rather to whether the concept has some kind of "continuous existence" by itself, other than mere spatial presence. The difference between 'story' and 'motor' on one hand and 'key' on the other is that a key is an inert object which is used passively for a single operation, after which it again becomes merely a piece of metal. A motor (like an animate being), once started, appears to function by itself. Likewise, a story and in fact most mental concepts can be thought of as having an effect or "continuous function" for those people who come in contact with these concepts. The significance of this feature is suggested by the many cases in which people speak of +DYNAMIC concepts as being "alive" or effective in themselves.

These features are all essentially binary ('+', '-') with a possible variable value ('?') for some features.

The 'FIXED' feature, for example, is "variable". A flower is +FIXED in its natural state, b ut -FIXED when in a vase or in many other circumstances.

3.2. Function descriptors

In addition to conceptual features which determine the conceivability of certain phrases, metaphorical or otherwise, there are specific non-conceptual function associations which apply to many NOMINALs, especially +MANMADE ones, which serve as defining elements. Also "size" criteria for dependencies are recognized in the form of a 0-5 scale value for physical objects. Although these descriptors are more important for problems not dealt with here (see (5)), they also enter the question of metaphorical interpretations. For example, the knowledge that the functions of both a ship and a tractor include the notion of 'going' or 'moving' is of use in recognizing the substitution of 'ship' for 'tractor' in 'the ship plowed the sea' vs. the literal 'the tractor plowed the field'. The function can then be incorporated into an approximation of the meaning of the former example.

Several types of function have been identified, according to the conceptual roles which the object plays in the action which represents the realization of this function. The type which is probably referred to most extensively in metaphorical interpretations is 'EXTERN L', meaning that the functional object appears as an external (to the actor) object in the conceptual representation of an action which

serves as an instrument to some result. In this experimental implementation an abbreviated function representation is used: 'knife (FN: INST (cut))'.

4. Method of Interpretation

As pointed out at the beginning of this paper, if a definition of metaphor is restricted to include only those usages which strike the speaker of the given language as poetic or colorful, that definition will be ambiguous, for language is constantly changing with respect to what is considered "original" vs. what is an established word sense or idiom. This phenomenon could prove to be a quandary for anyone defining verbs or other lexical items for entry into the dictionary. The question of what sense of a verb is literal and what is metaphorical can be expected to vary not only from one individual to another, but also over time.

In order to alleviate this problem, it is suggested that a definition of a metaphorical usage include any verb which is "borrowed" from another level, whether or not speakers are still conscious of this borrowing. For instance, the word 'destroy' is easily conceived of as applying to all levels ('destroy house, image, idea, privilege'). However, this system assigns it to the PHYSICAL level, from which it can be borrowed by extension

to other levels. A verb is simply always defined as applying "normally" only to a certain base level (which in case of doubt can be considered to be the PHYSICAL level, if that level is one of the alternatives). A human editor need not worry about whether usages of the verb at other levels are metaphorical.

Thus the proposed procedures rest on the assumption that the "metaphorical sense" of a verb is not in the lexicon as such: the semantic component should exhibit the analogy comprehension of humans, who do not need to have such senses explained to them. If we accept that analogies refer to the sharing of a conceptual component, and are therefore reflected in our "levels", which share one or more columns of our matrix, then the most significant way in which the verb description system can be applied is evident: given a verb which is defined in the matrix by an entry in a given column (structure) and row (level), a metaphorical sense of this verb is represented by a VERB with the same structure but a different level. This type of extension can be referred to as "level shift". A second type of extension, which abstracts the effects of animate actions and applies them to inanimate objects is described in Section 5.4.

4.1. Conditions on metaphorical extension

Identification of a metaphorical usage requires the

knowledge that semantic restrictions on the dependency context of the verb as used on the base level are being violated, but that this violation represents a comprehensible metaphorical substitution rather than an "anomalous" case which must be passed to some subsequent routine for interpretation. In other words, interpretations for metaphorical expressions must satisfy certain notions of conceivability, just as concepts underlying literal usages do. In terms of dependencies between an object, its location and/or its attributes as described above, the most important condition for "conceivability" is that the MENTAL and PHYSICAL levels can never "mix" across the dependency links relating an O and an R, though both types of levels may coexist in a PP which maps into one of these role-concepts (e.g. 'book'). In other words, in any metaphorical usage, as in a literal one, some correspondence between the types of components within a conceptualization must exist. In terms of syntax, if a direct object is conceptually a MENTAL object, then the verb must be either MENTAL-level or used metaphorically on the MENTAL level. Thus the dependencies on a verbal concept in a metaphorical use do not conform to the level of the verb in its literal sense.

The noun which maps into the object of a conceptualization determines the level to which other elements of the conceptualization conform. In general, non-PHYSICAL objects

are obviously specific to one level. Nouns with an underlying PHYSICAL component, on the other hand, often are mapped into conceptual constructs representing another level. For example, 'he heard a squeaky violin' is analyzed as a SENSORY-level conceptualization corresponding more accurately to 'he heard the squeaky sound of a violin', even though the syntactic object ('violin') is PHYSICAL-level.

A second, less rigorous criterion in distinguishing literal, metaphorical and "anomalous" uses of verbs is, respectively, the satisfaction of 'Narrow' restrictions on the dependent NOMINALs, the satisfaction of 'Broad' but not 'Narrow' restrictions, and the satisfaction of neither type of restriction as described in Section 3. The 'Broad' 'Narrow' restriction criterion is not to be overemphasized; it is not claimed that such a distinction presents itself easily. It is merely suggested that for a given verb, a subset of features (for which the above features serve as a starting point) used to restrict dependencies at a literal level plays a role in the determination of usages at a metaphorical level. It appears that some features are inherently more instrumental in such determinations than others. For example, a 'game' and a 'concert' can 'close' because they are conceived of as possessing a +CONTAIN feature value, whereas a 'touchdown' or a '(musical) note', in an <u>intuitive</u> rather than a <u>strict</u> sense, do not. The feature

FIXED, on the other hand, is less important than CONTAIN in the dete mination of a metapherical expression.

In judging the consequences of the uncertainty which may arise in the definition of these criteria, one should keep in mind that the distinction between a metaphorical and an incomprehensible expression is also vague and in "borderline" cases may vary from one individual to another. The problem in language understanding is more often to find an interpretation rather than to exclude "strange" constructs. A lexicon editor, therefore, may in case of doubt reasonably adopt a policy of minimizing the 'Broad' restrictions on the NOMINALs potentially dependent on the verb which is being defined.

A related problem of definition is the interpretation of the features in terms of which the foregoing restrictions are defined. The meaning of the presented features has been briefly described for the PHYSICAL level; a more complete interpretation of these features for other levels should eventually be concisely described. For example, at the PHYSICAL level there is a distinction between 'contain' in the sense of 'surround' and 'contain' in the sense of 'consist of'. At the MENTAL level these senses merge, or rather the former sense seems to lose its relevance.

In addition to the above criteria, there are semantic criteria governing the "target representation" which ensure

that the interpretation given as output satisfies the general requirements of conceptual dependency for any conceptual structure. Since these conditions are not peculiar to the problem of metaphor itself, it is noted here only that two labels exist which indicate "how seriously such criteria must be taken". The satisfaction of 'unconditional' criteria indicates that the resulting interpretation should be accepted in any case. 'Conditional' refers to criteria which support a "last resort" interpretation--an interpretation to be considered if no better alternatives are available to the parser. The implemented procedures do not yet exhibit this discrimination in their output.

