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ABSTRACT
                Twenty college students, ten each in the experimental
and control groups, were the subjects of an experiment designed to
demonstrate that integration of verb meanings occurs in connected
discourse. Six paragraph-length stories, each of which included one
or two critical sentences containing a general verb, were presented
orally to the subjects. The experimental versions included an extra
sentence or phrase whose meaning, when combined with the meaning of
the general verb, was hypothesized to produce the meaning of a
particular more specific verb. After hearing the stories, the
subjects were administered a recall test containing four to eight
sentences from each story, each with a missing word that the subjects
were asked to fill in. The verbs of the critical sentences were
always used. Results showed that subjects in the experimental group
were more likely to recall the specific verb than were control
subjects, that the effect of inserting material was stronger for some
pairs than for others, and that the inserted material acted
specifically to shift recall from the general verb to the particular
specific verb predicted. (TJ)

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Semantic Integration at the Level
of Verb Meaning

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Semantic Integration at the Level of Verb Meaning

Abstract

Subjects heard stories which contained general verbs (e.g., "give"). For half of the subjects, additional semantic information was included in each story. The hypothesis was that this additional information would combine with the meanings of the general verbs to produce the meanings of more specific verbs (e.g., "pay"). In a fill-in-the-blank recall task, subjects who had heard the extra material recalled these erroneous specific verbs often, while subjects who had not heard the extra material recalled the general verbs. These results are interpreted as providing evidence for integration of the semantic components of verbs from different parts of the passage.

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A great deal of recent work has focused on the phenomenon of semantic integration (Anderson & Ortony, 1975; Barclay, 1973; Bransford & Franks, 1971; Cofer, 1973; Dooling & Lachman, 1971; Kintsch, 1976; Loftus, 1975; Sulin & Dooling, 1974; Thorndyke, 1976). In a typical integration study, subjects are presented with meaningful information from different sources or at different times. It is commonly found that when the pieces of information are related in meaning, subjects are unable accurately to recall the information as presented and instead show effects attributable to integration of material from different sources.

Semantic integration appears to be a robust phenomenon, occurring over a wide variety of topic matters and presentation formats. However, relatively little is known about the process by which it occurs. Part of the reason for the lack of models of the integration process is that the representational structure of the materials themselves is not well understood; since models of knowledge structures are still in their infancy, it is not surprising that we lack precise descriptions of how those structures are combined in memory. However, one area in which reasonable well-specified models of meaning have been developed is that of verb meaning. Verb meanings have been analyzed by linguists (e.g., Chafe, 1970; Clark, 1970; Fillmore, 1971; Kartunnen, 1971; Lakoff, Note 3; McCawley, 1968; Postal, 1970;

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and Talmy, 1975); by workers of artificial intelligence, notably Schank (1972, 1973); and by psychologists (e.g., Abrahamson, 1975; Fillenbaum & Rapoport, 1971; Gentner, 1975, Note 2; Miller & Johnson-Laird, 1976; Rumelhart & Levin, 1975; Stillings, 1975). This paper examines semantic integration at the level of individual verb meanings in an attempt to trace in this relatively well-analyzed area the processes by which integration occurs.

Though models of verb meaning differ from one another in detail, there is widespread agreement on the idea that verb meanings can be represented in terms of interrelated sets of subpredicates, such as CAUSE or CHANGE, which express semantic relationships. A typical English verb conveys several such relationships between the nouns in a sentence; most verbs also involve subpredicates which express relations between other subpredicates. There are many ways of notating these connected sets of subpredicates. Figure 1 shows verb representations in a network format.[1] For example, use of the verb give in a sentence, as shown in Figure 1a, conveys that the agent did something to cause the possession of the object to change from the agent to the recipient.

