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Integration of Information
Within and Across Propositions

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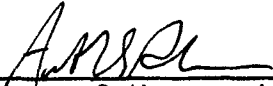
Bernard C. Beins

A dissertation submitted to the Graduate
Faculty in Psychology in partial fulfillment
of the requirements for the degree of
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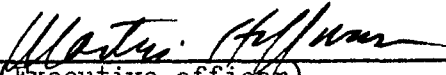
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Integration of Information Within and Across Propositions

Recent models of memory have offered suggestions about the nature of information storage and processing. With the alternatives in mind, the five experiments reported here deal with the degree to which subjects tend to integrate information within and across sentences consisting of simple ideas (i.e., propositions).

The first three studies utilized a verification time paradigm in which subjects learned sentence sets related by common actors and were later tested on their memory for the information. The results indicated that for sentences with minimal interrelationships, subjects interpreted input according to simple subject-verb-object patterns, consistent with expectations of associative models. When context in the form of a locative was added, however, subjects seemed to integrate the information into a conceptual cluster and were able to spot violations of the context generated in learning.

The final two studies employed cueing paradigms. Subjects learned groups of sentences differing in their verb properties. In the first, they learned sentences with verbs of varying complexity, and were later cued with subject, verb or object of a sentence. They recalled sentences comparably, regardless of verb complexity, although the efficiency of cue types differed with verb type. The implication was that when a single sentence conveniently embodies two ideas, subjects will process those two ideas while trying to remember the sentence, so the verb provides better access to the ideas underlying the sentence, relative to simple items. In the case of simple verbs, the subject was an efficient cue, while the verb was not. In Experiment 5, subjects learned sentences whose verbs were given meaning either by subject or object. Recall was better for object-oriented verbs, suggesting a close verb-object relationship that associative theories posit.

In general, the results indicate that subjects will integrate information to ease their task in coding and that the contexts they induce in learning persist. For individual sentences, though, subjects may also store simple subject-verb-object relations which can be accessed as well as the more complex relations subjects see in sentences.

OVERVIEW

Memory for ideas has had a long and often controversial past, beginning with Bartlett's (1932) seminal work and continuing to the present linguistic models (Chomsky, 1957, 1965; Katz and Postal, 1964), computer simulation models (Anderson and Bower, 1973; Anderson, 1976; Schank, 1972, 1975; Quillian, 1969), and purely psychological models (Kintsch, 1974; Fredericksen, 1975a, b). The various models posit diverse assumptions and the differences between the theories are often quite subtle or, in some cases according to some theorists, nonexistent (e.g., Chomsky, 1972). In psychological terms, one can conveniently, if arbitrarily, separate the various models into two general classes, associative or configural, for purposes of comparison.

The past twenty years has witnessed a dramatic series of changes in theories of memory and psycholinguistics. With the demise of strict stimulus-response analysis of language favored by the early behaviorists, mediational associationists (e.g., Osgood, 1957) began to postulate mentalistic concepts to handle metaphors, generalization of meaning, novel utterances and the general openness of language. Nevertheless, Chomsky's (1959) criticism of Skinner's (1957) Verbal Behavior was taken at the time to be the definitive confutation of all associationist approaches. Thus, encouraged by theorists like Miller (1963), psychologists turned to linguistics for replacement theories and new, potential paradigms (Reber, 1973).

Chomsky's (1957, 1965) theory of meaning through syntax attracted the largest following of psychologists who attempted to establish the psychological reality of the suggested linguistic mechanisms (Miller, 1962; Clifton, Kurcz and Jenkins, 1965; Clifton and Odom, 1966).

Starting with the late 1960's, however, the psychological notion of meaning started to drift away from pure syntax and psychologists began to wean themselves from linguistics. Influential in this move were the computer simulation models that emerged (Collins and Quillian, 1969; Anderson and Bower, 1973; Rumelhart, Lindsay and Norman, 1972). Psychology is not nearly bound to the information sciences, however as it was to linguistics. Anderson and Bower's (1973) Human Associative Memory, or HAM, and Anderson's (1976) ACT amalgamated elements from all three disciplines to their model, Kintsch (1974) has borrowed slightly from Fillmore's (1968) linguistic case notions without computer simulation, and Fredericksen (1975a, b) has developed a semantic network that can be safely called purely psychological. These paradigm shifts reflect psychology's difficulty in examining language behavior. Language analysis is enormously complex because human verbal ability is among the most flexible of the cognitive processes. It is probably safe to assume that further paradigm shifts will be necessary when psychology attempts to integrate the various aspects of communication, such as comprehension of discourse, presuppositions and inferences into a unified theory - a task barely begun and already too confusing.

One reason for this seemingly chaotic state of language studies is that in psychology experimentation, subjects are not restricted to the same limited processing modes that the experimenter examines. That is, they invoke numerous mnemonics and strategies to aid memory, and the mental operations addressed by the experimenter invariably fail to exhaust the variable modes of processing utilized by the subjects.

In spite of the different "memories" subjects have based on different strategies, most theorists and researchers assume that there is

some elemental form of storage of ideas, and they have termed it the "proposition." Unfortunately, the internal constitution of a proposition is a point that causes considerable debate. Propositions are thought to be stored as concepts linked relationally (i.e., subject, verb and object). The nature of the relations is one of the main differences between the theories suggested. The associative structure advanced by Anderson and Bower (1973) and Anderson (1976) indicates that the concepts within a proposition are stored independently of one another, joined only by their relational links. This implies that separate concepts in a given sentence accrue no added meaning by virtue of their being related to one another (e.g., as in a paired associate or free association task). ACT also presumes this independence of storage although HAM and ACT disagree on some points concerning both search and storage.

Configural theories, on the other hand, posit dependencies between elements in a sentence, whether they are related a priori or not. The overall meaning of a sentence arises from the functional relationships among the words within that sentence rather than with any simple compilation of meanings. In fact, the meaning of a word within a sentence may not emerge until the entire sentence is comprehended. On a relatively subtle level, sentences (1) and (2) differ only with respect to the grammatical subjects of the sentences, and yet the im-

(1) The bird flew over Pittsburgh

(2) The pilot flew over Pittsburgh

plications, hence the specific meaning of the verbs, differ considerably. The presence or absence of interrelationships in the "deep structure"

of a sentence should lend itself to a test between the two types of theories since a configural hypothesis would predict that even isolated sentences will develop a single meaningful unit in deep structure, while associative theories reject this notion of the unity of ideas. In fact some work (e.g., R.C. Anderson and Ortony, 1975) has addressed this point, indicating that in sentences such as (3) and (4) subjects attend to diverse aspects of the sentences, such as their implications and pre-

(3) The piano was heavy

(4) The piano sounded melodious

suppositions. That is, in sentence (3) the subject would consider the piano as a heavy piece of furniture, while in sentence (4), the piano would be a musical instrument. The question of the underlying representation of implication will need to be addressed in detail before firm conclusions can be drawn.

The Associative Models—HAM and ACT

One reason for the popularity of the associative models is that their assumptions and structures are detailed extensively (Anderson and Bower, 1973; Anderson, 1976). The aspects most relevant to this discussion focus on (a) the presumed independence of connected concepts in memory and (b) the search process through a binary tree structure, as in HAM, or an n-ary structure, as in ACT.

Basically, HAM and ACT postulate that each concept in memory is stored relationally in a proposition, which is defined as a topic and a comment about that topic. Figure 1 shows the propositional deep structure for a relatively simple sentence, such as sentence (5). Here the

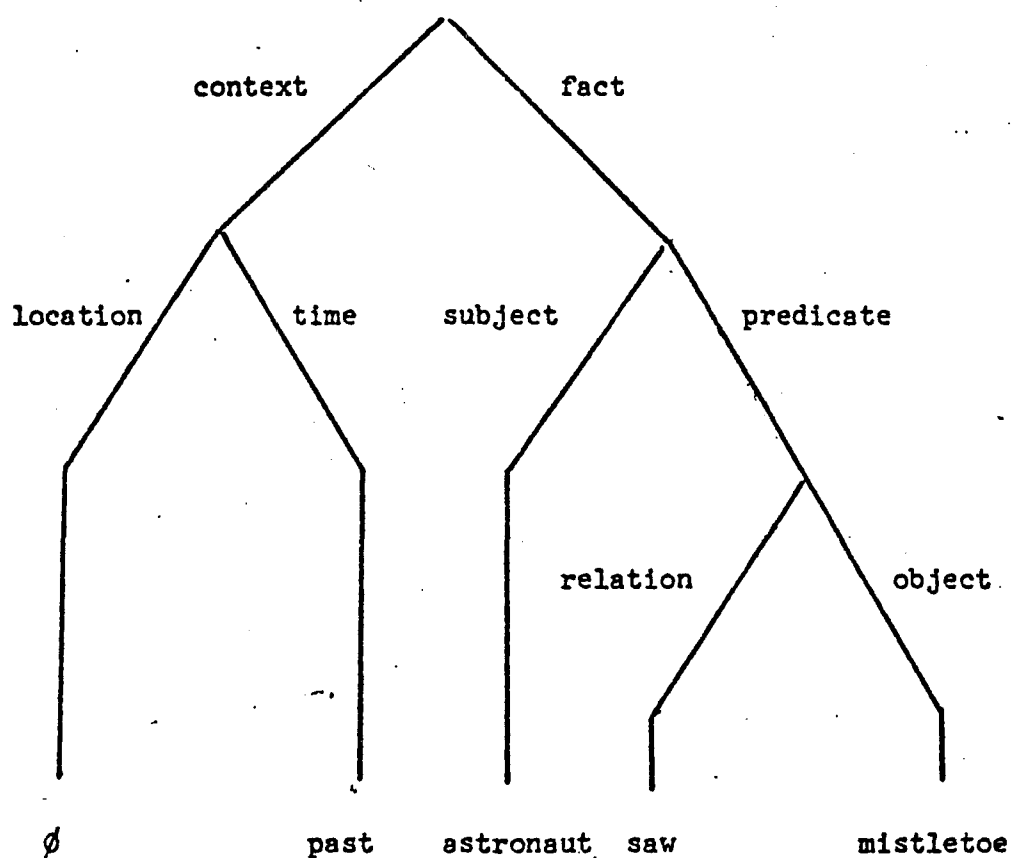


Figure 1. Associative representation of the sentence The astronaut saw the mistletoe. The words of the sentence are stored as abstract ideas rather than words, each item corresponding to a concept stored in long-term memory.

spatiotemporal context specifies that the action took place in some

(5) The astronaut saw the mistletoe
unknown locale. The fact nodes inform us that the astronaut (topic)
saw the mistletoe (comment).

In numerous studies, Anderson and Bower and their colleagues have used verification time paradigms to assess the nature of search through memory and to infer the structure of storage of information. Early studies supported the tenet that multiple searches proceed independently from each memory node (e.g., astronaut, saw, mistletoe) with a verification resulting from the fastest of all searches (Anderson and Hastie, 1973; Anderson, 1974a; Thorndyke and Bower, 1974). For example, Thorndyke and Bower used four sets of three sentences each in which there were three subject-verb-object sentences all having different content words; three having a common verb but different subjects and objects; three having a common subject and object, but different verbs; and three having a common subject and verb, but different objects. Their prediction concerning verification times was that since a search is serial from a given node, any triplet that had repeated elements would produce longer verification times than a nonrepeated triplet, due to the increased search time necessitated when one must make multiple searches from a given word (e.g., from a subject to each of three different verbs). A model of search suggested that the search through memory proceeds simultaneously from each node in the underlying representation, but only serially from each given node in the structure; a decision is presumed when the first completed search ends.

According to the assumptions of independence of nodes in memory, each search from a given node exists independently of all others. This

This controversial suggestion that was made in HAM proved inappropriate after further research was done. Anderson (1976) points out that one reason for Anderson and Bower's (1973) rejection of an intersection model for activated memory nodes was practically based; it is very difficult to simulate an intersecting model on a computer. Since HAM's development, though, such a program was devised; it is quite complex (Anderson, 1976). Thus, results that were previously adduced in support of HAM can not be employed to test an intersection model.

In the original model, the meaning of a sentence accrues from an additive combination of the separately stored memory nodes rather than through any semantic interaction or dependencies among ideas.

R.C. Anderson and Ortony (1975) and Foss and Harwood (1975) both questioned HAM's independence assumptions and found them untenable. Anderson and Ortony utilized cued recall to investigate the model. Their subjects learned sentences of the types (6)-(9). A given subject would

- (6) Coins can be flipped
- (7) Signatures are difficult to forge
- (8) Coins are difficult to forge
- (9) Pancakes can be flipped

sentences (6) and (7), another would learn (8) and (9). Both subjects would be cued with the word odds which was seen only at recall. Certain predictions concerning recall can be generated. Anderson and Ortony claim that according to their reading of HAM, the probability that a certain cue will allow retrieval of a target sentence, t, ought to equal the probability that there exists an intact path from the cue to any constituent of the target sentence. If s is the probability of an intact path from the cue to the subject of the target sentence and p

is the probability of such a path to the predicate, the probability of sentence recall is given in equation (10). Because of the construction of the stimuli used in the experiment, a path to either the subject or the predicate, but not both, was very likely; that is, the subject and the predicate of the sentences had very few a priori associations. Hence, in this experiment, the prediction for sentence recall, based on HAM, is given in equation (11).

$$(10) \quad t = s + p - sp$$

$$(11) \quad t = s + p$$

The view of Anderson and Ortony was that the senses of the individual words interact in the process of encoding. That is, recall of an entire sentence would be greater if one uses a cue that permits access to two items in a single sentence rather than to one item in each of two separate sentences, since a sentence whose cue relates to both subject and predicate has a greater context or configuration that may coincide with the sense of that cue. This does not hold for sentences with only one constituent relevant to the cue. For (6), the meaning of the sentence may involve the odds of winning something depending on the flip of a coin, so that the cue odds is directly relevant to both elements. For (8) and (9), though, the sense of chance or gambling is missing from both sentences, so the relevance of a cue like odds is minimal, even though the cue is meant to induce access to the same words in (6) as in (8) and (9). Thus, given (12) and (13), Anderson and Ortony would predict (14) concerning the cue odds to sentences (6)-(8). In (12)-(14), t_a equals the probability that the cue provides access to the subject of (8) and to the predicate of (9), but does not link with the predicate of (8) or to the subject of (9); t_b equals the

likelihood that the cue will generate access to the subject and the predicate of (6).

$$(12) \quad t_a = s_8 + p_9$$

$$(13) \quad t_b = s_6 + p_6$$

$$(14) \quad t_a < t_b$$

Two points should be noted here. First, the value of $s_6 \times p_6$ is treated as being equal to zero by Anderson and Ortony because any value greater than zero biases against their results; t_b is thereby a conservative estimate of the recall probability. Second, sentence (7) contains elements, none of which are probably accessible from the cue odds.