4.2. Operational context

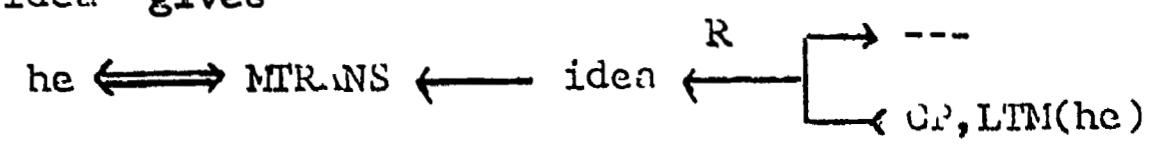
The parser with which the metaphor interpretation procedure is intended to function (Riesbeck (4)) operates on the basis of semantic expectations. To a large extent, these expectations are concerned with finding in the sentence being parsed an object which conforms to basic semantic requirements governing the dependence of that object on a verb which has appeared in the sentence. If there is more than one possible sense of the verb which has been found, the choice of sense depends on what kind of an object is found. This object is described by a few features such as PHYSICAL and ANIMATE. As the parser presently is "physically

oriented", expecting physical objects for verbs which ordinarily are interpreted in a physical sense, it is not able to find an interpretation for extended usages in which the only candidate for an object is non-PHYSICAL.

More specifically, suppose that the parser finds the verb 'drop' in the course of a sentence analysis; that only one sense of the verb is given in the dictionaryapart from idiomatic usages such as 'drop someone a line'; and that the minimal requirements for its object include the specification 'PHYSICAL'. If this restriction is not satisfied, the parser must turn to the metaphor routine for an interpretation. Thus if 'idea' were the only candidate for an object of 'drop', the parser would note that a PHYSICAL-level specification (which could be represented as a +PHYSICAL feature-value) is missing from the definition of 'idea'. It would then check with the metaphor routine, passing as information the candidate for an object ('idea'), the verb sense of 'drop' which would have been selected, had the object possessed a +PHYSICAL feature, and any potential dropper, source and/or goal.

As output the metaphor routine returns a representation for each level at which the verb can be interpreted. This representation, which is based on the semantic components introduced in Section 2 ('TR-L (O AT R) (VOL +) ...', O = 'idea', R is +ANIMATE, e.g. 'he'), provides the information

to build the correct conceptual structure (or to form an approximate paraphrase according to the program described below). That is, this information contains matrix dimension pointers which lead to the category of the involved action or STATE and to the ACT or conceptual notation which underlies this action or STATE respectively. For our example, the underlying conceptual information associated with the above semantic components at the MENTAL level as determined by 'idea' gives



, or,

the elimination of a component of the MENTAL STATE of an individual. (Additional notation representing the concept underlying '+VOL' is discussed in (7).)

4.3. General procedure

The general method of the metaphor routine for understanding metaphorical expressions can be specified as follows. The routine examines the semantic descriptors of the conceptual VERB which corresponds to the given verb sense. This semantic information can be obtained directly from the dictionary entry for that verb, or indirectly in case the entry is represented in terms of another verb and certain feature values. It notes the specified NOMINAL dependencies, including the 'Narrow' specifications on these NOMINALs, if any. The satisfaction of these specifications by the

NOMINALs which actually occur in the input would indicate that a base interpretation is available. The routine thus contains the capability of determining such interpretations; however, in actual operation it will be assumed that the parser 1) has unsuccessfully checked for the possibility of base interpretations before turning to the metaphor routine, or 2) has found a base representation, but is interested in possible metaphorical interpretations.

Case (2) reflects the fact that the identification of a base interpretation precludes anomaly but not the possibility that a metaphorical interpretation was actually-intended. This is particularly likely in the case that the NOMINALs involved have features which place them on more than one level, with the metaphorical level being more "usual" than the base level. An example of this type to be considered is 'Europe and America are drifting apart'.

In either case, the task of the routine is to determine, on the basis of the guidelines of Section 4.1, whether there are metaphorical interpretations for the given input, and, if so, to return representations for them. Interpretations for all possible levels should ultimately be given priorities. No definite method has been established for determining priorities in isolation from the context of discourse. Presumably such context would be the dominating factor in establishing the level of the expression. Thus if the

acti ns of humans are bein discussed, 'Europe' would be interpreted in its institutional or ANIMATE sense rather than its geographical PHYSICAL-level sense.

If the expression is accepted as metaphorical, its meaning remains to be represented. In order to arrive at the verbal concept which expresses the "effect" underlying the analogy employed, the program uses the structural elements underlying the input verb as a "roadmap" through the matrix to obtain the corresponding target verbal concept at the desired level. That is, the structural elements or feature values can be thought of as values of dimensions of the matrix which specify an entry. This entry, which may consist of a primitive ACT, for example, can then be inserted into the representation which gives an approximation of the meaning of the phrase.

Along with structural elements, any magnitude descriptors present, i.e. AMOUNT or INTENSITY: >, < are carried over to the target representation, since it is frequently these components which are focused on in a metaphorical expression ('he jumped (INTENSITY: >) to conclusions'). However, the program referred to here does not yet include this mechanism.

4.4. Operation of routine

The procedure to be described has been implemented in an extended version of FORTRAN IV, which was the only language conveniently accessible at the time. The outline

given here represents the procedure actually followed in the implementation, which was designed only for test purposes.

a) Input: The input consists of two or three lexical items in their "root" forms in the order 'noun verb (noun)'. This group represents a syntactic configuration determined tentatively by the parser as 'subject verb' or 'subject verb object'. In terms of roles, the first case may represent 'AGENT VERB' or 'O (OBJECT) VERB'; the second 'AGENT VERB O' or 'O VERB R (SOURCE or GOAL)'. Theoretically, then, the entire role configuration 'AGENT VERB OBJECT SOURCE and/or GOAL' need not explicitly be provided for in the input, since this configuration is covered by the two component configurations just given.

b) Dictionary definitions: First, the semantic definitions of all items are retrieved from the dictionary. Examples:

```
(noun) ship ((PHYS) (PART -) (CONT +) (FIXED -) (1D +) (2D -)
            (SHAPE +) (SIZE 3) (FLUID -) (ANIM -)
            (MM +) (FN: EXT (sail) )))

(verb) plow ((PHYS) TR-E (STATE (O BE SHAPE: )) (AGENT +)
            (ROLE O) (INSTR: TR (STATE (O AT R)))
            (O (NRW land) (BRD (2D +) (FIXED +))) ))
```

Control is then passed to the 'subject verb' (SV) or 'subject verb object'(SVO) routine for determination of roles.

c) Roles: At this point of the procedure, roles to be assigned are only temporary; a test for the "R-O switch" type of metaphor (Section 5.3), for instance, may determine

that the role configuration expected on the basis of syntactic information has been altered in the extended use.

The tentative roles are assigned according to role information given in the definition of the verb:

For SV: Role of verb (R or O) is assigned to subject.

For SVO: If verb is +AGENT:

AGENT is assigned to subject and role of verb is assigned to object.