If in connected discourse the representations of individual sentences are combined into larger structures, then a person who has formed such a composite structure may be unable to recall the

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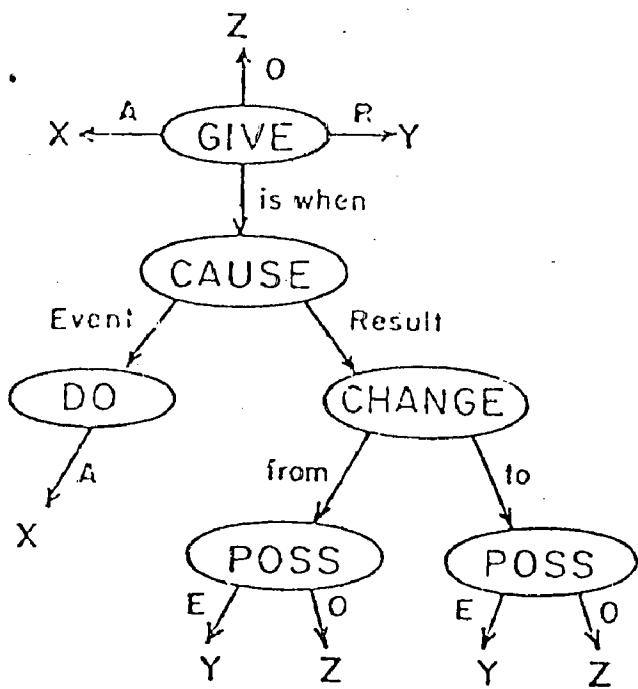
a. X gives Z to Y
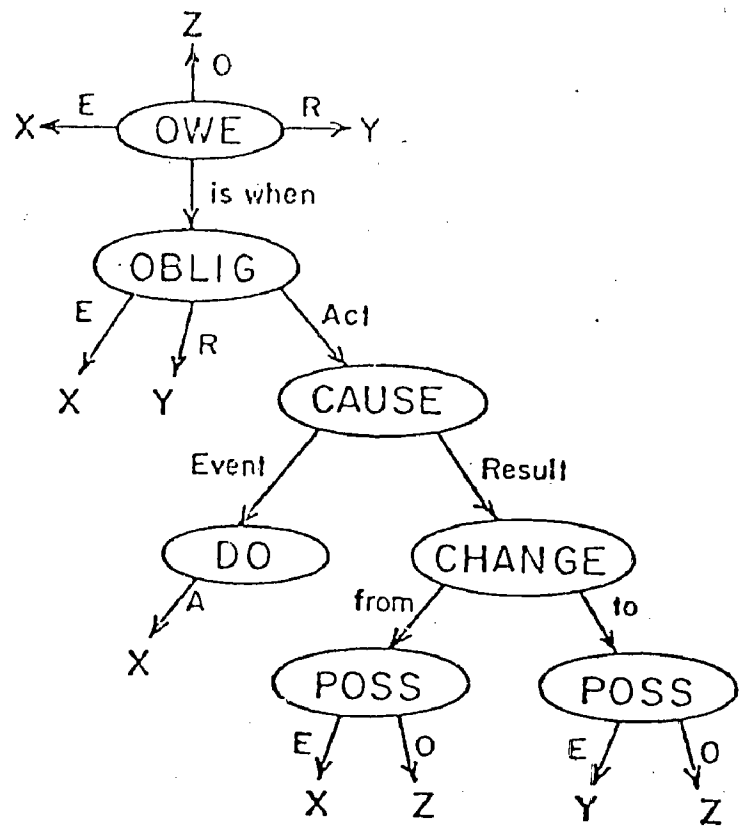
b. X owes Z (money) to Y

c. X pays Z (money) to Y

Figure 1.   Semantic representations of give, owe, and pay. (Abbreviations used are: A – Agent; E – Experiencer; O – Object; R – Recipient; OBLIG – State of obligation; and POSS – State of possesion.)