Using sentences (6)-(9), one predicts according to HAM that the probability of intact paths to subject and predicate exist. A more configural model would specify that the meaning emerging from sentence (6) would allow greater recall for it based on a related cue than for sentences (8) and (9) which alone do not have as close a relation to the cue as does the entire sentence (6). Their results supported a configural model. Inequality (14) predicts the data well. Table 1 shows their values for t, s and p.

Foss and Harwood (1975) also used cueing to investigate the "cross-over" experiments of Anderson and Bower (1973, pp. 337-341). These experiments produced a pattern of results that are highly counterintuitive but consistent with HAM's predictions. Anderson and Bower discovered that for sentences like (15) and (16), subjects' memories appeared to be structured such that a cue of the child praised was a better cue for recall of landlord than the child hit or the minister praised. The result followed from an associative hypothesis that with independent memory links presumed, and it counters configural expectations, which posit

Table 1. Proportion of sentences recalled according to cue type (from Anderson and Ortony, 1975). The equality represents a non-significant difference between $\underline{t}$ and $\underline{s} + \underline{p}$; the inequalities show significance.

See the test for the meaning of the symbols.

<u>Type of scoring</u>	<u>Probability of correct recall</u>
Verbatim	$\begin{matrix} t \\ .36 \end{matrix} = \begin{matrix} s & p \\ .27 & + .05 \end{matrix}$
Verbatim, but with changes in functors, verb tense, etc. permitted.	$.43 > .31 + .07$
Substitutions of synonyms permitted	$.66 > .44 + .11$
Recall of gist	$.69 > .46 + .12$

that one retains the functional relations of sentential items (i.e., who did what to whom), not just separate concepts. Foss and Harwood

(15) The child hit the landlord

(16) The minister praised the landlord

noted that Anderson and Bower were blessed with highly able subjects who remembered well. This contributed to a statistical artifact, Foss and Harwood claim, causing the appearance of an underlying associative structure. When their own less gifted subjects performed the same task, the results were predictable from a configural viewpoint, but not from an associative one.

Anderson's (1976) reply involved three experiments similar to the original Anderson and Bower and Foss and Harwood studies. Anderson found that with meaning-orienting instructions, subjects responded with higher accuracy to matched subject-verb pairs than to crossed subject-verb pairs. He interpreted this as evidence for the establishment of a context in learning that is also present at recall. This context effect seems to involve the verb. "Apparently under meaningful orienting instructions, subjects are particularly prone to let the context influence encoding of the verb (1976, p. 423). The configural effect is seen to be due to the fact that the verb contributes little context effect so that when the original grammatical subject is re-paired with it in testing, the context of that subject-verb pair induces the original context and the object appropriate to that context is produced in recall. Unfortunately, the data conform in total neither to ACT nor to a configural theory.

The picture outlined here suggests that HAM's characterization of the search process is, within certain settings, reasonably accurate; ACT, however, improves the representation. However, as with any set of

theories, no single one accounts for all the data.

The Configural Models

Conceptual Dependency Theory. Strictly speaking, Schank's (1972) Conceptual Dependency Theory (CDT) could be listed as an associative model since it is graphically depicted by means of a network of ideas, not unlike that of ACT. Moreover, it is regarded by some (e.g., Collins and Loftus, 1975) as a direct descendent of the original network theory of Quillian (1969). In terms of some of its processing and storage mechanisms of interest here, though, CDT departs from HAM and ACT. The verbs undergo considerable transformation in processing, according to CDT. For example, all verbs of transfer of possession are represented by the abstract primitive TRANS rather than as the words characterizing this transfer. As such, the final mode of storage may consist of a propositional network whose links may not be fully independent. Before the final structure is assembled, though, Schank asserts that "each concept is assessed with respect to the whole picture that is created. In other words, when part of a picture is ascertained, there are some valid predictions that can be made about the nature of what will follow. . . . Understanders do not carry along alternative parses of a sentence or alternative senses of words. Rather, they select one and if they are wrong, they go back" (1972, p. 603). The ultimate amalgam of ideas may not reflect the initial input form at all.

Since much interpretation and construction of ideas is presumed to occur according to CDT, it will be treated neither totally as associative nor totally configural; it should be noted, though, that a graphic characterization may resemble a network model. This latter point resurrects Hollan's (1975) point of isomorphism of models similar to

associative and configural models. In the present situation, however, CDT predicts different psychological effects than HAM and ACT.

Many points of Schank's theory are difficult to assess in psychological terms because it has not generated much empirical work. The tenets of major interest here are that sentential memory is thought to be verb-based, and the elements broken into semantic primitives. Further, the memory structure is highly processed and its elements related in long-term store. The main shortcoming of CDT as a psychological theory is that it does not deal with input to short-term store, nor does it consider any processing mechanisms, such as search and retrieval. This is not totally surprising, given that it is a computational linguistic theory.

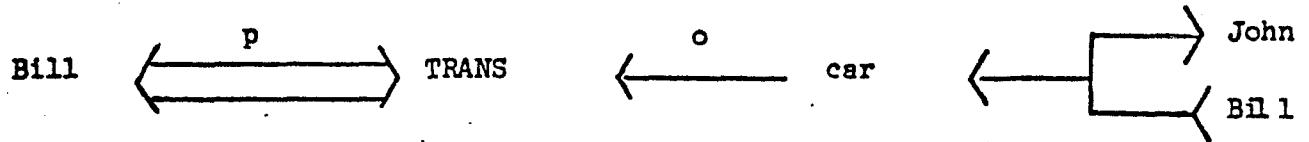
It derives its strength in its handling of long-term memory for complex information when the surface structure of the input is not available. That is, the subtleties of input are stored not through single word concepts but through interconnections of semantic primitives. In fact, the words themselves seem not to be stored as much as the relationships underlying the words. For example, the collection of words used in a metaphor or simile may bear little superficial resemblance to the concepts it represents (Honeck, Reickhan, and Hoffman, 1975). In addition, according to CDT the following two sentences would be related conceptually although according to Fodor, Bever and Garrett (1974), "no one would argue that these forms share a common base (p. 191).

(17) Bill sold the car to John

(18) John bought the car from Bill

That is, they are not transformationally related. Figs. 2a and 2b characterize CDT's representation of (17) and (18). The conceptual bases

(a)



(b)

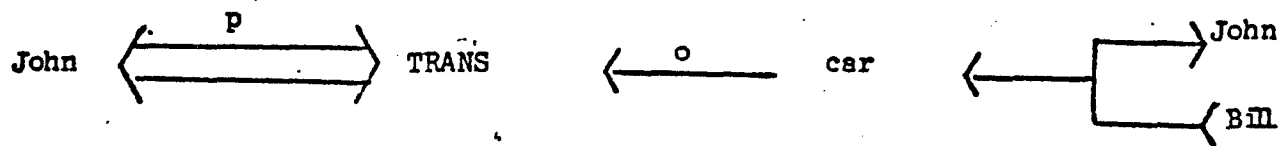
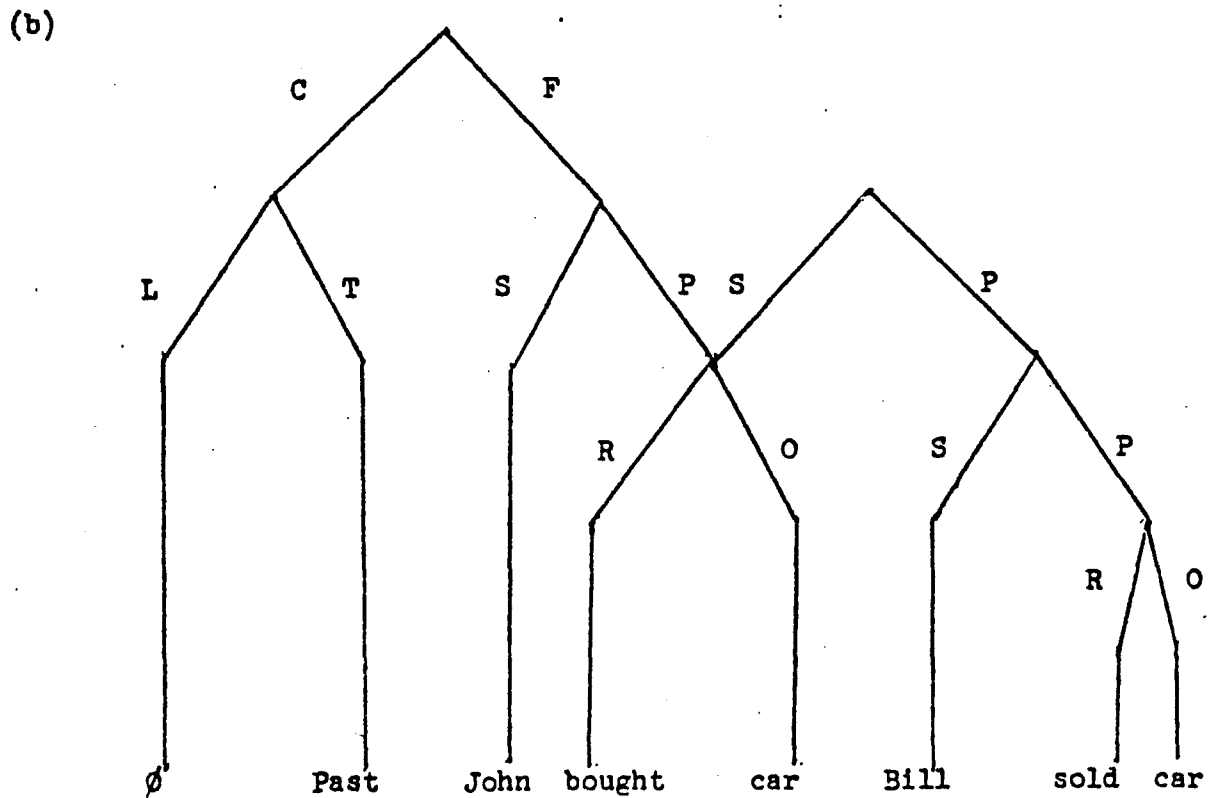
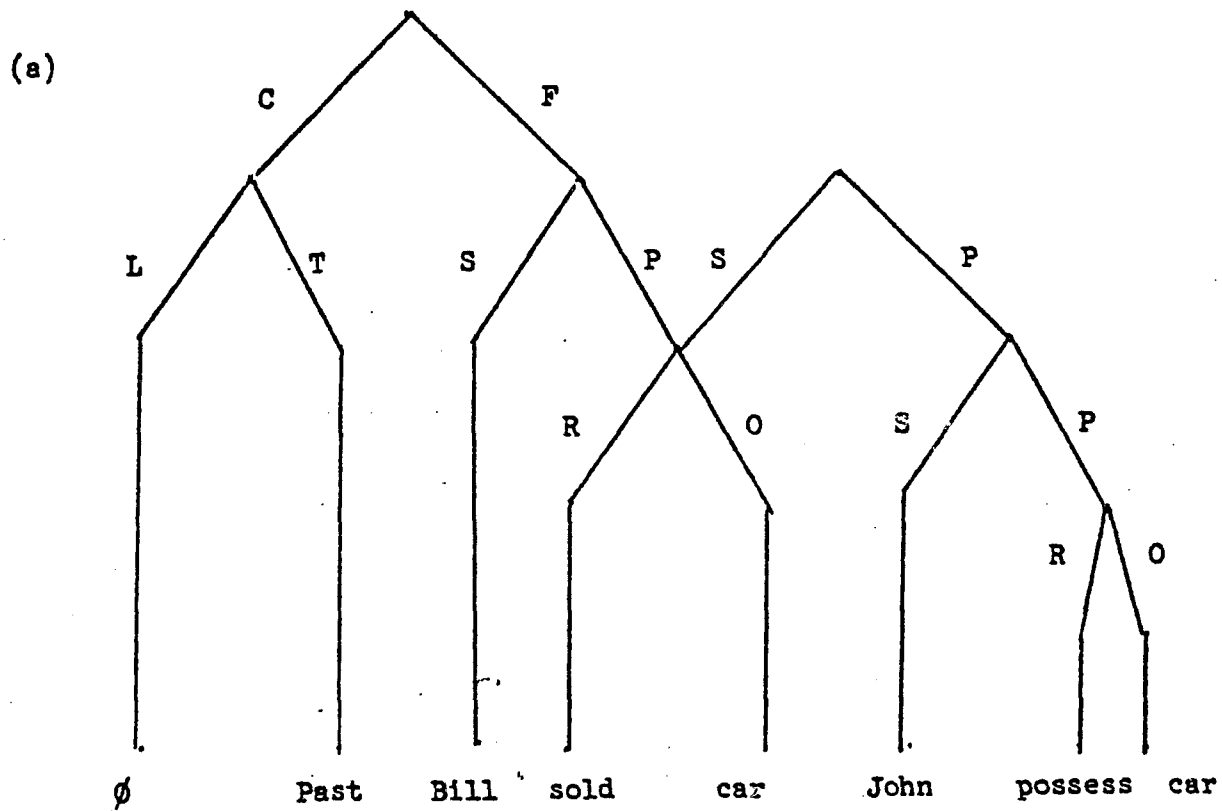


Figure 2. Sentence representations according to Conceptual Dependency Theory for (a) Bill sold the car to John and (b) John bought the car from Bill. One-way arrows indicate the relationship between two governors; one-way arrows show dependent concepts. The letter "p" represents the predicate relationship in the sentence; the letter "o" shows the object relationship.

Figure 3. Associative representation for sentences (a) Bill sold the car to John and (b) John bought the car from Bill. S = subject; P = predicate; R = relation; O = object; C = context; F = fact; L = location; T = time. 15



differ only in the logical subjects. The associative theories would characterize them as shown in Figs. 3a and 3b, in which they differ by more elements.

As can be seen in Fig. 2, the concepts to be understood exist in certain relationships to one another. There are nominal concepts called Picture Producers (PP), corresponding to nouns; in addition there are actions describing what the PPs are doing, ACTs. The modifiers of the pictures and actions are called aiders—PAs and AAs. The PPs and ACTs are termed governors of a dependency and the PAs and AAs dependents. The latter require the former, but the situation is not reversed. The four types of concepts relate in consistent ways to one another in a conceptual base involving a linked network of concepts and their dependencies. Further, closely related sentences, such as (19) to (21) might be characterized in deep structure by closely related conceptual bases. This stands in obvious opposition to the transformationalist view that two separate sentences will have two different deep structures.