If verb is -AGENT:

Role of verb (R or O) is assigned to subject and the other role (O or R respectively) is assigned to object.

d) Interpretations: Control is then passed to other routines, depending on which role configuration is present:

RV
OV
RVO
OVR
AVR
AVO

These routines return any interpretations found, according to the criteria to follow. In this version the interpretations are expressed as pseudo-paraphrases, i.e. paraphrases which ignore certain syntactic details such as word suffixes and tenses, in order to allow for some measure of judgment as to the extent to which the meaning of the metaphorical phrase is captured. However, in actual operation, the target representation will be a conceptual one, which could be operated on by a dialogue program or by a paraphrase program (Goldman (2)).

4.5. Tests and criteria

The following tests with corresponding criteria for application and for success represent procedures which have been implemented. Each test (b through d) refers to a certain type of metaphor as shown. The discussion of relevant examples in the next section complements these specifications by indicating the rationale used in the approach to finding metaphorical interpretations. A test for a base-level interpretation (a) has been included for purposes of comparison with examples seen as either metaphorical or (with respect to the given test) anomalous.

a) Base Level (always tried)

1) All NOMINALs are consistent with base level of verb, i.e.:

level of O is base level of the verb;

R for any -PHYSICAL verb is +ANIMATE or has an ANIMATE function (e.g. 'computer');

R for any +PHYSICAL verb is +PHYSICAL;

2) All NOMINALs fulfill 'Narrow' specifications found in the definition of the verb.

Interpreted: He drank the ink
The ship disintegrated

Not interpreted: The chair drank the ink
He closed his mind

b) Intra-level (PHYSICAL) Feature Shift (tried if all items have PHYSICAL level, but base interpretation fails):

Actor-feature shift:

1) Verb specifies +ANIMATE feature for R;

2) R is +PHYSICAL but not +ANIMATE;

3) O fulfills 'Narrow' specifications found in verb definition, or O is absent.

Interpreted: The chair drank the ink

Not interpreted: The ship plowed the sea

Object-feature shift:

subject and object fulfill the 'Broad' but not necessarily the 'Narrow' specifications by verb definition.

Interpreted: The ship plowed the sea
The skier plowed the sea

(The 'Broad' specification for the subject here is "something which goes", i.e. "something which changes location: 'TR (O AT R)'.)

interpreted: The chair plowed the sea

c) Level Shift (from PHYSICAL level only, at present)

(tried for each possible level of the object when no base interpretation is found or for all levels when input format is ⟨subject (+ANIMATE) verb⟩):

1) R is either absent, +ANIMATE or an ANIMATE (Inalienable) PART, i.e. ⟨PP +ANIMATE⟩ (IPART: ⟨R +MENTAL⟩) or ⟨PP +ANIMATE⟩ (IPART: ⟨R +SENSORY⟩ (eye, ear, etc.) for MENTAL and SENSORY levels respectively;

2) R and O fulfill 'Broad' specifications by verb definition.

Interpreted: He closed his mind

Not interpreted: He closed his prosperity

c') Category Shift (tried when no base interpretation is found):

1) O is some attribute of R or of a lexically absent conceptual NOMINAL;

2) R fulfills condition 'c-1';

Interpreted: Prosperity disintegrated
His indifference collapsed
Prosperity came to the country

Not interpreted: Prosperity was occupied
Prosperity came to the chair

d) Level Shift with R-O Switch (tried when no base interpretation is found or when implied source (goal) is not explicitly present):

1) Source or goal (temporarily assigned role R) has level MENTAL, SENSORY or CONTROL;

2) Temporary O is +ANIMATE;

3) Source or goal fulfills 'Broad' specifications for O given in verb definition.

Interpreted: The country leapt to prosperity

Not interpreted: The chair leapt to prosperity

5. Examples

Some samples of interpretations are given in Figure 1, which represents actual output. Input data is given in Figure 2. Particular details of the procedures used are given along with discussion of these and other examples as they occur in the following exposition of the various types of metaphor.

5.1. Level shift

Not all extensions are made from the PHYSICAL to the non-PHYSICAL levels. The MENTAL, SENSORY and CONTROL levels sometimes serve as a base from which metaphorical extensions

can be made. The examples which follow indicate certain extensions (some of which have evolved into idioms) which can be made between levels. Some types of extension are obviously more frequent or interesting than others. Examples for specified extensions are:

PHYSICAL - MENTAL:	He closed his mind. Protests rained upon the government. Europe and America are drifting apart. Kohoutek's tail points to its origin. (Ambiguous between PHYSICAL and MENTAL levels. On MENTAL level, 'tail' refers to 'information about Kohoutek's tail' and 'origin' to 'information about origin'.)
PHYSICAL - SENSORY:	Music flooded the room.
PHYSICAL - CONTROL:	The privilege of cleaning the erasers landed in his lap. Control of the situation slipped away.
MENTAL - PHYSICAL:	That chocolate didn't agree with me.
SENSORY - MENTAL:	I searched for an answer. Let us x-ray this political party.
SENSORY - CONTROL:	Their rights disappeared one by one.
CONTROL - MENTAL:	She offered him an idea.
CONTROL - SENSORY:	Her hat usurped his view.

'He closed his mind' appears in the output of Figure 1. The base--i.e. PHYSICAL--definition of 'close' is one of the more complicated verb definitions, since the syntactic object is either a space or an object containing the space (which is filled or eliminated), and its complete representation will not be discussed here. However, the "effect" portion of

the semantic representation for the sense in which the object is a space is that nothing can pass into or out of the object containing the space. The relevant portion of the "pass into" interpretation is represented by the nested definition:

```
(close ((PHYS) (TR-L) (STATE ((HYP +) TR-E (STATE (O IN R))))
        (ROLE R) (AGENT +) ...
        (R (NRM (CONT +)) (BRD ((CONT +))) )).
```

It is noted that the +HYP value refers to the potential character of the outermost STATE; the HYP value for the innermost STATE is negative, consistent with the observation in Section 2.2 that all physical relationships (excluding separation) can be considered "actual".

The role routine determines that, since 'close' is R-role, the direct object of 'close', i.e. 'his mind', maps into R. But the base-interpretation routine then discovers that R is +MENTAL and not +PHYSICAL as required by 'close'. The program therefore attempts an interpretation at the MENTAL level, the level of 'mind'. R = 'mind' is an ANIMATE PART ('he (PART: mind = +MENTAL') in fulfillment of criterion 'c-1'. It can therefore serve as a "location" at the MENTAL level. O is unspecified in the sentence and thus does not impose any level- or other restrictions. In checking to see that the 'Broad' specifications by 'close' are satisfied by 'mind', the program finds that 'mind' does have the +CONTAIN feature as required.

The verb can therefore be interpreted at the MENTAL level. The innermost structure--TR-E (STATE (O IN R))--is extracted and the MENTAL level is substituted for the PHYSICAL. The absence of a value indication is interpreted as '+'. The

"roadmap" through the matrix portion given in Figure 2 then consists of the dimensions: 'MENTAL (level) P. (sublevel) R (role) STATE (structure) -HYP (feature) + (value)'. For purposes of paraphrasing directly out of the matrix, the entry resulting from this search is the English verb 'think', which would correspond to a conceptual structure O $\Longleftrightarrow$ LOC (CP(R)), i.e. 'O be (mentally) located in the conscious processor of R'. With closer attention to the sublevel(s) of 'mind', a more specific expression could be determined. For instance, an association of both the P and V sublevels with 'mind' yields 'think about the truth of...' and 'think about doing...'.