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original packaging of the structure into separate word representations. Such semantic integration among underlying subpredicates would be manifested as particular inaccuracies in memory for verbs. In the present study such semantic integrations are systematically produced. The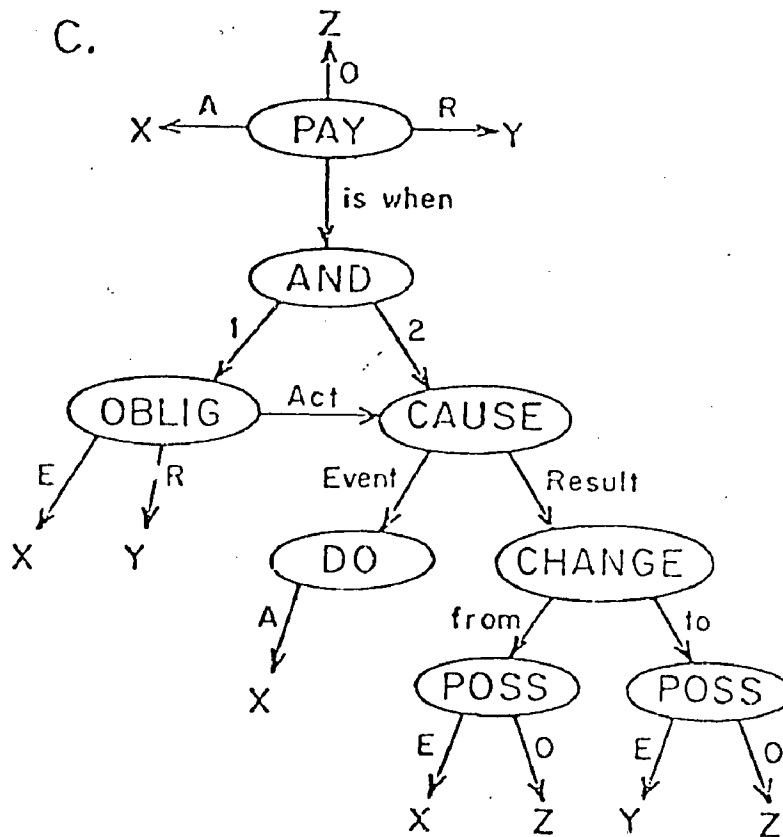 basic idea is to contextually combine the meaning of a given verb with additional semantic information, thereby producing a structure identical to the meaning of another, more complex verb. The hypothesis is that the subjects hearing the extra material will falsely recall the verb which best fits the composite structure, rather than the verb actually presented.

The study utilizes pairs of general/specific verbs, in which the representation of the specific verb contains the entire representation of the more general verb as well as additional semantic information. Thus, on the representational level, the process is additive: the meaning components of the original verb are never contradicted; rather, other components are added. These components are either directly contained in the meaning of the added information or derived as inferences from the added information. An example which illustrates the basic method is the pair give/pay. The sentence

    X gave Z to Y

conveys that there was a change in possession of the object Z from X to Y, and that X caused that transfer to take place. The

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verb pay is a more specific verb than give: Normally, when we talk of someone paying, we mean that the person transferred possession of some money and also that there was an obligation to do so. Paying money is distinguished from giving money by this state of obligation (written OBLIG in Figure 1). Thus, if a state of obligation to transfer money is contextually joined to the act of giving money, the resulting meaning should be that of pay, as shown in Figure 1.

In a pilot study, subjects heard one of two versions of a paragraph and, after a two minute delay, wrote out the story, with instructions to be as accurate as possible (Gentner, 1975). Both versions described Sam requesting money from his friend Max and ended with the sentence

(a) Max finally gave Sam the money.

The two versions were identical except that the experimental story contained the information that Max owed Sam the money, while the control story did not. The verb owe conveys the state of obligation to transfer money, which is what distinguishes paying money from giving money. Thus, if integration of the meaning of owe with the meaning of give occurred in the experimental condition, these subjects should have recalled paid erroneously in sentence (a) to a greater extent than control subjects. The results of this pilot study were that 47% of the subjects who heard the owe sentence recalled paid or paid back;

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none of the control subjects made these errors. These results support the idea that integration of verb meanings occurs in connected discourse. The present study replicates this phenomenon on a larger scale.