- (19) John stole the book
- (20) John lifted the book
- (21) John burgled the book

In discussion of these topics, Schank (1972) initially dealt with concomitant syntactic and conceptual processing, in which syntactic units are isolated and the dependencies within and across syntactic boundaries assessed. Then a conceptualization-memory interface activates for question answering or long-term storage (Schank, 1975). Later work addressed inferences and long-term storage more completely. CDT seems quite tenable as a computational linguistic theory. Unfortunately, it has generated relatively little supporting empirical work.

Kintsch's Representation of Meaning in Memory. Kintsch's (1974)

theory is relatively recent, but even so, there are considerable data to support it. Before proceeding to them, some of the underlying tenets need to be discussed. The model is holistic and constructive. That is, according to the theory, one receives input, constructs meaningful, holistic representations, and stores them with related information. The storage is hierarchical in that semantically dominant elements are more easily remembered and accessed than information of a tangential nature. Kintsch shows development of these hierarchies; a glimpse of such a structure appears in Table 2.

The most important of the propositions listed in Table 2 is proposition 1, and it dominates the hierarchy. The further each proposition gets from the top, the smaller its conceptual impact on the set. Thus, one would not lose much information here if one did not have the knowledge that Cleopatra was involved in the Roman world, but not knowing that she suffered a downfall would disrupt the central meaning of the information. As it turned out, subjects remembered the higher order elements best, independent of syntactic role and complexity (Kintsch, Kozminsky, Streby, McKoon and Keenan, 1975; Harris, 1976). Neither ACT nor HAM has incorporated this aspect of processing into its schemes.

Each proposition is holistic and the elements are interrelated. That is, as in the case of proposition 3, the three elements combine to form a configuration of their own, even though embedded within a larger proposition. And according to the theory, the number of propositions existing in a string of words depends more on the logical roles of the words than on the surface structure.

Sentences (22) and (23) have the same number of associative links

Table 2. Propositional analysis of a sentence according to Kintsch (1974). Each parenthetical expression represents a proposition, which in turn may be embedded within another proposition. The higher a proposition is in the hierarchy, the more impact it has for the entire idea. Consistent with the model, the predicate or verb of a proposition initiates its representation. Sentence: Cleopatra's downfall lay in her foolish trust in the fickle political figures of the Roman world.

- 1) (Because, a, b)
- 2) (Fell down, Cleopatra) = a
- 3) (Trust, Cleopatra, figures) = b
- 4) (Foolish, trust)
- 5) (Fickle, figures)
- 6) (Political, Figures)
- 7) (Part of, figures, world)
- 8) (Roman, World)

and content words, but different numbers of propositions, as defined by Kintsch. According to Kintsch, HAM, and ACT, sentence (22) has three propositions. Sentence (23) has one according to Kintsch and three

(22) The crowded passengers squirmed uncomfortably

(23) The policeman gave the driver a summons

according to HAM. ACT specifies only one. When subjects were asked to recall sentences like (22) and (23), percent recall of sentences like (23) exceeded that of items like (22), as predicted by Kintsch and ACT. HAM erroneously predicts equivalence (Kintsch, 1974).

More specifically, sentences composed of one proposition tended to be recalled in their entirety while multipropositional sentences were often recalled partially, even when the number of content words was controlled. Unfortunately, the syntactic complexity of the different types of sentences differed. Like the findings of R.C. Anderson and Ortony (1975), Kintsch's results call into question the assumption of independence of concepts in memory structures. However, Kintsch, unlike Anderson and Ortony, has generated an alternative structure to the binary and n-ary structures of the associative models. Increasing support for nonindependent links in memory is appearing, as mentioned. Even J.R. Anderson has abandoned the independence to some extent in ACT.

Another point of difference between the configural and associative models concerns the underlying deep structure representation of semantic input. CDT, HAM and ACT postulate a canonical deep structure, similar to Chomsky's concept; Kintsch prefers a verb-based theoretical structure rather than the subject-predicate dichotomy used by the associative theories. The most important testable implication of a

verb-based theory vis a vis the relational theory of HAM or ACT concerns the storage form underlying the verb of a sentence and in fact, its precise relation to other sentential elements. The associative view here is that in general the representation of a verb differs little from that of other content words. The verb is more abstract than nouns, but its storage form does not differ from the nouns. Only when more than one argument is required will the storage of a verb differ greatly from its input form. Specifically, the verb to give requires an object and a recipient, and will be treated by HAM as X transferred Y causing Z to possess Y (Anderson and Bower, 1973, p. 160). ACT sees statements requiring the indirect object as simpler than HAM does. ACT's suggestion is that such a sentence is simply represented as X gave Y to Z.

One suggestion that can be made from configural, verb-based models is that the verb need not be stored directly, but rather only abstractly to specify functional relations; according to Schank (1972), the verb is broken down into semantic primitives. Kintsch (1974) disagrees, stating that verbs do not undergo significant transformations in encoding although the meaning of the verb is abstractly stored.

The structures are depicted in Figs. 2 and 3 for the different theories. (Figs. 3a and 3b assume that the dative and ablative are processed similarly.) This discussion implies that one may process the verb or relation of sentences differently than other words. The verbs specify relations among agents, recipients, instruments, etc. and may be represented in long-term store in a less concrete fashion. That is, in contrast to HAM's suggestion, the verb may not occupy a specific memory node, but rather simply lend coherence to the concepts

connected by a given relation. With this type of storage, the verb might be a relatively weak cue for recall because it would not be stored directly. Further, this storage mode would provide for a memory structure in long-term store that would preserve the meaningful relations among items (i.e., who did what to whom) as long as the sentence had been processed semantically.

If these, or other observable processing differences between theoretical genera are not predicted, the alternate representations must be considered trivial variations on one another. Unfortunately, there is little basis for comparison on this point. The tests of the associative and configural theories have generally used different paradigms (speeded reactions for HAM and ACT, and recall for the configural theories). Certainly this is not completely the case, but it reflects the differences used by advocates of the various models.

For example, Thorndyke and Bower (1974) found, using verification times, that access to memory is simultaneous from all nodes but successive within nodes in a given sentence. Lewis and Anderson (1976) provided some limited support for a spreading activation of ACT's search, although ACT did not characterize all the data well. Anderson (1976) has opted for a spreading activation model to supplant the original mechanisms of the associative models, though, some support has been lent to a model specifying the salience of the verb. For example, Shafto (1973) has found that subjects tend to confuse sentences whose underlying verb representations were similar; verbs seemed not to be stored in lexical form as nouns were, but rather, more abstractly. Further, Ehri and Muzio (1974) found that subjects tend to omit in recall adjectives that are implied by the verbs they accompany in sentences. Sentences like

(24) and (25) illustrate this. Subjects were more likely to omit the

(24) The thief dragged the heavy suitcase

(25) The thief jumped over the heavy suitcase

adjective heavy in sentences like (24) but to retain it in sentences like (25) because one generally drags those things too heavy to pick up. That is, the notion of a heavy item is implied by dragged whereas one may jump over something regardless of its weight.

The implication underlying this is that one stores semantic concepts (or primitives, according to Schank) rather than the lexical items. After the surface information is lost, these primitives remain. This aspect of the theory has empirical support although the length of time that the input features exist is seen to be as long as two hours (Begg and Wickelgren, 1974) or even as much as 24 hours (Kintsch et al. 1975).

Unfortunately for Schank's theory, memory for simple sentences does not appear related to the supposed complexity of the deep verbal representation, but rather to the imagery value of the verb (Thorndyke, 1975). That is, according to CDT, relatively simple verbs like to obey. Touching requires only that an agent or instrument come into contact with some other object. Obedience, on the other hand, requires that one individual issue an order and another comply. Thus, there is one ACT invoked for touch, two for obey. This should have psychological implications; a more complex verb would require more processing and would be prone to errors in memory since there are greater numbers of opportunities for links between dependencies to become obscured. In Thorndyke's first experiment, his subjects appeared to remember sentences in accord with the supposed complexity of the verbs. Simpler sentences showed the best recall and very complex items the least.

There was a strong relationship, though between the imagery value of the sentence and its rate of recall. When the imagery factor was controlled, verb type had no significant effect on recall. One criticism of Thorndyke's study is that his subjects did not study the acquisition items other than to rate them on imagery, and this type of procedure may tend to induce surface processing rather than semantic integration. This possible effect of instruction should be considered further to assess its impact on the pattern of results.

CONCLUSION

The theories that have been mentioned all clearly attempt to relate to the same topics, even if they do it through different types of data, and through different models: Unfortunately, due to the different methodologies employed to test the different theories, the separate bodies of data cannot be unified for a quick comparison of the models. Obviously, each model has intuitively plausible mechanisms and can handle a considerable amount of data. What is necessary now is to develop a situation which bears on both models so that explicit tests can be made. Such piecemeal research will not topple any comprehensive theory, but will at least delimit its useful boundaries. This goal is attainable although one serious problem remains. The structures of Schank's CDT and the structures and processes of ACT are formalized much more completely than Kintsch's (1974) Representation of Meaning in Memory (RMM). Although Kintsch has specified organizational structures in some detail it is not always clear how this organization is implemented psychologically. This problem is present, although to a lesser degree in Schank's work.

In any case, according to the relatively mechanistic structures of ACT and CDT, one would not expect much elaboration of incoming stimuli beyond rendering it something like a simple, active, affirmative,

declarative sentence (SAAD), as in ACT, or "unpacking" the verb into more basic components, as in CDT. On the other hand, in Kintsch's RMM, one would anticipate more elaboration of input. That is, if stimuli are to be organized hierarchically in order of importance to the theme of the input, a reader must first comprehend and process information in order to decide what is of prime importance. This entails an interrelationship among information that is input.

In addition, if one spontaneously utilizes inter-sentence relations, one might also develop intra-sentence elaborations. In such a mode, a reader could try to assess the basic sense of individual words and figure out what potential relations are implied by the words' different meanings.

Both the inter- and the intra-sentence constructions seem plausible according to a model that specifies and stresses organization and inter-relationships, as does Kintsch's. In fact, of the three models discussed here, only Kintsch's is equipped to handle these contextual interrelationships.

Due to these considerations, a reasonable test of the models would include tasks in which subjects are forced neither to apply structure to inherently unstructured material, nor to ignore inter-relationships among related items. That is, the subjects should have the opportunity but not the prescription to integrate input. Such settings will answer the question as to whether subjects spontaneously use or induce constructive modes in information processing when either is possible.

Experiment 1

In most of the discussions of these recent models of memory in the literature, the form of information storage and the process of retrieval have received considerable attention. Not surprisingly, much of the data have revealed great flexibility of processing, and no single model has managed to capture all the elements of the processing system. Unfortunately for the status of the models, people seem to be able to adapt their memory mechanisms to make relatively efficient use of the information given to them in experiments and not necessarily in ways commensurate with the models. For instance, Layton and Simpson (1975) have found that subjects attend to surface as well as deep characteristics of sentences, when the sentences were learned singly or in pairs; with sentence tetrads or octuples, though, it appeared that the semantic aspects were more likely to affect speed and accuracy of retrieval than were syntactic elements. When the amount of information increased, subjects tended to lose surface components more quickly than when there was relatively little information..

In addition, although formal models do not address the topic in much detail, subjects appear quite capable of reorganizing input after initial storage. Gentner (1976) used repeated presentations of relatively long paragraphs and requested recall after each exposure. Initially subjects remembered the facts in the paragraph in a serial fashion, but with repetition the dominant factor for recall was the interrelationship among ideas. Fredericksen (1975a, b) has demonstrated the same phenomenon, noting significant intrusions that appear due to the encoding of logical but imagined information.

On the other hand, the strategy of integration of ideas, however

intuitively pleasing, does not seem to be consistently utilized. As Chomsky (1971) noted, even though $p \supset q$ is true, a subject may not be aware of it or may pay no attention to the implication, so different representations of a given concept will not be perceived as equal. For example, sentences (26) and (27) would have two entirely different encodings. The implication here is that complex relations may be

(26) The line measured 10 centimeters

(27) The line measured 4 inches

stored although in some situations, they may go unnoticed by subjects.

Moeser's (1976) work has implied a unifying theme which suggests why some stimuli and some experimental paradigms produce integration and organization of information while others do not. Two related factors are ease of integration and the amount of information present. If the sentential material is obviously thematically constrained, one can easily make assumptions and draw inferences about the information in the process of encoding it. Obvious interrelationships may provide the opportunity for integration and the reorganization of input without too much effort or attention on the part of the listener or reader (e.g., Haviland and Clark, 1974; Thorndyke, 1976). Within such a mode, a reader or listener may attend less to surface characteristics and concentrate instead on interrelationships. That is, one's attention need not be squandered in the attempt to develop separate constraints and trains of thought for unrelated sentences. When one learns material with no interrelationships, the exact structure of each individual item may become more important in the attempt to remember it. For this reason, the syntax of isolated sentences generally affects memory and retrieval processes (Anderson, 1974; Layton and Simpson, 1976) to a greater extent than for paragraphs or related sentences.

These separate findings can be seen as arguments against any monolithic representation or unification of related ideas; rather there seems to be considerable flexibility of storage and processing. These results can also be interpreted as progressive loss of syntactic and lexical information such that only the semantic orderings of ideas remain for recall after a time. It should be noted, though, that subjects can remember the surface elements after as much as two hours (Begg and Wickelgren, 1974) even though experiments seldom last that long.

The present experiments will attempt to assess the flexibility of processing and the use of semantic constraints by subjects in storing and retrieving recently learned information. The methodology of these experiments is based on a study by Anderson and Hastie (1974) in which they presented a series of actions predicated of fictitious characters to subjects, who at some point learned that two different forms of reference (i.e., a name and an occupation) represented one person. As their results related to the present work, Anderson and Hastie found that names and descriptions function differently in memory. The description was accessed quicker, but the name appeared to be the central focus of memory. In some cases, there was only partial integration of knowledge, with the name having easier access to all actions predicated of a single actor.

In addition, learning seems to have occurred during the testing process. That is, although there was no significant decrement in verification times from the first to the second of the test blocks, there was a noticeable diminution in processing time for inference items, that is, items whose grammatical subjects assumed alternate forms of

reference in learning and testing. The verification times for the delay condition fell, on the average, 0.50 seconds for inferences; no concomitant change was noted for noninferences, a decrease of only 0.03 seconds. This configuration of data indicates some alteration either in the retrieval strategy or storage mode across time.