In order to complete the paraphrase, the program assumes that 'he' has the same referent as 'his' and notes from the definition of 'mind' that 'mind' is an IPART of this referent. It then picks up those conceptual elements of 'close' other than those describing the innermost underlying STATE--(TR-L STATE (HYP +) TR-E)--and submits the entire list of elements (he (IPART: mind) TR-L STATE (HYP +) TR-E think) to a simple mapout routine. This gives the "paraphrase" 'he (IPART: mind) STOP POSSIBILITY-OF START think'. An actual generator could arrive at paraphrases such as 'he stopped thinking'. A corresponding O-role interpretation would be 'nothing can start to be in (i.e. enter) his mind', which is also a reasonable approximation.

The aspect of 'close' which implies that nothing can leave rather than enter would yield 'he started to keep everything in his mind'. This might be understood in terms of not forgetting or not expressing oneself. The inability of the described

method to identify exactly which meaning is intended is the price of its objectivity and flexibility in being able to arrive at an interpretation with no previous knowledge of what such phrases refer to in a given culture. In this respect the model represents the abilities of a language-user who is unfamiliar with the idioms of the speakers of his environment.

5.2. Category shift

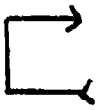
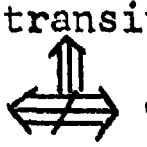
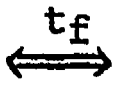
A "category shift" refers to the fact that instead of a PP or a conceptual NOMIN L, an attributive or verbal concept in the form of a noun appears as the concept which has been assigned role O. More specifically, these concepts are either "conceptual attributes" (of Objects) as represented by 'color', 'truth', 'beauty', 'value', etc., or attributes of animate Rs which might be described as MENTAL-, SENSORY- or CONTROL level VERBs in which the focus is on R rather than on the relationship between R and some O, as represented by 'confidence', 'perception', 'possession', etc. Metaphorical uses involving either type of concept often involve level shift, as in 'its value deflated' or 'she built up his confidence'. In this sense they resemble that class of expressions designated simply as "level shift". Also, the procedures for interpreting the (level- and) category-shift 'they decimated his joy' and the level-shift 'they decimated his version of the accident' are similar.

However, the designation of a category shift allows for the interpretation of the metaphorical 'his smile disintegrated', which does not involve a level shift in the sense described above. In addition, this designation preserves the theoretical distinction between 'joy' as an (animate) attribute and the NOMINAL 'version' ('story', etc.) as a concept which is isolated from its animate source, a distinction which is realized in the definition of O in each case. Rather than being defined as a NOMINAL, 'joy' or the noun 'smile' is defined as a noun with a basic VERB structure and level.

NOMINAL features, which are not as critical for non-PHYSICAL as for PHYSICAL NOMINALs, are even less distinguishable for attributes. The ANIMATE feature divides the class of attributes as described above; in general, however, feature values are presently ignored as possible restrictions on metaphorical uses of attributes.

A few examples of category shift in which the topical focus is on an attribute rather than on a human experiencer R, illustrate additional points concerning metaphorical interpretations. One of the general problems of metaphorical interpretation is to show in the representation of a phrase the analogy to a conceptual object, as well as "what is really happening".

The input example 'his smile disintegrated' should produce the same representation as that of 'he stopped

smiling'. Yet the ability to thus relate these expressions must be based on some underlying similarity with intuitive appeal. This task requires a verb definition procedure such as the one presented here, which rests on a small number of conceptual elements. The primitive element of TRANSITION underlies 'he stopped smiling', 'his smile disintegrated' and 'his smile left him', even though on the surface it appears only to underlie the latter (third) form of expression. This element is expressed in our semantic representation as TR-L. From there the TR-L structure could be incorporated into a conceptual diagram in a number of ways, e.g. by a transition arrow  , by a "cause-to-not" structure  or  , or by a "finish-ACT" notation  . The latter notation is the one actually used in conceptual dependency for examplesof the type given. This notation does not express any relationship between the three forms of the example given above. However, it is mapped out of TR-L, which does show this relationship and is referred to in the following analysis of 'his indifference disintegrated'

Briefly, 'disintegrate' is defined as changing from existence to non-existence of an object, on the PHYSICAL level: ((PH) TR-L (STATE (O BE))...). Since 'indifference' is not consistent with the PHYSICAL level, a base-level interpretation fails. Since 'he' is +ANIMATE, the MENTAL-level noun 'indifference' can serve as an attribute of 'he'

as experiencer R. There are no feature specifications which must be fulfilled by the attribute 'indifference'; therefore there are no obstacles to an interpretation on the MENTAL level. The definition of 'indifference' yields the descriptors '((BE A) (STATE (O AT R) (VAL +-)))', where 'A' represents AVAL, i.e. the MENTAL sublevel 'Attitude', and '+- is the value for 'neither positive nor negative'.

'Indifference' can be defined in terms of either the LTM or the OP, i.e. either as +HYP or -HYP; +HYP is arbitrarily assumed for non-PHYSICAL concepts. The program thus enters the matrix with dimension information (ME A R STATE +H +-) to obtain a corresponding R-role VERB. It finds 'be-indifferent-to', uses the R already determined as subject and adds structure element TR-L given by the verb to obtain 'he STOP be-indifferent-to...', leaving a slot for the object of the indifference.

The procedure is similar for 'his smile disintegrated'. The program determines a category shift and accepts the TR-L structure for 'disintegrate' with the "loss of existence" of O (O BE) interpreted as the "loss of state" of R (O AT R). Thus the resulting R-role representation is the same as that for 'he stopped smiling'. (It might be noted that the substitution of a concept such as 'smile' for a physical object could be represented as a PHYSICAL-to-ACTIVE shift, if an ACTIVE level ispostulated for NOMINALs snd VERBs (5). Pursuit of this approach would designate this example, like

the other examples of this section, as a case of level shift.)

The example 'truth burned up' is dismissed by Katz (3) as semantically anomalous. However, if humans can understand sentences involving verbs which apparently violate selectional restrictions, then such expressions are also subject to computer understanding. In terms of the matrix, 'truth', a conceptual attribute, represents a positive value of an attribute of a (lexically absent) MENTAL object, which is in turn dominated by a (lexically absent) R. Since 'burn up' differs from 'disintegrate' only in the means or manner of the action, the analysis of this example is similar to that of 'his indifference disintegrated', with a shift to the TVAL- rather than to the AVAL sublevel. By allowing for the assumed R and O, the output routine can obtain the approximation 'one STOP know...' ('people stopped knowing') or 'one STOP RELATE-TO true information' ('people stopped having or telling the truth'). Thus although contextual restrictions on 'burn up' would indicate a +PHYSICAL NOMINAL as actor, the program still "understands" the usage while recognizing that it is not a base or "normal" usage. This is possible because the system isolates the primitive structure of a verb from its ordinary selectional restrictions.

5.3. R-O switch

R-O switch isexemplified by 'the country leapt to prosperity' in that 'prosperity' rather than 'country'

appears to be the goal and is thus initially assigned role R rather than O. This kind of metaphor may actually include a category shift (which itself may include a level shift), and is used to express a change of state (of 'country') as a transition (of 'country').