Method

Subjects

The subjects were 20 students (10 each in the experimental and control groups) enrolled in psychology courses at the University of California at San Diego, who received class credit for their participation. They were run in groups of three to six people.

Stimuli

Six paragraph-length stories were used as stimuli. Each story included one or two critical sentences containing general verbs. There were two versions of each story, a control version and an experimental version. The two versions were identical except in that the experimental version included an extra sentence or phrase whose meaning, when combined with the meaning of the general verb, was hypothesized to produce the meaning of a particular more specific verb. There were nine verb pairs, shown in Table 1 along with the inserted information for each pair. A sample story is given in Table 2. The complete stories appear in Gentner (Note 1).

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Semantic Integration at the Level of Verb Meaning

Table 1

Stimuli

TEST SENTENCE OR CLAUSE (General Verb / Specific Verb)	INSERTED INFORMATION
1. He $\frac{gave}{paid}$ Joe the money without complaining.	He owed Joe the money.
2. They are $\frac{working\ on}{painting}$ the ballroom...	They are carrying whitewash and brushes; the walls later are wet.
3. ... he could but smile wanly and $\frac{tell}{warn}$ them about the walls...	The walls have wet whitewash.
4. They liked to $\frac{make}{bake}$ things together.	The things are fruitcakes, mincemeat, date bread, and fancy desserts.
5. He $\frac{got}{bought}$ some muffler tape and went to work.	This occurred in a store.
6. ... he knew where he could $\frac{get}{borrow}$ a tux.	His friend offered him use of a tux.
7. He decided to go ahead and $\frac{take}{borrow}$ a tux.	His friend offered him use of a tux.
8. If she hadn't $\frac{used}{played}$ it in the last year, it had to go.	The items are two violins, a piano, and a flute.
9. She $\frac{gave}{sold}$ them the things she couldn't use.	By doing so, she made money.

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Table 2

A Sample Story

Rosemary Kartovsky was pleased when the Chicago Symphony hired her away from the Boston Pops. She figured she could move everything in her camper, but first she had to go through her things and throw out the unnecessary items,

> Two beat-up violins, an upright
> piano and a plastic flute went.

If she hadn't (used) it in the last year it had to go. Fortunately, she had some friends who were glad to get her castoffs. She (gave) them the things she couldn't use.

> This way she made just enough money
> to pay for the gas on her trip.

The only thing that made her sad was parting with her toucan. She was used to hearing him sing along with her when she practiced.

As she drove out of the city limits, still reminding herself that it was for the best and that birds hate long trips, she heard a familiar croaking behind her. Sure enough, her pals had smuggled in the bird, and now she suddenly felt a hundred times better about life in Chicago.

Note. Parentheses denote critical verbs. Boxing denotes material inserted in the experimental condition. The predictions for the experimental group are used ⟶ played; gave ⟶ sold.

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Procedure

Subjects were told that their task was to recall stories as accurately as possible. They then heard a set of three stories. This required about four minutes and was followed, after a delay of about 1 minute, by a fill-in-the-blank recall test. Four to eight sentences from each story were presented on a test page; each sentence had a missing word, which the subject was instructed to fill in. The verbs of the critical sentence(s) were always tested. In the other sentences, nouns or modifiers were tested, in order to disguise the purpose of the recall test. Only the recall of the verbs in the critical sentences was analyzed.

The procedure was repeated for the second group of three stories. The order of presentation of the two story sets and the order of stories within each set were varied randomly across groups of subjects. However, in any given set, the order of testing for stories was the same as the order of presentation.