The present experiments will attempt to assess the nature of the primacy effect of proper names and to determine whether any primacy is limited to certain experimental contexts. The present technique is a modification of the Anderson and Hastie (1974) methodology of random presentation of predications and subsequent verification of test items. An attempt will be made to assess the likelihood that subjects will form some type of relationship among sentences if the opportunity arises. In both studies, instead of random presentation of sentences, subjects will learn them in a fixed order in which all predications of a single form of reference will appear together. This should take some of the burden from the subject to maintain an up-to-date file on an individual who performed some activity several sentences ago. The hypothesis following from this is that the salience of the proper name, as described by Anderson and Hastie, should diminish because the descriptive form of reference will have its own basic context with fewer interfering associations to compete with. In the second study, the presence of locations among sentences to be learned should further reduce the primacy of the proper name and increase the effect of inducing semantic constraints in related sentences.

Further, as King and Anderson (1976) have shown, the role of nonexperimental sources of knowledge constitutes more than just a trivial component of information retrieval. What is missing from a

test stimulus may play as important a role in information retrieval as information present. The experiment utilizing locations in test items will address the question of what happens to information present in memory that is not involved in search.

Thus, this set of experiments will attempt to conjure up the same learning processes that characterize Anderson's work, and then try to take a step by step look into the nature of the retrieval process. One assumption underlying this method is that from judgments of retrieval, one can extrapolate to the structures invoked in the retrieval processes, that is, storage mechanisms. In a similar vein, Anderson and Bower (1973), Thorndyke and Bower (1974), Anderson and Hastie (1974) and Anderson (1976) have utilized this philosophy of deciding how people store linguistic information based on how they search through it and manipulate it.

METHOD

Subjects. Twenty Brooklyn College undergraduates, naive as to the purposes of the experiment, received course credit for participating in the study.

Apparatus and Materials.² Six actions were predicated of each of four fictitious individuals. Each individual had a name and an occupation. The sentences learned were five words long and were of the form The banker (Dave Grant) bought the paper.

These items were typed on index cards, each card containing three predications of an individual, all predicated of the name or of the occupation, but not of both. There were eight such cards, two for each individual.

During testing, when subjects prepared for the visual display presented on a Scientific Prototype Two Channel Tachistoscope, they fixated on a dot on the screen which indicated the point at which the first word of the sentence could begin. When visible, for five seconds, the test item subtended an average of about five degrees visual angle horizontally and about .25 degrees vertically. The sentence occupied one line of type and was of the same format as the learning items. Response times were recorded to the nearest hundredth of a second with a Hunter Timer (Model 120C). Stimuli were the five-word sentences typed on an Olympia typewriter in upper case letters.

Procedure. The learning phase was divided into two sections during which the predications were learned, separated by the learning of the identities of the individuals. Thus, a subject would learn 12 predications about four individuals, then the identities of these characters (e.g., Dave Grant is a banker) and then 12 more predications about the same

four individuals. Subjects were asked to learn the sentences by imagining the individuals doing the actions depicted. This procedure generated one variable, Time of Learning--Before or After learning the identities.

When the subjects learned the predications, two of the four individuals were always referred to in the same way, by name or by occupation, before and after identities were learned. The other two were referred to differently in the two parts of the learning phase.

Subjects were simply told that this was an experiment designed to assess how well they could remember information concerning fictitious characters and that they were to imagine the fictitious characters performing the actions depicted in the sentences to be learned. The subjects were given one index card at a time, learned the three items on it and then returned the card and recalled the items. After the first exposure to all the items, subjects were asked to recall the items without looking at them. If they erred, they viewed the card again. The procedure was repeated until the criterion for learning was achieved, three successive correct reproductions of all items without an error.

The procedure required from 20 to 40 minutes, depending on the individual subject. Following the learning phase, testing began immediately after subjects were instructed about the procedure to follow. They were informed that half the sentences to be verified came from the learning set although the form of reference for a given fictitious character might change. Thus, they were told, if the sentence originally was Dave Grant broke the vase and that Dave Grant is the banker, it is true that The banker broke the vase. Finally, they were tested in their knowledge of the identities of the characters with the tachistoscope and told that the rest of the session would also utilize the tachistoscope. Feedback on correctness of responses was given at this point. No feedback was given during verification of the propositions.

With respect to test items, there were 32 sentences, half of them true. The false probes were constructed by pairing the grammatical subject of one sentence with the predicate (i.e., verb and object) of a sentence predicated of another fictitious character. This re-pairing was random subject to the condition that no two sentences contain the same predicate. There was no repetition of test items.

There were two orders for learning stimuli, one the reverse of the other, and two test orders, again one order reversing the other.

The true probes differed according to grammatical subject of the probe--proper name versus description--and whether the subject of the test item corresponded to that of the learning item. If the same grammatical subject was used in learning and testing on an item, it was called a noninference item; if the forms differed, it was called an inference. These two variables are called reference and inference, re-

spectively. Thus, the study used a 2x2x2 design with repeated measures on all factors. Since all stimuli appeared in each condition for different subject, the quasi-F statistic was not used. That is, the analysis was conservative in that the error term reflected the subject by stimulus interaction.

Another consideration relevant to the data analysis involves error subjects made in testing. Because only correct responses were included in the analysis of variance, the grand mean on a subject was used to estimate the verification time when the subject produced no correct responses in a particular cell.

RESULTS AND DISCUSSION

The results to be presented here involve verification times (VTs) for positive ("true") probes and error rates.

Positive Probes. Probes beginning with descriptions were verified somewhat faster than those beginning with names (2.10 seconds versus 2.94 seconds), although because of considerable variability, this difference only approached but did not reach significance ($p < .10$). Significant differences in this variable have consistently emerged in previous work (Anderson and Hastie, 1974; Beins, 1976). Inference items were significantly slower than noninferences, $F(1,19) = 18.34$, $p < .001$. The means are 2.53 sec and 3.00 sec for noninferences and inferences, respectively. One sees no effect of time of learning the identifications, $F(1,19) = 0.25$, $p > .50$. The means are 2.77 for items learned before the full identity and 2.75 for items learned after. No significant interactions appeared, all p 's $> .10$.

Errors. Error rates often showed the same patterns that positive probes did. It was easier to process descriptions than names (19% versus 34% errors), $F(1,19) = 19.27$, $p < .01$. Once again, the time of learning was unimportant (29% for items learned before full identity and 22% for those learned after), $F(1,19) = 1.67$, $p < .25$. And again there were fewer errors for noninference items than inference, $F(1,19) = 5.90$, $p < .01$.

One interaction approached significance. The effect is Time of Learning by Inference by Reference, $F(1,19) = 3.21$, $p < .10$. It results from consistently high error rates for the proper name-inference condition and consistently low error rates for the descriptive noninference group, regardless of time of learning, while the

name-noninference and description-inference conditions showed marked decreases in their error rates from Before to After. The entire set of means is given in Table 3.

 Insert Table 3 About Here

Two supplementary analyses were performed, to see if subjects produced differential verification times depending on whether they had learned six actions predicated of a single form of reference, or three each for two synonymous forms of reference; and to assess subject performance for positive and negative probes depending on whether the subject responded correctly or not to items in testing.

With regard to number of actions per form of reference, the only significant effect for VTs was according to inference status, $F(1,19) = 23.96$, $p < .001$. There was no effect of number of actions per form of reference, $F(1,19) = 1.81$, $p < .20$. The two factors did not interact, $F < 1$. The means are presented in Table 4. An analysis of the errors revealed that only the inference effect made a difference, $F(1,19) = 6.45$, $p < .025$. Number of predications per reference and the interaction of the two factors was again nonsignificant. As one sees in Table 4, in

 Insert Table 4 About Here

the case in which a subject learned all predications of a single form of reference, inference items show peculiarly fast VTs and strikingly high numbers of errors; they were virtually at chance in their accuracy. This probably indicates the relative lack of familiarity with the form of reference used in inference items in this condition.

Table 3. Summary of verification times and error rates for Experiment 1.

Times are in seconds. Marginal means are shown in parentheses.

Time of Learning	Before	Noninference	2.32	2.85	(2.59)
		Inference	2.84	3.22	(3.03)
		(2.58)	(3.04)		
	After	Noninference	2.03	2.93	(2.48)
		Inference	3.21	2.74	(2.98)
		(2.76)	(2.84)		
		Description	Name		
Time of Learning	Before	Noninference	.13	.15	(.14)
		Inference	.33	.18	(.26)
		(.23)	(.17)		
	After	Noninference	.33	.20	(.27)
		Inference	.38	.43	(.41)
		(.36)	(.32)		

Table 4. Verification times and errors as a function of number of predications per form of reference. Marginal means are in parentheses.

3 Predications Per Reference	2.63	3.19	(2.91)
6 Predications Per Reference	2.51 (2.57)	2.77 (2.98)	(2.64)
	Noninference	Inference	
3 Predications Per Reference	.21	.26	(.23)
6 Predications Per Reference	.23 (.22)	.44 (.35)	(.34)

Subjects may not have formed adequate links between occupations and predications here. The nonsignificant interaction of number of references and inference results from very high intersubject variability.

The second analysis , assessing differences in VTs depending on whether a probe was true or false and whether the subject responded much more quickly to items on which they were correct than incorrect items, $F(1,19) = 11.75$, $p < .005$. The means are 2.73 sec and 3.35 sec, respectively. Subjects were also quicker to respond to descriptive references than to nominal, $F(1,19) = 4.87$, $p < .05$. The means here are 2.92 sec and 3.16 sec.

These main effects are expected given that 1) names are harder to access than descriptions, probably due to processing effects, presumably independently of the truth value of the probe and whether it was answered correctly, and that 2) if a subject searches through memory without finding a match to a probe item, then guesses that the item is true or false according to some criterion, it should take longer than if a match or mismatch is definitely achieved. That is, correct and incorrect items come from distinctly different populations. Fortunately, there was no speed-accuracy tradeoff; consequently, the data can be interpreted, although with caution.

Only one interaction emerged significant, Time of Learning by Truth Value of the probe, $F(1,19) = 5.25$, $p < .05$. The means are shown in Table 5. The interaction reveals a trend toward lower VTs for items learned in the After condition relative to the Before condition, except for one cell (false items with descriptive reference) which had no change.

 Insert Table 5 About Here

Table 5. Verification times as a function of truth value of the probes.

Times are in seconds. Marginal means are shown in parentheses.

Proper Name	Before	3.35	3.24	(3.30)
	After	3.17	2.07	(2.62)
Description		(3.26)	(2.66)	
	Before	3.07	2.90	(2.99)
	After	2.71	2.99	(2.85)
		(2.89)	(2.95)	
		True	False	

Discussion

The results concerning the inference effect generated here suggest that subjects store related (i.e., by the actor) information separately in the absence of motivation to do otherwise. In this experiment, subjects took longer to verify inference items regardless of when they learned the full identity of the fictitious characters, in contrast to the study by Anderson and Hastie (1974). Simply because subjects knew of a name-occupation synonymy, they did not necessarily store together all the actions about that given character.

Thus, given a relatively minor change in the procedure relative to that of Anderson and Hastie, there is a noticeable change in the pattern of results, the most striking of which reflects an inference effect with nominal references as well as with descriptive. Anderson (1977) has also noted this nominal inference effect. The primacy of the proper name has diminished considerably with the procedural change. The inference effect with proper names should not occur if the nominal form of reference links directly with all actions predicated of a single individual. One suggestion as to the manner of storage involves using a form of reference as simply one more predication of an individual, i.e., an IS-A link, when only one form of reference is cited as having performed actions (six actions per reference). If this argument holds, one can conclude that if a subject is allowed to learn all predications of a single form of reference together, then the primacy of the name decreases because the subject has relatively little difficulty maintaining separate mental files on each actor.

It is very clear that at least qualitatively the search process induced by the methodology of Experiment 1 can be characterized by

associative mechanisms. However, all the assumptions that Anderson and Hastie postulated may not generalize completely. The present results suggest that forms of reference may function as simple predications of an individual. The second inference is that neither form of reference has necessarily special salience in the memory structure, and both forms require inference in reasoning. It is true that nominal references did not display a consistent inference effect, but the presence of one such inference calls Anderson and Hastie's statement on the centrality of the proper name into question for some conditions. It also suggests that subjects may in fact postpone integration of comparable references unless it is worth their while, a conclusion Anderson (1977) has also reached.

One does not need to postulate any sort of mental elaborations to account for these results. Some type of associative model should be able to handle the data without too much difficulty.

If the storage resembles an associative structure such as that of Anderson and Hastie, the addition of new information to the learning task in the present study should not cause qualitative changes in storage. However, if additional information induces more integration of material than do the isolated sentences used here, a configural or constructive representation would seem valid for sets of coherent information. An associative model might pertain only when it is the only logical course open to the subject to form relatively mechanical links among concepts in memory. That is, the stored information may be clustered in configurations when possible and search may proceed through the configurations when possible and necessary. The next study addresses this question.

EXPERIMENT 2

The second study will assess the effect of adding a locative to the types of sentences previously used. When one is informed that a series of unrelated actions has occurred in a common location, it will provide the opportunity for development of stronger relationships among sentences. In associationist terminology, there are more common memory links; in terms of mental elaboration, there is more opportunity for coherent mental constructions to occur. However, while the associative model would not assume anything other than more shared elements, a theory of elaboration might assume that the additional information would be likely to induce coherent semantic processing than a totally unrelated (except for agents) set of sentences. If the same procedure is used in the second study, HAM would expect either no change or a decrement in verification times with the appending of a location. HAM's parallel access mechanisms would provide for more starting points in search, therefore greater opportunity for quick matches of probes and memory set information to occur; a response occurs when the fastest of the independent searches terminates successfully. For a more elaborative theory, if clusters of information are built up with the adding of locations, then their inclusion should be a redundant feature of the agent, requiring little attention or processing time, but providing a relatively high amount of information. Thus, the verification times should not increase very much. Offsetting this decrease, however, might be the time needed to encode the longer sentences having the locations. In any case, HAM and elaborative expectations are similar.

In complete contrast, ACT (Anderson, 1976) expects a marked slowdown in response because the rate of search through a memory set

decreases with increased amounts of material to be searched. There are two reasons for this. First, ACT supposes that verification times are determined by the last, or slowest, intersection of activated paths in the memory set. Second, as the number of paths leading from a given concept increases, the rate of search decreases; this effect should obtain as the locative is introduced.