Looking up 'prosperity' in the dictionary, the program finds (prosperity ((CO E PH) (ROLE R) (STATE (+) (AMT >))
(R (NRW (HUMAN +)) (BRD (HUMAN +)))).

That is, 'prosperity' maps into an attribute on the CONTROL level (Extrinsic control of PHysical concepts), is positively valued, of a great AMOUNT, and dependent on any +HUMAN concept. 'Country' has the feature required for an R on the CONTROL level (+ANIMATE), and further, it satisfies the +HUMAN specification demanded by 'prosperity'; 'leap to' specifies no particular restriction for R other than +PHYSICAL.

We therefore wish to take over the structure for 'leap to', but to indicate the CONTROL rather than the PHYSICAL level. The structure essentially is TR-E as found in the definition of the O-role verb 'leap-to'. The concept of 'start to be' or 'become' which underlies TR-E at any level is transformed to 'start to have' in an R-role expression. The object of the control involved in 'prosperity', which is given as 'PHYSICAL', can be mapped into the word 'material' for purposes of generation. Thus our representation yields the R-role 'country START have-material' in the implementation,

and could be the basis for other non-metaphorical paraphrases such as the O-role 'the country was becoming prosperous'.

Another example, interesting because potentially all levels are involved in its metaphorical interpretation, is 'Europe and America are drifting apart'. Subject to the context of the discourse, the metaphorical interpretation in this case may turn out to be a more likely interpretation than the base (PHYSICAL) one. 'Drift apart' is defined in the dictionary as a symmetric, i.e. +SHARED verb on the PHYSICAL level:

((PHYS) TR-L (STATE (O AT R)) (ROLE O) (AGENT -)...(SHARED +)).

Since the syntactic joint actors, 'Europe' and 'America', are both defined as having a +PHYSICAL component, i.e. their geographical areas, we have the PHYSICAL interpretation that the continents of Europe and America are in the process of going away from one another. That is, Europe or America or both are losing the location they once shared.

Since 'drift' potentially takes a source or goal as indicated by 'AT R', the example satisfies the condition for testing for an R-O switch. The missing NOMINAL or attribute (which would correspond to 'prosperity' in the previous example) implied in the sentence can have any level, since it is not explicitly given. 'Europe' and 'America' as institutions fulfill the +ANIMATE condition for R:

(Europe/America (... (ANIM +) ...)). The level of the missing NOMINAL or attribute from which they are drifting is unknown. Thus the program determines that interpretations on the MENTAL, SENSORY and CONTROL levels are also possible. On the MENTAL level, the above structure for 'drift apart' is the structure which underlies a possible paraphrase generation of 'Europe and America no longer agree'; on the SENSORY level it is the structure for 'Europe and America no longer perceive the same things'; and on the CONTROL level it is the structure for 'Europe and America no longer have the same rights, responsibilities or types of control'.

5.4. Intra-level feature shift

In the level shifts described above, a verb is usually borrowed from one level and applied at the level of the object with which it will be used. In intra-level feature shifts, all components conform to the same level, usually the PHYSICAL, but a specification(s) or feature(s) of the object is violated. When the +ANIMATE feature of an actor is violated, a kind of personification or anthropomorphic behavior results, as in 'the chair drank the ink'. This can be referred to as an "actor-feature shift". (A corresponding example on the MENTAL level might be 'that painting says something to me', where the painting does not literally say anything, but the result of looking at the painting is the same as if something had been

said.) If, however, it is the object which does not meet the specifications of the verb definition and yet the phrase is "comprehensible", there is an "object-feature shift". An example is 'the ship plowed the sea'.

5.4.1. Actor-feature shift

As stated above, there is no change in level for this type of metaphor, but the +ANIMATE restriction on the actor is violated. Thus 'the chair drank the ink' is an example of intra-level shift, but 'the boy drank in the poetry' is not, as it involves an extension to a different level. In general, the semantic requirements on the object of such an expression are the same as those in a non-metaphorical usage. In 'the chair drank the ink', both the 'chair' and the 'ink' are ordinary physical concepts, although the use of 'drink' is not quite the ordinary one. An examination of this example by the semantic component reveals nothing unusual about 'drank the ink'; 'ink' is +PHYSICAL and +FLUID as required by the 'Narrow' specifications of 'drink'. 'Chair', though +PHYSICAL, is noted to lack the +ANIMATE feature value specified by 'drink', so the ordinary sense is rejected, while the conditions for an actor-feature shift are satisfied.

The determination of a metaphorical interpretation implies that the effects or linguistic inferences derivable from the underlying conceptualization are similar to those derivable from a conceptualization containing the literal

sense of 'drink', which is 'to INGEST a +PHYSICAL, +FLUID substance'. Since the input example is already in R-role form, i.e. with the Recipient as subject, an O-role form is given as paraphrase in the output. Because the structure is a TR-E one, with O = 'ink', it is known that the ink was removed from somewhere and is now in the chair. The information given as a result is 'ink START BE in chair'. Considering other variations on this input, we note that we could not readily interpret 'the blotter drank the chair', since 'chair' is -FLUID.

5.4.2. Object-feature shift

The example 'the ship plowed the sea' fails a literal interpretation on the basis of the definition of 'plow':

```
(plow ((PHYS) TR-E (STATE (O BE SHAPE: )) (ROLE O) (AGENT +)
      ... (INSTR: TR (STATE (O AT R)))
      (O (NRW land) (BRD (2D +) (FIXED +))) )),
```

since 'sea' is not a synonym for 'land'. However, 'sea' fulfills the 'Broad' specifications of 'plow' for O. 'Ship', the syntactic subject, is assigned the role of AGENT. In (5), it is explained that an AGENT, i.e. a NOMINAL which has some role in a causative action, either 1) is +ANIMATE, 2) itself represents an action and therefore has the ACTIVE level, or 3) has a specific function which enters into the causation. Since 'ship' isneither +ANIMATE nor ACTIVE-level, it is assumed to have a functional role in the causing conceptualization. The program checks to see that certain

requirements of an instrumental involvement of 'ship' in 'plowing' are fulfilled. The function of 'ship' is given as 'sail'. The structure underlying 'sail' is TR (STATE (O AT R)). Although the noun 'plow' might be given as the explicit instrument of the verb 'plow', the program ignores the failure to agree with such specific information, just as it ignores 'Narrow' restrictions on objects when considering metaphorical expressions. On examining the general structure given for the instrumental conceptualization of 'plow', the program finds TR (STATE (O AT R)) , which agrees with the verb structure of the function of 'ship'. In other words, although only a 'plow' can truly 'plow', in a metaphorical interpretation anything which "physically goes" can conceivably have a "plow-like" effect. The program therefore arrives at the rough interpretation 'ship DO (sea START (BE SHAPE:))'. Conceptual dependency rules would then transform 'ship DO' into a structure corresponding to 'one operate ship'.

Consider now a verb--'kill'--which is subject to metaphorical use. but in a non-straightforward way, since a level shift and/or an object-feature shift may be involved. In the examples 'John killed the cat' and 'the House killed the bill', the ordinary object of 'kill' ('cat') is no more a mere physical object than the metaphorical object ('bill') is a mere mental object. The PHYSICAL-to-MENTAL extension

in the second example is obscured by the simultaneous presence of an object-feature shift.