Results

Verb recalls were scored as to whether the general verb, the predicted specific verb, or some other word was used. The results are shown in Table 3. Subjects who heard the inserted material were considerably more likely to recall the specific verb than subjects who did not. A mixed-measures analysis of

Table 3

Proportions of Response Types in Sentence Completions,

for Stories With and Without Inserted Material

Verb Pair	Correct General Verb	Predicted Specific Verb	Other
Working/painting			
With	0	.7	.3
Without	.8	0	.2
Got/bought			
With	.3	.5	.2
Without	.3	0	.7
Get/borrow			
With	.3	.4	.3
Without	.6	0	.4
Gave/sold			
With	.6	.4	0
Without	1.0	0	0
Take/borrow			
With	.1	.5	.4
Without	.1	.2	.7
Gave/paid			
With	.7	.2	.1
Without	.8	0	.2
Make/bake			
With	.3	.2	.5
Without	.2	0	.8
Used/played			
With	.9	.1	0
Without	.9	0	.1
Tell/warn			
With	.7	0	.3
Without	.6	0	.4
TOTAL			
With	.43	.33	.23
Without	.59	.02	.39

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variance of the number of predicted specific verbs produced by each subject revealed that the effect of inserted material was significant [$F(1,18) = 24.13$, $p<.001$]. The effects of items and of the interaction between insertion and items were both significant, indicating that the effect of inserting material was stronger for some pairs than for others [$F(8,144) = 6.96$, $p<.001$; $F(8,144) = 3.03$, $p<.01$, respectively].

A Check for Bias

In order to conclude that the inserted material acts to create the representation of the predicted specific verb, it was necessary to rule out the possibility that the inserted material simply biased against the presented verb, thus causing a generalized increase in the number of substitutions in the experimental condition. To check this possibility, an analysis of variance like the one described above was performed for the total number of substitutions for each presented verb, other than the predicted verb. Here, the effect of insertion was not significant [$F(1,18) = 2.49$]. Thus, the inserted material acted specifically to shift recall from the general verb to the particular specific verb predicted. As in the analysis of predicted substitutions, the effect of items was significant [$F(8,144) = 8.96$, $p<.001$].

Item Effects

The strength of the substitution effect varied considerably across verb pairs, as shown in Table 3. To understand these differences, it is useful to divide the pairs into two classes, according to the kind of information that must be added to the general verb to create the specific verb. All of the general verbs used here are agentive verbs with a meaning roughly of the form CAUSE (ACTION(agent), RESULT). That is, these verbs convey that an animate agent did something that caused some result, generally a change-of-state of some kind. One way in which these semantic structures can be amplified to create a specific verb is for the action and/or the result to be further specified. The pairs working on/painting, make/bake, and used/played are all pairs in which the specific verb gives more information about either the actions performed or the result of the actions or both.

The situation is quite different with the pairs got/bought, gave/sold, gave/paid, get/borrow, and take/borrow (these last two used in the same story). As is typical in the domain of possession, the specific verbs used here do not amplify the meanings of the general verbs by specifying the actions performed; the precise nature of the actions is not usually of interest in describing a change of possession. Rather, the specific verbs convey that additional transfers or states of obligation are involved.

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Action-result-specification. The substitution effect was strongest in the pair working-on/painting; 70% of the experimental subjects substituted painting for working on. The story for this pair involved both action-specification and result-specification. To say that the men are working on the ballroom conveys that the men are performing some actions which will result in a change in the condition of the ballroom. In the experimental condition, the information was added that the men carried whitewash, brushes and rollers, and that subsequently the walls were covered with whitewash. Consider the meaning of the verb to paint: to cause, by means of an action-routine which involves a liquid and a brush (or roller), a change such that the liquid comes to be spread upon an object. To shift from working-on to painting, the experimental subjects had to connect the information about brushes and about wet walls with the working-on structure. There were then two converging inferences: from the fact that the walls are wet, the inference that the change-in-condition conveyed by working-on is the walls' being covered with whitewash; and from the presence of brushes and whitewash, the inference that the actions were painting-actions. This combination of action-routine and resulting change-of-state corresponds to the meaning of painting.

The pairs used/played and make/bake showed only very weak effects. Here, the added information specified either the

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objects involved in the action or the objects resulting from the change-of-state, but not both. In the story for used/played, shown in Table 2, the experimental subjects learned that the objects used were musical instruments. The actions appropriate to musical instruments are playing-actions. However, no mention was made of any specific musical result (e.g., a sonata or mazurka) of performing these actions. In the pair make/bake, the objects resulting from the action (fruitcakes, date bread, etc.), were specified in the experimental condition, but no mention was made of the actions performed (e.g., mixing, turning on the oven), or of the objects involved in the actions (e.g., bowls, spoons). Thus, in each of these pairs only half of the more specific verb -- either the action or the resulting change-of-state was specified.