If appending more information to an individual's existence allows one to highlight the individual in a more coherent fashion due to the additional contexts provided (i.e., due to elaboration of the basic input), one might expect that the greater number of contexts or locations associated with that character, the easier any mismatch in a probe sentence will be spotted. That is, the individual will be remembered as having done certain things in a specific context and a false verification sentence will violate the contextual constraints. Sentences (28) and (29)

(28) The executive ignored the paper
in the office

(29) The executive ignored the paper
in the park

provide an example of how the different meanings associated with a given word, paper, will depend on the sentence in which it appears. In (28) the paper is likely to be something that should be read or signed while in (29) it is probably waste paper. This encoding specificity should manifest itself in quicker verification times in false probes according to an elaborative hypothesis.

The different senses of a word, according to HAM should make relatively little difference in processing since the meanings of words in a sentence are independent of one another in storage and retrieval. However, in ACT, disambiguation of the meanings of a word occurs through

an enrichment or elaboration of the concept entering memory. This enrichment, which relates only to encoding of input, has been implicated in the learning of simple word pairs (Reder, Anderson and Bjork, 1974) as well as for sentences (Anderson, 1976, pp. 413-423). Pursuing the assumptions of ACT, one would suppose that there are pre-experimental or a priori associations to each concept within the sentence. The associations to the concepts may themselves be related and then mediate a conceptual link between different elements of the sentence so that the senses of individual words are fairly constrained within a sentence.

These conclusions were reached by Anderson with cueing studies, rather than with verification time experiments. Should the same effects obtain in speeded reaction studies? In the latter paradigm it is often assumed that only a match is required, not retrieval. It can therefore be argued that the activation of nodes in memory is less affected by the subtle interrelationships among sentential elements than in cueing studies, since disambiguation occurs, according to ACT, at encoding and not at retrieval. That is, in a speeded reaction, verification times depend on rate of activation of memory nodes that already exist, and a match between a test probe and a memory item may not require the same extent of processing and disambiguation as new sentences to be coded for storage in memory. It is logical, however, to consider at this point ACT's parameter which specifies the rate of activation of memory nodes. This parameter will change when associations among items are strong or weak, affecting the verification times. Stronger associations generate a shorter verification time (Anderson, 1976, pp. 276-278). In the context of the locative, there is little reason to assume that

subjects would generate sentence meanings that would consistently elevate the rate parameter because few senses are probably attached to given words and these senses are arbitrary, thus different for different subjects (Anderson, 1976, p. 386). In a verification time paradigm, then, one would not necessarily expect the effects of disambiguation to play a great part since the relationships between words exert influence only during encoding, not during retrieval.

METHOD

Subjects. Thirty-two subjects from introductory psychology courses at Brooklyn College served in the experiment. They received course credit for their participation.

Apparatus and Materials.² The material to be learned consisted of 32 eight-word sentences of the form The banker (Dave Grant) wrote a letter in the office. The sentences had as grammatical subjects one of four common occupations or one of four proper names.

When the subjects had learned the sentences, they were exposed to test items. The positive probes either matched learning probes exactly or had an equivalent form of reference as grammatical subject. The negative probes could be constructed by two means: first, an actor could be appended to an inappropriate location or action, or an inappropriate location could be appended to the action. These two procedures were also combined to form probes in which the actor, action and location had not been associated in learning.

In testing, these items were shown using a two-channel Scientific Prototype tachistoscope with times to respond displayed on a Hunter Timer, Model 120C.

The test stimuli fell into two categories with respect to physical characteristics. The first type involved no locations. Thus, even though subjects learned all the items in this study with the locative, some test items lacked this feature. Such items, like those in the first study, were typed in upper case letters on one line. The sentences subtended approximately 5 degrees visual angle horizontally and .25 degrees vertically. Items with the locative appeared on two lines.

On the first line was the sentence fragment containing subject and predicate; on line two was the location. Line one again subtended an average of about 5 degrees horizontally, line two about 2.5 degrees. The display subtended an average of .65 degrees vertically. A small dot on the blank pre-stimulus field indicated the point at which the sentence would begin.

Procedure. Subjects learned 32 sentences predicated of four individuals, two by name and two by occupation. Half the subjects learned all predicated about a given form of reference in one location; the other half saw two two locations for a given form of reference. As such, it was possible for more than one fictitious character to be implicated in a single location. That is, for a given subject, Dave Grant was involved in two actions in each of the same two locations. For another subject, Dave Grant would be associated with four actions in the park and Herb Clark would appear only in the office, also with four actions there. This created one variable, number of locations for a given form of reference. (Ultimately, all fictitious agents were paired with two locations, one form in both locations or a different form of reference with each location.)

The learning phase here followed the same procedure as in the first study. Immediately after learning, the testing phase began. It was divided into two parts. In one, the subjects verified sentences with no locations (e.g., Herb Clark ate his lunch), and in the other the sentences contained a location (e.g., Herb Clark ate his lunch in the park). However, no subject was tested with the same action in location and no-location phases. This constituted another variable--presence or

absence or location. Negative probes consisted of actors paired with inappropriate predicates and/or inappropriate locations. For every false item, there was either a subject-predicate or subject-location agreement, but not both. Within the testing phase, subjects either verified a block of location items first, or the no-location items first, creating another variable—order of presentation of test items.

In addition to the variables just mentioned, three additional repeated measures variables from Experiment 1 were included. They were form of reference of the subject of the test sentences (name or occupation), whether the subject had learned a particular form of reference before or after learning which names corresponded to which occupations (before or after), and whether the form of the sentence in testing matched the form in learning or whether the name in the learning items were replaced by the description in testing, or vice versa (noninference and inference).

RESULTS

Positive Probes. There were only two significant main effects for VTs. First, inference items (INF) were significantly slower than noninference (NONINF) items, $F(1,28) = 20.38$, $p < .001$, and they generated more errors than NONINF items, $F(1,28) = 3.52$, $p < .10$, although the effect was only marginal. The means are 2.94 sec (0.22 for errors) and 3.37 sec (.32 for errors) for NONINF and INF items, respectively. Second, items without locations (NOLOC) were responded to quicker than those with locations (LOC), $F(1,28) = 4.56$, $p < .05$. The means are 3.24 sec for LOC and 3.07 for NOLOC items. The reliability of this effect is suspect, though, since NOLOC items showed more errors than LOC, .36 and .24, respectively, $F(1,28) = 19.82$, $p < .001$. This difference suggests that if subjects had erred less on NOLOC items, they would have slowed down and generated VTs comparable to those of the LOC conditions.

Subjects showed greatest accuracy when the location was present in the probe. This could be due to a number of factors. For instance, the context might provide enough information for the subject to be able to assess quickly and accurately whether the agent of a given probe had acted in the given location, or whether the action itself had been performed there. (According to Anderson, 1976, the verb is less informative than the grammatical subject although the relative importance of their roles here is unknown.) A second reason for the advantage of the locative might be some type of similarity between learning item and test probe, since LOC items resembled the learning items closely.

The VT effect for presence and absence of the location is further

mediated by two related interactions. First, there is a Location x Order of Testing interaction, $F(1,28) = 4.56$, $p < .05$. The means are given in Table 6. (For purposes of exposition, the order variable will be discussed in terms of whether a given test item had been preceded by practice items or not. Specifically, for LOC items, the LOC First condition represents no practice; the NOLOC First condition, practice. For NOLOC items, NOLOC First represents no practice; LOC First, practice.)

 Insert Table 6 About Here

This effect indicates that practice proves beneficial for NOLOC items but not for LOC items. That is, there is a 0.60 sec decrement in verification times for NOLOC items with practice and a mere 0.04 sec change, an increase, for LOC items. The change for NOLOC items occurred even though the practice items contained the location and the NOLOC items had not been previously tested. This interaction may reflect the fact that LOC items were initially easy to verify because of their contextual cues or due to similarity to the learning items, and practice exerts no benefit. NOLOC items lack the same cues and so may benefit from any learning that occurs during testing. When LOC items intervene between learning and the testing of NOLOC items, added learning or integration may occur as the subjects are forced to respond in general to the recently learned information. Some type of spreading activation among related information could account for this, as suggested in ACT, and the peripherally activated information may become easier to retrieve.

The second interaction involves Location x Order x Inference, $F(1,28) = 11.14$, $p < .005$. The means also appear in Table 6. For

Table 6. Mean verification times for Order of Testing x Location x Inference interaction for Experiment 2. Marginals are in parentheses.

		Order of Testing	
		NOLOC First	LOC First
Items without Locations	NONINF	2.97	2.67 (2.82)
	INF	3.78 (3.37)	2.86 (3.32) (2.77)
Items with Locations	NONINF	3.20	2.93 (3.07)
	INF	3.26 (3.23)	3.52 (3.39) (3.23)
		(3.30)	(3.00)

NOLOC items, practice exerted a positive effect on verification times for both INF and NONINF items. The changes are -0.92 sec and -0.30 sec. There is a decreased mean verification time for items without locations when prior items with locations have been presented. With respect to LOC items, the practice effect was more variable. There was a +0.27 sec change in times for NONINF items with practice, which was offset by a -0.31 sec change for INF items. Here one sees no overall advantage for items with locations with early exposure to NOLOC items. If one examines comparable data from Experiments 1 and 2, shown in Table 7 (i.e., the data from Experiment 1 and NOLOC items without practice in Experiment 2), one finds that descriptive references follow similar patterns in both experiments. Nominal references, on the other hand, show notable differences with respect to NONINF-INF

Insert Table 7 About Here

comparisons. In Experiment 1, the overall means show little effect for names; this effect also obtained in Anderson and Hastie's study. In Experiment 2, however, a striking inference effect occurs. Going one step further, however, if subjects have already verified LOC items, when they attempt to verify NOLOC sentences, all inference effects diminish. Thus, during the process of testing, subjects appear able to consolidate information; in effect further learning occurs. (The high error rate for descriptive inferences is troublesome, approximately matching the error rate for the same condition in the Anderson and Hastie study.

Table 7. Comparisons of verification times and errors for Experiments 1 and 2, NOLOC items.

		Experiment 1		Experiment 2			
				No Practice		Practice	
		Noninference	Inference	Noninference	Inference	Noninference	Inference
Before	Description	2.15 (.13)	2.70 (.33)	2.44 (.44)	3.63 (.38)	2.69 (.12)	2.91 (.53)
	Name	3.13 (.30)	3.00 (.38)	3.35 (.28)	3.83 (.38)	2.62 (.31)	2.87 (.38)
After	Description	2.08 (.13)	3.18 (.18)	2.76 (.18)	3.85 (.47)	3.04 (.40)	3.25 (.40)
	Name	2.83 (.20)	3.01 (.35)	3.31 (.35)	3.81 (.25)	3.33 (.34)	3.34 (.19)

as they suggested, it may be due to incomplete searches, not to forgetting or nonlearning.) One suggestion for these results is that LOC items, by virtue of their context contain more coherent information than NOLOC items, and that exposure to them familiarizes the subject with the learning material more than exposure to NOLOC items does.

An argument that the advantage of of NOLOC items with practice derives from lexical storage of items rather than any abstract representation (e.g., Hayes-Roth and Hayes-Roth, 1977) is vitiated here since the practice in this instance was limited to LOC items. If subjects in fact store material in a form not too transformed from the original input form, no special effect of practice on LOC items should appear since the form of LOC items differs considerably from that of NOLOC items.

With respect to forms of reference, nominal forms generated fewer errors than occupations did (0.25 and 0.35), $F(1,28) = 13.55$, $p < .001$. This effect is due largely to a very high error rate for descriptive inferences relative to nominal, while there is little difference between descriptive and nominal inferences. The means appear in Table 8. This configuration of data resulted in a Reference x Inference interaction, $F(1,28) = 4.93$, $p < .05$.

 Insert Table 8 About Here

Finally, two higher order interactions appeared. First, with verification times, there was an Order of Testing x Time of Learning

Table 8. Mean proportion errors for positive probes for the Reference x Inference conditions.

	Description	Name
Noninference	.29	.26
Inference	.41	.24

x Form of Reference x Inference interaction, $F(1,28) = 4.49$, $p < .05$. Basically, when NOLOC items were tested first, INF items took longer to respond to than NONINF, with descriptive items taking longer than nominal regardless of inference status. When LOC items were tested first, for unknown reasons, verification times for nominal inferences decreased and nominal inferences took longer. There was no change for descriptive items. The other interaction involves errors, the Location x Number of Locations x Time of Learning x Form of Reference interaction, $F(1,28) = 4.63$, $p < .05$. Its origin is unclear; the data merely indicate that in most conditions inference items are more accurately responded to when they were learned in the After condition while nominal items were more variable. There are numerous surprising data points, and this effect will not be interpreted. The means for the verification time for the interaction are in Table 9.

 Insert Table 9 About Here

Negative Probes. For "false" test items, the results are remarkably simple. Only two main effects emerged. First, subjects were much quicker to respond to items whose agents had appeared in two locations rather than one, $F(1,28) = 5.14$, $p < .05$. The average time for One Location is 3.37 sec and for Two Locations, 2.74 sec. Second, verification times were faster when a probe was rendered negative by an agent-location mismatch relative to a predicate-location mismatch, $F(1,28) = 11.06$, $p < .005$. The means are 3.29 and 2.82 sec.

The only other significant effect involving verification times

Table 9. Comparison of verification times for the four-way interaction of Order of Learning x Time of Learning x Form of Reference x Inference. Times are in seconds. Marginal means are in parentheses.

		Before		After	
		Description	Name	Description	Name
NOLOC First	Inference	3.44	3.58 (3.51)	3.39	3.66 (3.53)
	Noninference	2.74 (3.09)	3.34 (3.04) (3.46)	3.03 (3.21)	3.23 (3.13) (3.45)
LOC First	Inference	3.21	3.52 (3.37)	3.27	3.07 (3.17)
	Noninference	2.79 (3.00)	2.77 (2.78) (3.15)	2.61 (2.84)	3.04 (2.83) (3.06)

was a four-way interaction of Order of Testing x Form of Reference x Location x Inference, $F(1,28) = 4.42$, $p < .05$. The interaction revealed a general decrement in verification times for the false items with differing locations relative to those with the same locations although with nominal inferences the decrease diminished for subjects tested on LOX items before NOLOC. Also, descriptive inferences required longer for processing than descriptive noninferences in the NOLOC First condition, while such inferences were quicker for LOC First subjects.

The error rate was relatively low for false items (0.14) and more manageable than that for true items. The only significant main effect is that of location match-mismatch (relative to learning), $F(1,28) = 13.05$, $p < .005$. Subjects were more likely to err with a match than with a mismatch of locations; the means were 0.19 and 0.09. The analysis also revealed nonsignificant tendencies for more errors with one location per reference in learning than with two and more errors with descriptions than with names (both p 's $< .10$). There were several interactions involving form of reference and time of learning; they do not relate to present considerations and will not be treated.