To clarify the role which each type of shift plays, a similar example is first presented which involves only object-feature shift: 'he killed themotor'. This example could be more explicitly paraphrased as 'he did something which caused the motor to die'. The interpretation depends on what it means for the object, 'motor', to 'die' or 'be dead'. It would be desirable to obtain the interpretation 'he stopped the operation or running of the motor', while rejecting a similar interpretation for 'he killed the stone'. 'Motor' and 'stone' are both PHYSICAL NOMINALs; no level shift is involved. Rather, the +ANIMATE specification on the object is violated, yielding a metaphorical interpretation in the first case and no interpretation in the second. 'Motor' is a meaningful object of 'kill' because it is a +DYNAMIC NOMINAL, its function being to 'run'. (It is recalled from Section 3.1 that the +DYNAMIC feature value specifies a function which can be identified with the particular meaning of a NOMINAL.) When a motor is 'killed', this function attribute is eliminated--a consequence which differs from e.g. the disintegration of the motor which might represent its being 'destroyed'.

The procedure of the program operating on the first two examples can be outlined as follows. The semantic representation for 'kill' is:

```
(kill ((PHYS) TR-L (STATE (0 <FN(0)>)) (ROLE 0) (AGENT +)
       (TRY -) ...
       (0 (NRW (ANIM +))) (BRD (DYN +)) )).
```

For the example 'John killed the cat', the program will find that all specifications on the NOMINALs by the definition of the verb are met by the words of the input. In particular, '0 = "cat"' is +ANIMATE; that is, in terms of DYNAMIC FUNCTION, it 'lives' in a literal sense. Thus the literal sense of 'kill' is accepted. If the input 'John killed the stone' is encountered, the program notes that 'stone' has no +ANIMATE feature value and therefore fails a base interpretation. Furthermore, 'stone' isnot +DYNAMIC and therefore does not satisfy the 'Broad' specifications necessary for a meta-phorical interpretation.

The input 'the House killed the bill' presents a more interesting case. 'House' in the sense of 'House of Representatives' or 'Lower House' has the +ANIMATE feature preferred by the target representation conditions on an AGENT as specified above with respect to 'ship'; however, 'bill' does not have the +ANIMATE feature value as required by 'kill'. Thus a base-level interpretation is rejected. However, 'bill' does have the +DYNAMIC value, corresponding to the observation that it has a "continuous effect" on people. Thus the basic components are satisfied for an interpretation. Since the dispensable 'Narrow' +ANIMATE descriptor, i.e. the literal 'live' function, is violated, but the minimal, i.e.

'Broad' requirements are fulfilled, the employment of 'kill' is considered a metaphorical extension from the PHYSICAL to the MENTAL level. The structure TR-L (STATE (O <FN(O)>)) (AGENT +) then yields the paraphrase 'House STOP bill become law', where 'law' is a CONTROL concept represented in terms of 'one must' and 'one may'.

By noting that which is common to both the base sense and metaphorical senses of 'kill', we can compare the meanings of these senses. The underlying structure of the verb itself specifies in all cases that an action was successfully taken to eliminate the DYNAMIC function or effectiveness of the Object. The effect component of this structure says that the Object no longer exists in its previous state, for this is the interpretation assigned to the TR-L structure. Thus the cat no longer lives; the motor no longer runs; consideration of the bill stops, and the intended result, defined conceptually as <↑>, is prevented--thus the prohibition, order or permission contained in the bill is never realized.

5.5. Noun compounds

This type of metaphor analysis can also be applied to noun compounds in which the nouns are defined in terms of verbal concepts. The further development of the above mechanimsms must precede an implementation of the more complex noun-compound metaphor analysis; however, the approach to interpretation of such constructs can be indicated. An

example is given by the noun compound idea factory', which is close in meaning to the verb-noun compound 'think tank'. If the +PHYSICAL objects or matter usually associated with 'factory' or 'tank' are ignored, noun-compound interpretation procedures (5) can be used to arrive at 'institution which makes ideas' or 'environment in which one thinks' respectively. Here the verb 'think' and the noun 'idea', which is an object of thought, retain their literal sense, whereas the functions underlying 'factory' ('make') and 'tank' ('be in') undergo an abstraction process similar to that involved in level shift.

Consider also the example 'the foreign-born may hold the White House key soon'. It is possible to understand 'White House key' in its metaphorical sense because: 'key' is a NOMINAL described as having the function 'open'; 'opening' implies the possibility of 'entering' (cf. 'close', Section 5.1); and 'White House' is not only a PHYSICAL building, but is also defined with the features of an institution, which includes ANIMATE beings. Thus the framework exists for handling some metaphorically used noun constructs with underlying verbal and/or attributive concepts.

6. Conclusion

The examples of Sections 5.1-5.4 are representative of the various metaphor mechanisms which have been identified. The question arises as to the extent to which such mechanisms hold for any metaphorical use of a verbal or attributive

concept. An assessment of the validity of the analysis method for such metaphorical uses depends upon 1) the completeness of the identified categories, i.e. whether such categories cover all types of verbs in the class under consideration; 2) whether such categories are based on the most "important" component which enters into metaphorical extensions; and 3) the extent to which variations within a category affect the plausibility of an interpretation. The first two conditions are concernedwith the question of a "minimal" interpretation, i.e. the exclusion of a "false" interpretation, the third with an "adequate" interpretation.

With respect to the first point, the verb description system presented has intentionally focused on the breadth or scope of the categorization rather than on a more detailed illustration of any one category. Such an overview must have prior consideration because the translation of a metaphorical verb requires comparison with other verbs, which themselves must be assigned a "location" within the system before any refinement of interpretations can begin. The given system outlines t is categorization in terms of three related primitive structures-- STATE, ENTER-STATE and LEAVE-STATE, which are subject to embedding, as in the case o 'close' (Section 5.1). Roles define the ap lication of rhese structures to an "object", a "location" of an object and an "agent" of any change, the result of which is represented by such a structure.

These roles, which are few in number and relatively simple to identify for any given verb, are adequate to relate any lexical verb form to an underlying structure. This structure-role description divides the class of predicative concepts with the exception of "logical" terms such as 'imply' or 'equate'. Thus the field of verbal and attributive concepts is covered by this minimal classification based on intuitive abstract concepts. These abstract structures can be primitively realized in the literal output paraphrases as 'be (or not be) in a certain state', 'start to be in a certain state' and 'stop being in a certain state'. The nature of the 'state' can then be described to the extent allowed by the level/sublevel definition of the Object of the phrase. The identified levels which define the field of metaphorical extension can always be expanded or refined to give more information, since they do not affect those components--structures and "structural" features excluding HYP and VOL--which remain constant in an extension.

It is claimed that these structures are the most basic characterizing elements of a verb in the sense that the identified primitives and mechanisms are those which can also be recognized as underlying conceptually simpler linguistic constructs not usually thought of as metaphorical. Although a phrase such as 'he reached prosperity' is not obviously metaphorical, there is a "translation" between it

and the phrase 'he became prosperous' which is similar to the translation between the more colorful 'he leapt to prosperity' and 'he became (suddenly) prosperous'. In each case, the primitive TR-E representing 'start to' relates the two forms of the expression. This similarity rests on the fact that all linguistic expressions which treat abstractions ('prosperous') as objects ('prosperity') might in a sense be considered metaphorical. It seems reasonable to ap roach the problem of metaphor with an analysis valid for the simplest form of such expressions. The analysis represented by the structural descriptors is trivial but basic in that it is a prerequisite to any more complete interpretation, and in that it relates expressions exhibiting varying degrees of metaphor without resorting to ad hoc definitions or rules.