Addition of states or changes-of-state. The possession pairs -- got/bought, get/borrow, gave/sold, take/borrow, and gave/paid -- showed fairly strong effects. The story for get/borrow and take/borrow concerned Hank's need for a tuxedo, and experimental subjects were told that a friend had offered to let Hank use his tuxedo temporarily. This information combined with the notion of Hank's getting (or taking) a tuxedo to produce the meaning of borrowing a tuxedo: namely, assuming temporary possession of the tuxedo with the obligation to return it. Little inference was required beyond simply combining the

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information given into a unified structure. In the pair gave/paid, as discussed earlier, the information that Max, the giver of money, owed the money was added in the experimental condition. The combined structure was then that of a person transferring money which he is obligated to transfer. This corresponds to the meaning of pay. The pairs got/bought and gave/sold both required some inference based on world knowledge. The experimental story for got/bought provides the extra information that the getting occurred in a store. Similarly, the experimental story for gave/sold, shown in Table 2, states that Rosemary made money when she gave some things to her friends. Knowledge of plausible money-making situations suggests that the friends gave Rosemary money in return. The combined set of transfers is captured by the word sell.

The pair tell/warn is a separate case. The difference between telling and warning lies in specification of the kind of message communicated. To warn guests about the walls is to tell them something roughly like: "Certain events involving the walls are possible, which if they occur will cause you harm." In the experimental story, subjects heard that the walls were wet with whitewash; thus, subjects might have inferred that Alexander's telling his guests about the walls referred to his warning them that brushing against the walls would prove harmful. In fact, no subjects replaced tell with warn.

Discussion

In the research presented here, the integration process was modeled on the assumption that verbs have structured componential representations which are evoked during comprehension, and which can combine with one another in discourse to yield larger meaning structures. General verbs appeared in stories along with semantic material which could combined with their meanings to form the meanings of more specific verbs. Subjects given this extra material produced the predicted specific verbs to a greater extent than subjects not given the material. In some cases, such as gave/paid, the shift from general to specific verb could be accounted for by simple combination of the semantic structures from various parts of the paragraph. In other cases, such as working-on/painting, additional inferences beyond the semantic information directly presented were required to produce the representation of the specific verb. However, in all cases, the shift was based on integration of meaning components from different parts of the paragraph. The results obtained are analogous to those of other studies in that elements originally presented separately are later recalled together. Here, meaning components presented in different words are later recalled in one word.

The present study probably underestimates the strength of the integration effect for two reasons. The first is that, in

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every case, the word frequency of the specific verb is lower than that of the general verb for which it was substituted. The average word frequency was 50 per million for the specific verbs and 471 per million for the general verbs (Kucera & Francis, 1967). Normally, high-frequency words are better recalled than low frequency words (Kintsch, 1970); yet, here the result is that low-frequency words replace high-frequency words in recall. A second reason that these results may underestimate the amount of semantic integration is that there is an asymmetry between general and specific words which acts against the predicted shift. Use of a specific term implies that the general term is also true, but not the reverse; e.g., if the men painted the ballroom, then it is also true that they worked on the ballroom, whereas if the men worked on the ballroom, it is not necessarily true that they painted it. This asymmetry was important, for it allowed the construction of stories in which the meaning of the general verb was amplified but not contradicted by the inserted material. However, this meant that subjects who had performed the desired integration could still choose to use the general verb in recall (e.g., a subject who had stored that the men painted the ballroom could still report that the men worked on the ballroom). Thus, the general-specific shift is a conservative measure of the degree of semantic integration.