The former interaction reveals that as the subject became more familiar with the stimuli, i.e., with practice, they made more errors on noninference items whose agents and locations corresponded to the agent-location pairings in learning. They also make a relatively high number of errors when either agent and predicate or agent and location correspond, regardless of inference status or practice. Finally, they show fewest errors when test items are very dissimilar to learning stimuli, that is, when agent and location do not correspond

and the item is an inference. That is, the closer the wording of the test item to learning item, the greater the incidence of errors. This is consistent with Hayes-Roth and Hayes-Roth's (1977) statement of direct lexical storage of information, although their suggestion is not completely supported by all the data.

The results of this experiment suggest that a simple associative account of linguistic storage fails to characterize much of the data. That is, the locations affected information retrieval even though the test sentences were presented without locations. An alternative to the associative theory is a more configural theory which suggests that the diverse aspects of a single sentence create in that sentence a character that represents a unique union of the separate elements. Thus, a locative will induce context effects and a meaning in the sentence or sentence group that facilitates retrieval, presumably because the information takes more coherent form for storage. As a result, relational as well as contextual cues can be used in accessing memory. With no context, and only simple S-V-O sentences, only relations are available.

In comparing Experiments 1 and 2, one sees that the similar methodologies employed in the two studies produces quite dissimilar results. Consequently, it is tempting to speculate that a learning or testing procedure per se does not necessarily lock a learner into one set of strategies of encoding and retrieving information. Rather, the nature of the stimuli may engender differences. And it is the presence of "reality" or coherence in a sentence that facilitates its storage. As Anderson (1976) points out, one must attend not only to the form of memorial structures, but also to the mechanisms

employed in developing these structures. The manipulations of the two present studies, in fact, demonstrate that no simple coding or structural mechanisms will capture all the data adequately.

EXPERIMENT 3

The difference in VTs between LOC and NOLOC items was relatively small, only 170 msec. Reading three additional words on the second line of the display in testing could easily occupy that amount of time. ACT specifies that with added relations to search, the rate of search slows down; this suggestion is questionable given that the added time with locative sentences is not very large. On the other hand, HAM specifies a speeding of verifications when more entry points, hence more chances for spotting mismatches, are introduced. A configural theory also suggests a speeding of memorial search with context present because an out-of-context probe can be easily spotted.

The third study will attempt to measure the differences in processing times for sentences with and without locations, but in a task that does not involve memory search. In such a task, the time needed to process the longer sentences will give a very rough estimate of the response times not involved in memory. These can be compared with the times in Experiment 2.

METHOD

Subjects. Sixteen subjects from introductory psychology courses at Brooklyn College received course credit for their participation.

Apparatus and Materials.² The same tachistoscopic and timing equipment was used here as in the first two studies. Half of the sentences (16) were taken from the stimuli in the second study. They were randomly selected to produce four items in each of the reference (name/occupation) by sentence length (long/short) factorial combinations. The other half of the sentences was of the same form, but made little sense (e.g., the banker ate his lunch in the cloud). Either the verb

or the object of the sentence, or the location could generate the nonsense. A preliminary study with 16 different subjects indicated that the only dimension affecting the realism of the sentence was the meaningfulness factor. The meaningfulness of the sensible sentences was rated as 1.39; it was 6.27 for nonsensical sentences. A rating of "1" indicated good sense; a rating of "7" meant pure nonsense. There was no overlap between the two groups.

Procedure. Subjects saw a dot on the blank pre-stimulus field and were told that the stimulus would begin at that point. When the stimulus appeared, for five seconds, subjects responded "yes" or "no" as to whether the sentence was sensible by pressing an appropriate button. They were instructed to respond quickly but to make sure that their judgments were reasonable before responding. Thus, the three variables of interest here are sentence length, form of reference and order of testing (locatives first or second).

RESULTS

Several interesting results emerged. First, long sentences (i.e., those with locations) required an average of 2.64 sec while the shorter items took only 2.14 sec. The difference was significant, $F(1,14) = 26.87$, $p < .001$. Names also took slightly more time than occupations, 2.45 sec versus 2.33 sec, respectively, $F(1,14) = 5.38$, $p < .05$. Unfortunately, it is not clear why this latter effect occurred, whether it pertains to the greater length of names, or to the relative infrequency of any given name. Order of testing made no difference, $F > 1$.

In addition to the main effects, there was one significant interaction, Order of Testing by Sentence Length, $F(1,14) = 10.37$, $p < .01$. The means, shown in Table 10 as a function of practice, indicate that subjects require less time to respond after they have some practice.

 Insert Table 10 About Here

(They had only 8 practice trials before the experimental stimuli appeared.) However, the effect was larger for items with locations. In Experiment 2, the effect of practice was beneficial for items without locations (an improvement of 0.60 sec with practice) and virtually nonexistent for items with locations (a change of 0.02 sec).

Comparing the relevant results in Experiments 2 and 3, one can see that the differential times to respond to location and no location items vary in the two studies, which indicates some relative benefit for location items in Experiment 2. That is, with context as part of the learning task, subjects seemed to speed up their responses when

Table 10. Mean response times as a function of sentence length and practice in meaningful judgments.

	Sentence Length	
	Short	Long
Practice	2.01	2.45
No Practice	2.26	2.83

context was also involved in the testing phase, but not when the locative was missing in testing. Likewise, with the interaction, the benefit of practice was limited to test items with no context (i.e., with no location) in Experiment 2. VTs for location items reached an early, stable plateau. In contrast, both items showed decreased response times in Experiment 3. These patterns reveal that the locations play a central role in the search process and can aid one's memory, probably by providing cues for appropriate searches through information stored in memory.

One might argue that the facilitation for no location items in Experiment 2 results from some sort of practice effect, as if possible here in Experiment 3. However, the "practice" never involved items without the locative; thus, the effect is likely due to processes involving the search through or organization of memory. Further, one would expect both sentence types, location and no location to benefit from practice. Obviously, this did not happen in Experiment 2. Conclusions to be drawn from these data include (1) a facilitation in the search process due to the presence of the location in learning and testing, and (2) some type of continued learning that takes place during the first testing phase. The nature of the learning might involve a restructuring of connections among predications that provides more direct linkage of related ideas. Location items with their initial advantage due to context may not benefit in the reorganization. The suggestion of restructuring in the testing process has been proffered by Anderson (1977) and seems reasonable to adduce here.

DISCUSSION

The present data suggest that in certain settings, as in Experiment 1, an associative model predicts memory for linguistic input well. With regard to the data of Experiment 2, one implication is that when information is added to one's memory store (via the locative), the time to search for a match increases although the increase seems related only to the increased length of the probes. When no memory search was required, the longer sentences required about half a second longer than shorter items. The 0.17 second increase in Experiment 2 falls short of the half second difference by two thirds. Although the two tasks are undeniably different, memory search versus sensibility judgments, one might suggest that in the memory task search, verification times may actually benefit from the presence of the locative, once reading times are accounted for.

When the same basic procedure is used as was employed by Anderson and Hastie (1974), the pattern of results accords almost totally with the expectations of HAM and ACT. When the location was added, however, it produced results at variance with the associative models of long-term memory. Note that in the cases in which the predictions of HAM and ACT are verified, the cross-experimental agreement is striking. It is also obvious that such a pattern of results obtains in Experiment 2 only in that condition in which the subjects had previously verified LOC items. When the location was introduced, the pattern of results no longer conformed as closely. In particular, when NOLOC items were probed without intervening practice on LOC items, the verification times averaged 0.60 sec longer than when subjects practiced with different items having no locations. Clearly, the

introduction of the locative is more than a simple addition of another nuclear proposition to be scanned and stored like all others, as ACT would maintain. This practice effect obtained for INF and NONINF items without locations, although inference items with locations showed no such effect.

There are two tenable hypotheses which might account for the 0.60 sec change. One emphasized a shift in search procedures, the other implies a different type of store in LOC and NOLOC predictions.

A search hypothesis would explain the change in results in terms of more efficient access to stored information. As one practices, perhaps one needs less time to search due to simultaneous activation of multiple pathways with increasing familiarity with the material. This general pattern was suggested by Lewis and Anderson (1976) as well as in ACT. Nevertheless, it does not explain the differential advantage for NOLOC items. Nor does it accord with HAM's tenets which assume serial search processes.

Thus, a simple change in search procedures cannot account for the observed effects. On the other hand, a hypothesis based upon modification of the form of the memorial store can provide at least a post hoc interpretation about the differential effects of LOC and NOLOC items.

Suppose that as the items are learned with locations, the presence of the locative serves to define that particular proposition in a very constrained manner as was suggested above for the word paper in sentences (28)-(29). If a later probe sentence now contains the location, the same context in learning and testing is invoked and the

verification process produces a direct match of the probe to the learning item. If, however, the location is missing, the sense of the test item may not match that of the encoded item so that the subject needs to invoke another strategy such as an actual word match or a search for a context that corresponds to the learning context. Thus, time needed to verify location items, despite their additional length and the addition of the context, is less than the time needed to verify the same item without the location. (Note that this analysis holds for items without practice only.) A relative reduction in verification time, as was found, supports HAM, which predicts such decrements with locations appended. ACT does not predict these findings; it predicts a lengthening which occurs only in limited settings.

The data, moreover, imply that the contextually directed configurations may be more "natural" since the LOC probes remained at asymptote throughout the experiment, while NOLOC items showed practice effects. In other words, concerning NOLOC items, with practice the subject may consolidate information or simply become more familiar with the actions predicated of each fictitious character, and thus become more effective at accepting test items as correct or rejecting them as inappropriate.

In traditional verbal learning, it is known that if subjects learn two lists of paired associates (A-B, A-C paradigm) and receive repeated test trials with the A-C list, as practice continues with the second list, subjects tend to confuse them less and less with the original, B, responses (Barnes and Underwood, 1959). The same type

of learning may occur in the present studies; with practice on test items, related to but different than subsequent probes, subjects seem to show less interference among items (i.e., fewer errors). Not only do the VTs to the NOLOC items benefit with practice, but the error rate drops significantly.

This differential practice effect does not necessarily embarrass any single model. As suggested in Anderson and Hastie, one can quite easily establish a practice parameter. However, the acceptance of HAM or ACT would seem strained by too many post hoc assumptions such as a postulate of different parameters of change for LOC and NOLOC items. Another rescue of associative tenets can be offered if it is assumed that during learning, subjects try to retain meaning and clusters of information, but that in testing, different search strategies obtain. For LOC items, the subjects attempt to verify probes by assessing the likelihood that a given action occurred in a specified context; for NOLOC items, subjects complete the verification task by searching for relevant subject, verb and object concepts in memory, assessing their relational links and attempting to match the probe to the stored information. This strategy, though, implies that subjects store more than simple relations in memory. The agent-location cluster, for example, may be a salient feature of the subject's memorial store.

A configural theory, less well defined than its associative counterpart, predicts this contextual constraint, and also differential practice effects. That is, if one stores the contextual constraints, then verifying test sentences with locations should involve matching these specifications, while prior practice on items without locations

should avail no benefit since a different strategy, the subject-verb-object (S-V-O) relational search is used, not a contextually based search. With practice on location items first, subjects may have the opportunity to familiarize themselves with contextual plus relational information. This hypothesis posits that the contextual plus relational storage is more basic than only a relational storage since a relational search can derive from the contextual storage, but the contextual search appears not to occur as a result of mere relational information.

In general, then, with LOC items, the locations seem to play an integral part in the retrieval process since their absence generates relatively long verification times in some cases. However, subjects showed a strong inference effect for both LOC and NOLOC conditions. Even though they integrate material within a proposition, integration across different forms of reference separated by intervening items is not necessarily automatic or spontaneous. As Moeser (1976) showed, unless stimuli are obviously related and presented together, subjects tend to store related sentences separately. When integration is not complete, the need to draw inferences occurs. However, the storage properties of memory do not alone produce the appearance of inferences. Different search modes may occasion inferential reasoning. The descriptive items revealed a strong inference effect with NOLOC items, but less so with LOC items.

The obvious implications here are that once again different experimental settings will produce quite varied results and these results can be explained through either storage or search mechanisms or both. Fredericksen (1975a, b, c) has found just this with

connected prose. When his subjects attempted to recall elements from a paragraph, they tended to draw inferences about concepts appearing in the paragraph. The results of this processing remained an integral part of memory for the information. The subjects tended to recall these inferences over and over with repeated recall requests. On the other hand, subjects also tended to "recall" information not logically derivable from the paragraph; the derivations appeared only at the time of the subjects' responses and only inconsistently from trial to trial, tending to disappear as the subject became more familiar with the actual details of the story. This latter output was not a stable part of encoded information, but rather a confabulation based on incomplete storage of information. In the present experiments, changes in verification time patterns probably reflect alterations both in storage and in search. The storage change would result from obviating the need to treat inferences as such as the subject becomes familiar with the agents and predications; the search change would indicate a search priority for previously inferential items over noninference items as well as a contextual S-V-O relational assessment for NOLOC items.

The details of contextual search and storage are not unequivocal although the data reveal important patterns. First of all, with newly learned information some type of serial search occurs through recently acquired memory nodes. Experiment 1 here and studies by Anderson (1974a, 1975), Anderson and Hastie (1974) and Thorndyke and Bower (1974) have all indicated this recency effect. However, the search suggested by HAM simply cannot account for all the processes taking place.

In Experiment 2, for example, subjects were faster to reject

false sentences whose agents had been involved in two rather than one location. (Unfortunately, there are no data on any differences in the degree of learning for the different types of stimuli.) According to a random entry or serial search model, predicted verification times arise from the number of links issuing from a given concept, e.g., the number of predicates associated with a single subject. In the present work, there are equal numbers of links, four, from each location regardless of the number proceeding from a given location for a given agent. There are at least two ways of describing the locus of the verification time advantage of fewer predications per agent. The first is that a search through a specified context will produce faster times due to an easier rejection of an improbable event in that context. The subject considers the test item and due to the stability of encoding allowed by the location, accepts or rejects each proposition in memory without the need to search through the proposition (e.g., subject, verb, object and then location). The advantage of fewer propositions per agent arises from the relative lack of confusability among items in a single context with fewer predications associated with it. That is, the location provides more information as its uniqueness increases. A second explanation involves associative terminology. If the subject initiated search at the subject, verb, object and location simultaneously, as suggested by HAM, and in addition stored the location twice, once for each agent, with the search proceeding simultaneously from each instance, then the search process would terminate quicker with fewer propositions for each instance of the location. Thus, two notations for park might be useful, park₁ and park₂. This latter

mechanisms has not been posited for HAM although its descendent, ACT, easily handles the idea. According to ACT, the greater the number of links issuing from a given concept, the slower the search rate from that concept. So with two separate codings of park, there will be a faster search than if there is only one encoding. Unfortunately, this two-location effect appears only with false items, a finding not commensurate with ACT's characterizations.