Although they provide a basic interpretation, the structures and features which render an extension meaningful are not necessarily the focus of a metaphorical expression. The focus may be an attribute which, while provided for and

broadly classified by the structure-level definition of the verb, itself remains to be defined. To take a rather difficult example, the verb 'bleach' can be defined as '+AGENT TR-L STATE (O BE COLOR:) (NOLL O)', or, 'to cause an object to LEAVE a STATE of COLOR'. If 'bleach' is used metaphorically, as in 'she bleached the story', this definition gives the minimal information that some attribute of the story disappears. This is the most basic or necessary part of the interpretation, but is not very interesting. It would also be desirable to know how the attribute itself enters into the metaphor, i.e. what the color or loss of color signifies.

For quantitative attributes, i.e. those with magnitudes as values, the primitives 'AMOUNT' and 'INTENSITY' are included in the definition at the PHYSICAL level and are easily extended to other levels. The characterization of qualitative attributes, such as 'with or without (a certain) color', is more difficult. A suggested approach (5) assigns POSITIVE/NEGATIVE value "connotations" to attributes where they suggest themselves; for example 'bright: POS', 'flat: NEG' (but 'even: POS' !). These assignments can be expected to reflect cultural differences in understanding metaphor. For the present example, even this minimal definition is difficult, because literal bleaching can be done for different purposes: bleaching might be perceived as NEGATIVE in the sense of 'removing color', but POSITIVE in the sense

of 'launaering' or 'removing stains' (TR-L ST TE (O (IP ..T:) BE COLOR: NEG)). However, the resulting ambiguity in any metaphorical interpretation largely reflects the ambiguity of any literal use of the verb. In both cases a knowledge of the linguistic or situational context is required for a correct understanding of the use of 'bleach' ('he bleached the report of the war casualties', 'he bleached the anecdotes').

This example points out the accomplishments and limits of the system in defining components significant to metaphor. What it does is to specify a structural framework in terms of which those properties of predicative concepts relevant to metaphorical usages can be methodically defined. In other words, the system distinguishes the conceptual structure component underlying a verb form from those semantic attributes which are "non-structured". Thus the structure underlying 'bleach' is automatically specified, as above, and provides "slots" such as POS/NEG for the attribute represented by 'white' or 'without color'. The specifications for qualitative attributes must remain flexible, subject to the associations which a culture or subculture assigns to such attributes; the symbolic value of an abstraction such as 'black' is difficult to define in a general manner, apart from any context. In this sense the reduction of a verb use to quantitative primitives and qualitative attribute-values may represent the limit to which metaphorical analyses can be generalized.

Given that this system of representation produces minimal interpretations wherever possible, as opposed to the alternative of dismissing an expression as anomalous, it remains to consider the third condition listed above, namely the adequacy of the method as applied to verbal concepts which are claimed to fall <u>within</u> a category, i.e. which are assigned the same configuration of descriptors. It is assumed that the primitive structure underlying a verb is always carried over in a metaphorical usage, although it may be magnitude (which is allowed for in terms of AMOUNT and INTENSITY) or some other aspect of "style" (which is <u>not</u> provided for) which is emphasized. Thus 'leap to', 'drift into', 'land on', 'hit' and 'plow into' or 'plow through to' (which share the same structure and feature values except for VOL) all lead to similar interpretations, given a common goal, e.g. 'prosperity'. All yield 'the beginning of a prosperous state'; with incorporation of the INTENSITY descriptor, 'leap to' and 'hit' yield 'sudden beginning'. Treating (one sense of) 'hit' and 'leap to' as nearly synonymous (TR-E STATE (O ON R for 'hit', O AT R for 'leap to') (INTENSITY: >) (ROLE O)), which they are not, entails some loss of information, of course, but the resulting approximation is useful. In the case of 'plow through to', on the other hand, the lack of the information that a "laborious effort" is involved weakens the interpretation to a greater degree; this kind of style, which depends

on the specific mechanics of the action or the attitude of the actor, is difficult to incorporate into a systematic characterization. However, such information, independently determined, could be added to the verb description. For example, the descriptor 'INTENSITY:>' appended to the feature value '+VOL' could be assigned to the verb 'plow'. These descriptors would be carried over to the incomplete but more informative metaphorical "interpretation": 'he very consciously did something to become prosperous'.

Thus it can be concluded that the method presented covers a major class of predicative concepts, and that the resulting approximation to the meaning of an expression is reasonable but varies in the amount of information conveyed. It is of significance that the emphasis on inclusive classes together with a specific suggested format allows for extension of the system. Interpretationsproduced on the basis of relatively minimal information will not always be completely satisfactory, nor will they provide all the nuances of linguistic expression. However, the possibility that interpretations of a large class of metaphorical expressions can be approximated by a systematic analysis of the concepts involved ensures further opportunities to develop computer understanding of novel expressions.

FIGURE 1

OUTPUT INTERPRETATIONS

Format: <INPUT PHRASE>
<TYPE OF METAPHOR> <INITIAL ROLE CONFIGURATION>
<OUTPUT PARAPHRASE>

(CHAIR DRINK INK)

FEATURE-SHIFT RVO

(INK START BE IN CHAIR)

(HE DRINK INK)

BASE RVO

(HE DRINK INK)

(HE CLOSE INK)

(NO INTERPRETATION)

(HE CLOSE MIND)

LEVEL-SHIFT AVR

(HE (IPART: MIND) STOP POSSIBILITY-OF START THINK)

(SHIP PLOW SEA)

FEATURE-SHIFT AVO

(SHIP DO SEA START (BE SHAPE:))

(SHIP PLOW CHAIR)

(NO INTERPRETATION)

(CHAIR PLOW SEA)

(NO INTERPRETATION)

FIGURE 1--Continued

```
( SHIP DISINTEGRATE )
BASE    OV
( SHIP DISINTEGRATE )

( INDIFFERENCE DISINTEGRATE )
CATEGORY-SHIFT    OV
( HE STOP BE-INDIFFERENT-TO )

( COUNTRY LEAP-TO PROSPERITY )
RO-SHIFT    OVR
( COUNTRY START HAVE-MATERIAL )

(PROSPERITY DISINTEGRATE )
CATEGORY-SHIFT    OV
( HE STOP HAVE-MATERIAL )
```

FIGURE 2

SAMPLE INPUT DATA

Dictionary Entries:

(CHAIR ((PH) (PART -) (CONT -) (FIXED -) (1D -) (SHAPE +) (SIZE 2)
(FLUID -) (CX -) (ANIM -) (MM +) (FN: LOC (ON))))

(INK ((PH) (PART -) (CONT -) (FIXED +) (1D -) (SHAPE -) (FLUID +)
(CX -) (ANIM -) (MM +) (FN: EXT (WRITE))))

(HE ((PH) (PART -) (CONT -) (FIXED -) (1D -) (SHAPE +) (SIZE 2)
(FLUID -) (CX -) (ANIM +) (MM -) (DYN +) (FN: ACTIVE (LIVE))))