In modeling these effects, we are faced with the problem of where to draw the distinction between linguistic knowledge and world knowledge. Linguistic treatments of meaning seek to define systems in terms of which all word meanings can be specified. These systems are typically decompositional, based on representing word meanings analytically in terms of semantic features or components (e.g., Bierwisch, 1970; Katz & Fodor, 1963). Psychological applications of decompositional theories assume that a set of meaning components is substituted for each word during comprehension. This word-by-word substitution process is immediate and automatic and the set of components associated with a given word-sense is reasonably stable across tasks and contexts. In contrast, the world-knowledge approach emphasizes goal-sensitive rules of inference that relate propositions to other propositions (Kintsch, 1974; Stillings, 1975; Thorndyke, 1976). These active, high-level inferences are affected by both linguistic and non-linguistic context, including the goals of the listener and his understanding of the task. The world-knowledge approach emphasizes understanding of the overall situation; it is top-down, while the decompositional approach is bottom-up.

The approach taken here makes two assumptions concerning the nature of semantic processing. The first is that, although inferences and context-based expectations are undoubtedly an

important part of meaning processing, still these top-down processes must be based in part on the bottom-up knowledge derived from the individual word meaning. Therefore, to postulate that inferential processing occurs does not remove the necessity for modeling word meanings. The second assumption is that there is no sharp dividing line between world knowledge and semantic knowledge. Rather, the components that make up a word's meaning represent the "almost-inevitable-inferences" that follow from the use of the word, and are not different in nature from the conceptual components derivable from other sources of knowledge.

In addition to the almost-inevitable-inferences which are represented as components of meaning, other inferences may be made depending on the context, as was seen in some of the stories (e.g., in the got/bought passage). Anderson and Shiffin (1978) have shown that people reading a passage often instantiate: that is, they create models that are based on the text but are more detailed than the text. Given the word fish, a person might imagine a shark, for example. Anderson and Shiffin have shown that these instantiations are highly context-sensitive. Thus, in the representational scheme proposed here, the relatively context-independent inferences are included in the word's representation. More context-dependent inferences are derived from interactions between word meanings. Moreover, at times some

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of the normal inferences may be contextually overridden; for example, in metaphorical extension, a word is used in a context in which not all of its normal meaning-structure is applicable (Gentner, 1975). Thus, the representation of the meaning of a verb is intended to capture the basic psychological meaning of the verb. This basic meaning is usually amplified, and sometimes partially suspended, by context and by other existing knowledge.

Barclay (1973) and Bransford, Barclay, and Franks (1972) have argued persuasively against a strictly linguistic account of the comprehension process, pointing out that comprehension frequently goes beyond the linguistic information presented. Further, the results of the Barclay (1973) sentence-memory experiment, in which subjects were found to integrate information such as, "The bear is to the left of the moose," and "The bear is to the right of the giraffe," disconfirm a binary-feature model of meaning. However, these results are compatible with a richer theory of meaning, such as the subpredicate model proposed here for verb meaning. Further, such demonstrations of the importance of integrative processing do not imply that word meaning is unimportant. On the contrary, the constructive inferences made by subjects in the Barclay (1973) and Bransford et al. (1972) experiments must have been based in part on their knowledge of the meanings of such words as left and right. The more clearly we specify discourse structure from the word level meanings at

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every level up to the higher levels (story patterns, plan structure, etc.), the better our models of the interactions between levels. What is needed is a representational theory in terms of which integration among different word meanings, and between word meanings and other sources of knowledge, can be discussed. The analysis of verb meaning in terms of interrelated subpredicates may provide the beginnings of such a theory.

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Footnotes

1. The representational format shown here was developed at the University of California at San Diego in a seminar headed by David E. Rumelhart and attended by Adele A. Abrahamson, Danielle Dubois, Dedre Gentner, James A. Levin and Stephen E. Palmer. The system is explained in detail in Norman and Rumelhart (1975).

2. Miller and Johnson-Laird (1976) make the similar point that a theory of meaning "should represent meanings of words and sentences in compatible form" and "should allow for the differing significance of sentences depending on their context..." (Miller & Johnson-Laird, 1976, p. 706)

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