In summary, it appears that while neither HAM nor ACT can account for all the data, there are aspects to each model consistent with the data generated here. Unfortunately, there is no clear reason why the data do not reconcile with either model considered alone. The area that seems to produce the greatest number of potential discrepancies between the models and the data involves the presence of the locative. HAM virtually ignored such constraints, while ACT assumes that they affect encoding only. Further work will determine whether contextual constraints affect storage, as was suggested here, or encoding and retrieval. At the present time, the very real effects of context seem to be due to a certain amount of integration not expected by associative models.

This integration might be facilitated due to subject strategies. That is, with the locatives, subjects can conjure up conceptual "pegs" on which to hang their ideas. The easier the pegs emerge and the more of them there are, the easier it may be for a subject to store and to access data in memory.

These three experiments have given some insights into storage and retrieval mechanisms. Unfortunately, a verification time paradigm has certain built-in limitations. One of those is that

is that one may not know for certain the locus of differences in the data; they may involve either the memorial structure or search strategies. Another limitation is that one has less confidence in development of models underlying the data as the error rate increases, particularly when speed-accuracy tradeoffs are implicated. That is, the subjects may be rambling mentally into areas inappropriate to the information for which they are searching, which could lead to long verification times having little to do with the information at hand.

For these reasons, the next two experiments will utilize another methodology, that of cued recall. Fortunately, the switch in procedures is possible and even desirable because associative and configural models both specify mechanisms of sentence storage relating to individual sentential concepts.

EXPERIMENT 4

This study will approach the question of the form of verb storage from the same theoretical attack used by Thorndyke (1975). That is, it will utilize the verbs labelled simple, causative and complex, in Schank's terms. The grammatical subjects and objects relate to one another with varying degrees of complexity. That is, as exemplified in sentences (30)-(32), the verbs imply differing amounts of interaction among subject and object. In (30), the janitor initiates the action and the teacher is relevant only to the extent that a caller must have a callee, thus this is a simple verb. In (31), however, although the janitor instigates the

(30) The janitor called the teacher

(31) The janitor surprised the teacher

(32) The janitor obeyed the teacher

activity expressed in the sentence, the teacher also ends up in some different state as a direct result of the janitor's action, as specified by a causative verb. While there is not any very involved interaction, the teacher's supposed role here becomes less passive than that in (30). In the most complex interaction, that of sentence (32), the teacher must first initiate a request for some behavior that the janitor must carry out before the verb obey can be properly used. Thus, there is more than just one simple idea underlying sentence (32). That is the reason this type of verb is labelled complex.

In Thorndyke's (1975) work, subjects briefly saw a series of sentences and were asked to rate them as to how imageable they were. The subject underwent a cued recall task following the learning

phase. There were no essential differences in recall occasioned by the different verb types. He did find, though, that the verb cue produced the lowest amount of recall, relative to subject and object cues. The largest effect was due to the imageability of the sentence; the higher it was, the better the recall. When imageability was controlled, there was no support for Schank's postulates.

Unfortunately, Thorndyke's procedure left little time for the subjects to process the sentences they saw. If the verbs do vary in complexity, one might reasonably assume that the more involved actions require more time to be processed fully, independent of imagery factors. In the present study, this added time will be given to the subjects. They will study each sentence for 15 seconds before proceeding to the next. If there is differential processing for the different verb types, it might surface with this revised methodology.

The expectations for later cued recall, more intuitive than formally defined are relatively simple. According to a configural hypothesis, for simple verbs, the subject cue should produce best recall since the agent here is really the only person engaging in any activity. The verb cue should be poor since it does not serve the function of relating the subject and object in an intimate fashion. The role of the direct object is quite passive and the individual in that role has only tenuous semantic links with the subject.

For causative verbs, the subject, as initiator of action, should elicit good recall, as should that object. That is, both ultimately engage in some specific behavior, the subject as an instigator and the object as the affected recipient, and both should be quite salient.

The verb can be regarded as the concept specifying the relationship between subject and object although for the causative sentences, the verb need not be directly represented in an underlying memory scheme. For example, considering sentence (31), two underlying ideas are advanced. First, the janitor did something (like step out of a dark doorway suddenly, or enter a room quickly and quietly) which caused some reaction by the teacher (like a startle response). The idea of surprise can be reasonably conveyed as such, and if psychological processes follow this pattern, then the verb cue should produce a relatively large amount of recall since it specifies the functional relationship between subject and verb. In contrast, although the subject and object are quite salient within their own realms of action, the action each engages in does not relate to the other, except through the connection expressed in the verb. Thus, the subject and object should be relatively ineffectual cues for recall due to their indirect relationship.

For complex verbs, there is an intimate link between subject and object, and both also engage in a specific action. The complex verb, though, differs from the causative in that the object of the sentence is more than a simple recipient or is put in more than just some altered emotional or physical state. For some complex verbs, in fact, the object of the sentence may be the initial actor, and the subject a consequent actor. For example, in sentence (33), built around a complex verb, believe, the prostitute must say something for

(33) The jury believed the prostitute
the jury to believe or disbelieve. Not all complex verbs are structured like this, but all involve some sort of interaction on

the parts of the subject and object.

These three verb types provide obvious differences in predictions based on Schank's CDT. In summary, one does not necessarily expect varying amounts of recall based on the verb types, but the efficacy of the different cue types should change as the verbs change. If such differences do not appear, Schank's CDT would reduce to an associative model resembling ACT. In this present situation, the associative models would not generate predictions about differential amounts of recall since they have not really addressed the question of the nature of storage or implications underlying verb structure.

METHOD

Subjects. Fifty-four subjects from introductory psychology classes at Brooklyn College served in the experiment. They received course credit for their participation.

Materials and Stimuli.² Each subject learned 24 sentences which were presented in small booklets, one sentence to a page. Eighteen items were included for data analysis while six were used to control for primacy and recency effects in recall. All sentences were of the form The Noun₁ Verbed the Noun₂, in which the grammatical subjects and objects were always people.

This experiment used 54 sentences containing 18 critical verbs, six verbs in each of three categories specified by Schank's (1972) Conceptual Dependency Theory. The verbs and subject/object pairs are shown in Appendix M. All verbs were rated either A or AA in the Thorndike-Lorge (1945).¹ Determination of verb status was made by considering the entailments of the verbs in terms of the subject-object relationship. In constructing three sets of 18 sentences, care was taken to avoid peculiar or unlikely sentences such as The clerk fired the family. One verb used, wrote, is considered intransitive given that the particle to is often appended in a dative situation. Previous work (Ehri and Rowrer, 1969) has shown that such verbs are processed much the same as transitive verbs.

Prior to the present study, a group of pilot subjects rated the stimuli on a scale of 1 to 7 according to imageability. No differences in imageability appeared due to the complexity of the relationship implied by the verb.

The verbs themselves were representative of Schank's simple, complex and causative verbs. The experiment here is based in part on Thorndyke's

(1975) examination of Schank's theory. That study, however, was inconclusive and the present research has made several alterations and emendations in order to allow subjects sufficient processing time for considering the sentences.

Procedure. Subjects were simply instructed that they were participating in an experiment involving memory for sentences. They received booklets containing the stimuli, one to a page, and studied each one for 15 seconds, paced by the experimenter. There were two orders of stimuli such that the stimuli appeared in one order for half the subjects and in the reverse order for the other half. Within the booklets, the order of sentences was random with respect to verb types. For recall, subjects each got a single sheet of paper containing a column of 18 words, each representing a subject, verb or object of the learning sentences. These words served as cues for recall of the rest of the sentence. Subjects were permitted as much time for recall as desired; it never required more than 15 minutes. Subjects were told to recall verbatim if possible, but to write down as much as they remembered in any case. They returned two days later for the ostensible reason of filling out a questionnaire. Instead, the second recall was given. There was no feedback given after either recall session.

The 54 subjects each received one of three possible sentence sets; each set contained the same verbs, but in the different sets the subject-object combination was paired with different verbs. The sentence frames in which the verbs appeared differed; ultimately, each verb appeared in one of three sentence frames.

Data analysis. For the purposes of data analysis, data from one subject was drawn randomly from each sentence set. These three subjects

were then treated as one statistical subject by taking recall data for the sentence frame corresponding to a given verb and treating the combined recall of all three real subjects as one data point. For example, one subject might learn that the janitor obeyed the teacher; another, the convict obeyed the guard; and a third, the actor obeyed the nurse. All subjects were given the same grammatical cue for the sentences containing common verbs. Due to this manipulation, each data point would consist of four possible values, zero through three sentences recalled. This should provide more stable estimates of the variability. One obvious drawback involves the loss of degrees of freedom (18 instead of 54). However, in all analyses, sentences were treated as fixed effects, against some caveats of Clark (1973). Since there were only two different sentences within a single cell, an analysis using sentences as random effects would provide very little power. The loss of degrees of freedom should in part offset the possibility of an elevated alpha level. Further, since the population from which these stimuli were drawn is unclear, the advisability of using a random effects model is suspect (Clark, 1973).

The data generated were subjected to a three-way analysis of variance. The variables were Time of Recall (Immediate or Delayed), Verb Type (Simple, Causative or Complex) and Cue Type (Subject, Verb or Object). The design was thus a 2 x 2 x 3 analysis with repeated measures on all factors.

RESULTS AND DISCUSSION

The results for this study are quite illuminating concerning the role of the verb and the processing of the functional relations implicit in the different sentence types. As indicated by the analysis of variance, two significant main effects emerged. First, subjects forgot a significant amount across the delay period. The decrease in proportion recalled was from 0.53 to 0.44, $F(1,17) = 34.77$, $p < .001$. The second main effect involved Cue Type, $F(2,34) = 3.67$, $p < .05$. The proportions recalled according to cue were 0.53 for subject, 0.42 for verb, and 0.48 for object.

In addition, there were three notable interactions. The first, Delay x Cue Type, $F(2,34) = 3.41$, $p < .05$, reflected an increasing diminution in recall for subject and object cues across time, while the verb cue remained essentially the same. The means appear in Table 11. Another two-way interaction, Verb Type x Cue Type, appeared, $F(2,34) = 7.32$, $p < .001$. This indicates marked differences in cue effectiveness as a function of verb type. The means appear in Table 11. This pattern of results reflects the relatively high effectiveness of the subject and object cues with simple and causative sentences, with greatest efficacy for the verb cue for complex verbs, in which the subject and object are poor cues. It appears that the relation between subject and object is recalled with some difficulty although it remains fixed once encoded, while the memory for the subject and object fades over time.

For the simple and causative verbs, the subject of the sentence provides by far the greatest amount of information for retrieval. For complex sentences, the verb acts as an efficient access to memory;

Table 11. Proportion recall for the first cueing study, involving simple, complex and causative verbs (N = 18 subjects).

	Immediate			Delayed		
	<u>Cue Type</u>			<u>Cue Type</u>		
	Subject	Verb	Object	Subject	Verb	Object
Simple Verbs	0.63	0.35	0.56	0.59	0.32	0.38
Complex Verbs	0.50	0.56	0.55	0.39	0.52	0.45
Causative Verbs	0.59	0.39	0.37	0.48	0.40	0.44

however, the object of the sentence also allows for a relatively high recall rate. This would follow if the object of the complex sentence were actually treated as a very salient, possibly instigating force in the relationship implied in the sentence. It actually turns out that when the cue was the direct object, subjects showed better recall of complex sentences than of either simple or causative. This pattern resulted in the three-way interaction of Delay x Cue Type x Verb Type, $F(4,68) = 3.82$, $p < .01$.

If one supposes that complex sentences actually constitute two or more underlying propositions, then one might expect that subjects may recall one unit of a complex sentence (e.g., one of the underlying propositions) but not the entire item. There is a small amount of support for this notion, as shown by analysis of the data on partial recall. There are relatively few data points (only 10 percent of all errors involved partial recall), so no statistical analysis is feasible. However, the pattern of results is interesting.

Given that the subject did not recall the entire sentence, what is the likelihood that something would be remembered? The probabilities are given in Table 12. The causative and complex sentences generated more partial recall than the simple sentences, especially with the subject and verb cues. The object, however, of all three types of sentences served as an effective cue for partial recall. If subjects tend to recall whole propositions, as Kintsch (1974) suggests, these bits of data indicate that complex and causative sentences may be stored as more than one proposition; that is, the implications of the sentences may be stored rather than the sentence alone. It is not clear why the object of simple sentences proved so effective in

Table 12. Partial recall for first cueing study, involving complex, causative and simple verbs (N = 18 subjects).

		Verb Type		
		Simple	Causative	Complex
Cue Type	Subject	0.047	0.133	0.111
	Verb	0.047	0.140	0.090
	Object	0.185	0.124	0.160

partial recall; in general, the object was effective for all types, though. Closer examination reveals that 28 of 42 instances of partial recall to the object cue (for the three types) involved recall of the subject, indicating that storage of relations is more difficult (or at least qualitatively different than) storage of nouns. Other patterns emerging involved a strong verb-object connection since the verb cue elicited recall of 19 objects and only 4 subjects. When the subject was the cue, the only noticeable pattern involved causative sentences. In this case, of 15 instances of partial recall, 14 were objects recalled. This suggests that, once again, verb storage is difficult to achieve relative to subject and object.

In summary, these results suggest that different verb types are stored in different ways, although not in the fashion offered by Schank's theory, which posits that the different verb types are broken down differently in memory, with sentences containing complex verbs most difficult to recall, causatives next and simple verbs the easiest, due to decreasing interconnections among concepts. There was equal recall for all types of sentences. The complex sentences show, however, most efficacious access through the verb, while simple and causative items show easiest access through subjects and objects. According to Schank, causatives should resemble complex items more than simple items because causatives imply more than one proposition. The partial recall data hint at some special storage effects for causatives and complexes, although not as Schank proposes.

Two points need to be mentioned concerning the nature of the stimuli and their effect on sentence processing. First, one must consider whether the surprisingness of sentential relations induces

greater memorability of the sentences. This question was not addressed in these studies; one measure to insure equal surprisingness (or lack or it) across verb classes included using each subject-object pair in each class of verbs. As such, the noun pairs were constant. Only the relation of the verb could affect surprisingness, and the verbs as well as the nouns occur frequently enough to diminish any pronounced surprises.

The second point involves the uniqueness of the subject-object pair; if it is especially rare, subjects might find the sentence quite memorable. On the other hand, if the pair were especially common, the cueing of one might facilitate recall of the other.