(MIND ((ME P) (PART (ANIM +)) (CONT +) (FIXED +) (1D +) (SHAPE +)
(FLUID -) (CX +) (ANIM +) (MM -) (DYN +) (FN. INT (THINK))))

(SHIP ((PH) (PART -) (CONT +) (FIXED -) (1D +) (2D -) (SHAPE +)
(SIZE 3) (FLUID -) (CX +) (ANIM -) (MM +) (FN: EXT (SAIL))))

(PLOW ((PH) (PART -) (CONT -) (FIXED -) (1D -) (SHAPE +) (SIZE 2)
(FLUID -) (CX -) (ANIM -) (MM +) (FN EXT (PLOW)) (DYN -)))

(LAND ((PH) (PART -) (CONT +) (FIXED +) (1D +-) (2D +) (SHAPE -)
(SIZE > 3) (FLUID -) (CX -) (ANIM -) (MM -) (DYN +)
(FN: ACTIVE (PRODUCE))))

(SEA ((PH) (PART -) (CONT +) (FIXED +) (2D +-) (2D +) (SHAPE +)
(SIZE 4) (FLUID +) (CX -) (ANIM -) (MM -)
(DYN +) (FN: LOC (LIVE))))

(COUNTRY ((PH) (PART -) (CONT +) (FIXED +) (1D +-) (2D +) (SHAPE +)
(SIZE 4) (FLUID -) (CX +) (HUMAN +) (ANIM +)
(MM +) (FN: LOC (IN AT)) (DYN +) ( )))

(INDIFFERENCE ((ME A) (STATE (O AT R) (VAL +-)))

(PROSPERITY ((CO E PH) (STATE (O AT R) (VAL +) (AMT >)))

FIGURE 2--Continued

```
(DISINTEGRATE ((PH) TR-L (STATE (O BE)) (ROLE O) (AGENT -)
              (O (NRW ) (BRD )) ))
(LEAP-TO ((PH) TR-E (STATE (O AT R)) (INTNS  ) (ROLE O) (AGENT -)
         (INSTR FN: INT (LEGS)) ))
(DISAPPEAR ((SE EYE) TR-L (STATE (O SENSED-BY R)) (ROLE O)
         (AGENT -)    (O (NRW ) (BRD ) )) )
(CLOSE ((PH) (TR-L) (STATE ((HYP +) TR-E (STATE (O IN R))))
       (ROLE R) (AGENT +) (R (NRW (CONT +)) (BRD (CONT +))) ))
(DRINK ((PH) TR-E (STATE (O IN R)) (ROLE R) (R (NRW (ANIM +)) NIL)
       (O (NRW (FLUID +)) (BRD (FLUID +))) (AGENT -) ))
(SAIL ((PH) TR (STATE (O AT R)) (ROLE O) ))
(PLOW ((PH) TR-E (STATE (O BE SHAPE: )) (AGENT +) (ROLE O)
       (INSTR: TR (STATE (O AT R))) (O (NRW LAND) (BRD (2D +)
       (FIXED +))) ))
```

Matrix Segment:

```
ME (P (R (STATE (-H (+ THINK - ())
                +H (+ BELIEVE - DISBELIEVE)) TR-L () )
         O (STATE (-H (+ (IN CP) - ())
                +H (+ (IN LTMP) - ())) TR-L () ))
        (R (STATE (-H (+ ENJOY - NOT-ENJOY +- BE-UNAFFECTED-BY)
                +H (+ LIKE - DISLIKE +- BE-INDIFFERENT-TO))
           TR-L (~) )
         O (STATE (-H (+ (IN CP) - ( ) +- () )
                +H (+ (IN LTMP) - () +- () ))
           TR-L (") )))
```

FIGURE 2--Continued

```
CO (E (PH (R (STATE (-H ( )
                    +H (+ HAVE-MATERIAL - () +- () ))
               TR-L (-H ( )
                    +H (+ LOSE - GAIN +- () )) )
          O ( ) )) )
```

Mapping into Paraphrase Words

(STATE TR-E TR-L (HYP +)) (BE START STOP POSSIBILITY-OF) ;

Input Phrases:

CHAIR DRINK INK;

HE DRINK INK;

HE CLOSE INK;

HE CLOSE MIND;

SHIP PLOW SEA;

SHIP PLOW CHAIR;

CHAIR PLOW SEA;

SHIP DISINTEGRATE;

INDIFFERENCE DISINTEGRATE;

COUNTRY LEAP-TO PROSPERITY;

PROSPERITY DISINTEGRATE;

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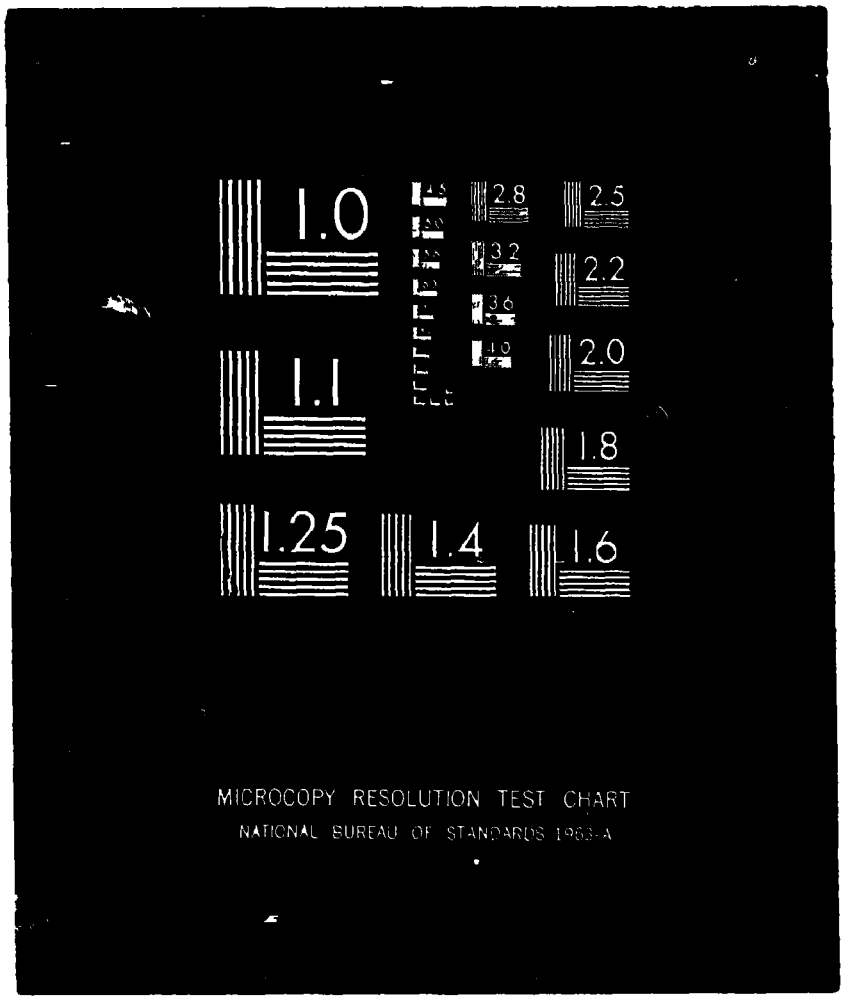
END


1.0
1.1
1.25
2.8
3.2
3.6
4.0
1.4
2.5
2.2
2.0
1.8
1.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A