Thus, any argument involving uniqueness must specify how facilitation of retrieval works. Both types of facilitation could occur. In any case, a resolution of the question of facilitation is suitable for further experimentation.

EXPERIMENT 5

The second cueing study reported here will go beyond the question of the disassembling of verbs in an attempt to assess how closely the verb actually interacts with other sentential constituents. It is clear from Exp. 3 that the verbs' functioning alone defies simple analysis. Depending on its semantic implications, the verb may be stored as a copular, connecting two seemingly unrelated propositions, or it may be stored more directly as a link between an agent and an object of an action.

Much work has suggested that one stores sentences in an underlying subject-verb-object format, some linguistically empirical (Chomsky, 1957, 1965, 1972), some psychologically empirical (Anderson and Bower, 1973; Anderson, 1976; Moore, 1972; Wannemacher, 1976). Most of the psychological work has in addition posited a closer relation between verb and object than between any other pair (cf. Anderson, 1976). This structuring has derived from what is now the traditional psycholinguistic model originally offered by Chomsky (1957). There has been only equivocal support for these notions. Anderson and Bower (1973) document considerable support for them although others have offered less than favorable data. For example, Moore (1972) showed his subjects sentence frames of the form Adj-Noun-Verb-Adj-Noun, with one item missing (e.g., subject noun). The subjects had to assess the grammaticality of the sentences when the missing item was provided; the dependent variable was time to respond. (The grammatical violations involved selection restrictions). He found that subjects initially attended to the subject-verb-object relations and then to subordinate (adjectival) relations. (Incidentally, subjects regarded

grammatical errors located in the subject, verb and object as more deviant than errors involving adjectives.) Moore claims little support for Chomsky's suggestion that if there is some sort of violation within a sentence, the later in the derivation that it occurs, the more grammatical that sentence will be seen to be. Further, when the verb is the element causing ungrammaticality, response times to spot the deviation are much longer than for missing subjects or objects.

Moore suggests that the subject-verb-object assessment is foremost although subjects may consider the subject-verb relation first, then the verb-object relation, and only then put the sentence together. If this analysis is correct, the verb contains more information than the subject and object about the potential relations into which the trio can enter.

Shafto (1973) has provided further evidence that a simple subject-verb-object analysis is too simplistic a picture. First of all, his subjects sorted sentences in a concept-identification task involving cases of nouns as postulated by Fillmore (1968). Subjects saw a series of sentences, with each sentence having one noun underlined; the subjects had to identify the role of the noun within the sentence by placing the stimulus item in piles labelled one to four. The four piles represented agent, experiencer, instrument and object, although the subject did not know this. The subjects were given feedback on the correctness of their guesses. Shafto found that agent and experiencer were reliably and easily learned, but there was little evidence for learning of instrument and object. He attributed this pattern of data to the psychological reality of agent and experiencer, but reserved judgment for instrument and object because "it seems likely that the

latter two cases encompass a variety of notionally distinct semantic relations, even though there may be syntactic criteria for combining them into just two deep cases" (1973, p. 561).

In a second experiment, he found that subjects incorrectly "recognized" sentences as having been seen before when their verb structures resembled one another (e.g., rob and steal) rather than when the same nouns are used in the same logical roles but with different verbs in a stimulus item and in the distractor. As did Moore, Shafto concluded that one stores information revolving around the verb, the core of the sentence. Shafto further suggests that verbs may be stored abstractly such that different lexical verbs may have similar or identical predicate structures. This latter point is obviously shared by Schank's CDT.

The present experiment in this series will examine the effect of the predicate structure of verbs as they interact with other sentential constituents. In the current experiment, subjects will learn a series of sentences whose verbs differ in two crucial ways. First, the verbs will either take the dominant (i.e., more frequent) denotation or a secondary meaning, as indicated by the ordering of definitions in Webster's New Collegiate Dictionary. For example, a subject might learn either (34) or (35), the first holding dominant denotation and the second the less dominant meaning. Second, the verbs will receive their specific meaning either from the grammatical subject's role in

(34) The child fixed the game

(35) The gambler fixed the game

(36) The student planted the flowers

(37) The student planted the bomb

the sentence or from that of the grammatical object. Sentences (34) and (35) show the subject-oriented sentences; (36) and (37), the object-oriented.

If a direct verb storage occurs with a subject-predicate dichotomy as suggested by HAM and ACT, then one would expect a close verb-object correspondence in memory. Likewise, if storage of lexical items occurs at a level more concrete than an abstract representation, as suggested by Hayes-Roth and Hayes-Roth (1977), the traditional subject-predicate breakdown would occur. On the otherhand, a subject might store a given sentence according to the meaning imparting dimension. That is, if the sentence is subject-oriented, there should be a close link in memory between subject and verb, while with an object-oriented sentence, there should arise a verb-object connection.

With a subject-verb link, an item should be processed with relative ease, especially if the subject utilizes a subject-verb, then verb-object process. This would occur since the appropriate sense of the verb would be obvious with the subject-verb analysis, and only the verb-object analysis would remain, with no surprises for the comprehender.

The final addition to this study includes assessment of dominant and nondominant verb denotations. One would suspect that this variable should have little effect on recall in general except that the nondominant sense of the verb should produce less recall than the dominant when the former verb is used as a cue since a subject's access to verbs in memory would probably tend toward the dominant sense. This serial access to verb meanings would not hold, however,

if one overrides individual verb meanings in favor of the entire meaning generated by the sentence, or if one regularly processes more than one sense of a given verb. In any case, no one theory holds a special predictive advantage here.

This study should shed some light on the likelihood that one stores information in a simple subject-predicate dichotomy. That is, if the subject and object show a close semantic relation, an object cue should produce poorer recall than the subject or verb would because it provides very little link with the gist of the sentence. On the other hand, a subject or verb cue should conjure up the idea of the sentence. The same type of argument would hold for cases in which the verb and object determine sentence meaning and the subject is less crucial to overall meaning. With a strong and stable subject-predicate relationship, the semantic links of subject and verb should not disrupt the dichotomy. If anything, a subject cue could debilitate recall because, although it imparts gist to the verb, it would not be as close in memory as the object would, thus possibly more likely to be interfered with in storage or recall.

METHOD

Subjects. Fifty-four students from introductory psychology classes at Brooklyn College served as subjects in this experiment. They received course credit for their participation.

Materials and Stimuli.² Each subject learned 18 critical sentences. Six of them were filler items used to control for primacy and recency effects. They were presented in a test booklet, one sentence to a page. There were two test sessions; subjects were tested on the same items on two recall sessions, two days apart. The crucial sentences differed from one another on two dimensions: first, whether the meaning of the verb was the dominant or nondominant sense (e.g., to fix a game, as by a child or by a gangster), and second, whether the meaning of the sentence was dependent on the subject or the object of the sentence. That is, in the child (gangster) fixed the game, the grammatical subject determines the meaning while in the foreman boarded the ship (window), the object is instrumental in interpretation.

Determination of dominance of meaning was made with Webster's New Collegiate Dictionary. For each verb, two meanings were selected; the first definition used for the stimuli was considered dominant in American usage. Pilot work had revealed the common meaning attributed to each sentence used in the study. At least 11 of 16 subjects interpreted each sentence in accord with either the dominant or nondominant sense of the verb; for most stimuli, there was agreement among 13 of 16 subjects as to a consistent meaning of the given sentences. In no case did any subject see a given verb with two different meanings. Such considerations are crucial here since the exact meaning of the verbs is one of the variables of interest.

Procedure. The procedure used here was the same as that used in Experiment 4. As with the first cueing study, there were three sets of sentences and three subjects who, having learned the same verbs in different sentence frames, were treated as one statistical subject. Thus, three real subjects learned the sentences and their data were pooled to generate better estimates of variability.

Data Analysis. Data for analysis were obtained using the same techniques described in the first cueing study. The data were subjected to a four-way analysis of variance. The variables were Time of Recall (Immediate or Delayed), Cue Type (Subject, Verb or Object), Verb Type (Dominant or Nondominant), and Semantic Orientation (Subject-Oriented or Object-Oriented), creating a $2 \times 3 \times 2 \times 2$ analysis with repeated measures on all factors.

RESULTS AND DISCUSSION

The pattern of results for this experiment is relatively straightforward. The only significant main effect was semantic orientation; object-oriented sentences showed better recall than subject-oriented sentences, $F(1,17) = 6.61$, $p .025$. The means appear in Table 13. There was one additional effect involving a four-way interaction of Delay x Verb Type x Cue Type x Semantic Orientation. For object-oriented sentences like (38) with dominant verb senses,

(38) The student planted the flowers

the grammatical object was the most effective cue for recall (0.69), followed by the verb (0.67), and the subject a distant third (0.59). When the verb sense was nondominant, the subject cue was quite effective in immediate recall, relative to the verb, while with delayed recall, the verb showed supremacy. The object cue was still relatively effective although not nearly as much as when the verb took the dominant sense. With respect to the subject-oriented verbs, the subject was generally the most efficacious cue (0.67 for the subject, 0.50 for the verb and 0.57 for the object), although in delayed testing with the dominant meaning of the verb, the object cue manifested a distinct advantage over the subject cue (0.52 versus 0.61), $F(2,34) = 8.37$, $p .005$.

Only one suggestion comes to mind here as an explanation. On initial testing, the subject-verb link was still very strong and the subject had to ponder somewhat to retrieve the object. With delayed testing, the object benefitted from a greater degree of processing while, as the delay between testing sessions increased, the subject-verb link weakened and was forgotten since the subject spent so little time encoding it. Such forgetting would not have occurred with the

Table 13. Mean proportion recall for the second cueing study, involving verb orientation and dominance of verb senses. Marginals are shown in parentheses. (N = 18 subjects)

		Dominant Sense				Nondominant Sense			
		<u>Cue Type</u>				<u>Cue Type</u>			
		Subject	Verb	Object		Subject	Verb	Object	
Day 1	Subject Oriented	0.63	0.52	0.57	(0.57)	0.63	0.50	0.52	(0.55)
	Object Oriented	0.57 (0.60)	0.65 (0.59)	0.74 (0.66)	(0.65)	0.67 (0.65)	0.63 (0.56)	0.65 (0.59)	(0.65)
Day 2	Subject Oriented	0.52	0.54	0.61	(0.56)	0.72	0.44	0.56	(0.57)
	Object Oriented	0.56 (0.54)	0.67 (0.61)	0.78 (0.70)	(0.67)	0.59 (0.66)	0.72 (0.58)	0.59 (0.58)	(0.63)

secondary sense if the subject needed to consider the subject-verb link more carefully in order to assess the correct denotation of the verb. (Obviously, this implies an ordered search of verb meanings.) This depth of processing suggestion receives further support from the already mentioned data that show that a subject cue advantage occurs for subject-oriented items and an object cue has advantage for object-oriented sentences because in both cases, the meaning imparting element presumably important in encoding, is the best cue for recall.

Finally, the verb cues show a great advantage for object-oriented items over subject-oriented (0.68 versus 0.50). If one assumes that the effects of initial processing are reflected in recall, one can find support for a hypothesis that during encoding one scans the subject-verb-object connections looking for relations (Wannemacher, 1976) and considering only one possible relationship as the sentence is analyzed (Schank, 1972), and if the true meaning of the verb becomes apparent only after the object is considered, reassessing the subject-verb-object links a second time until comprehension is achieved.

In summary, this experiment has shown that sentences with the same surface subject-verb-object type of structure may be psychologically different. Different sentential elements provide varying amounts of effectiveness as retrieval cues. In general, the more the experimental subject must process the sentence, the more memorable the sentence becomes. The amount of processing is determined by which element imparts a specific meaning to a sentence, and greatest memorability occurs if the focal element is the final sentential element.

This experiment seems strikingly different from the previous

cueing study in that there was little, if any, forgetting between recall sessions in the second cueing study. Two explanations come to mind. First, there were fewer sentences to be recalled in this study, and this may have caused less confusion among sentences to be recalled and better memory for them in general. Second, due to the close subject-verb and verb-object links, a sentence was possibly quite memorable for subjects, and they may have gained access to both closely related elements if one was found, having at most one other element to be searched.

The results of this study can be seen as supporting or refuting neither Anderson and Bower's HAM, Anderson's ACT or Schank's CDT because none of them specifies the processing mechanisms for relative salience of constituents within a given sentence. There is limited support for Kintsch's theory which suggests that the most memorable items are the most meaning imparting. However, his work has not dealt extensively with single-proposition items, but rather with text. One final point to be made is that case notions, as an alternative to canonical deep or surface structure models of memory, do not account for differential recall of sentences here because almost all of the propositions were of the form verb-agentive-object in Fillmore's (1968) sense. The crucial variable that remains as a predictor of recall, if the above theories are seen to exhaust the currently popular models and mechanisms (which is questionable), is the status of the verb within the proposition. Finally, the subject-predicate dichotomy of the associative theories seems to have psychological reality, as evidenced in the results of this experiment.

One must also consider the nature of the relationships among

sentential elements in general however. That is, in object-oriented sentences, the verb and object are often closely associated. Thus, they should be recalled together as a rule, and this pattern does occur. However, evidence for the subject-predicate dichotomy still exists given the lack of facilitation for the subject cue in subject-oriented sentences relative to the verb cue in those sentences. Further experimentation could explore this consideration.

GENERAL DISCUSSION

The data from the five present experiments have supported no single theory exclusively, but do rule out several mechanisms of search and storage posited by the different models. As a general statement, the configural models outlined so far tend to explain the recall data better than the processes outlined in HAM and ACT, although ACT fares reasonably well for some of the verification time data.

In all experiments it is obvious that when information was added to a learning set, either externally imposed (i.e., locatives) or internally generated through the subjects' renderings of the detail of verb structures, subjects never experienced detrimental effects and, in fact, there sometimes appeared an advantage to their search and storage processes, as evidenced in fewer errors in the verification time task and comparable or greater recall of specific relative to general information. There are several reasons why these results obtained.

The first question to be addressed in this regard involves the matter of verb importance in the memorial process. The next questions concern the form of storage of information and the nature of the retrieval processes involved in the search for stored input. Beyond that one must consider the factors which determine what a subject will store and how he gains access to such information. These factors include an assessment of the focal points of input, the implications underlying the foci and the inferences extending therefrom.

It is not surprising that the verb should be seen as the core around which sentence meaning derives. As a general statement, nouns exert less constraint on the sentential elements that may appear with them than verbs do. The verbs, on the other hand, influence sentence

meanings greatly, contain implications, and expose inferences. As Miller (1972) has noted

nouns and verbs carry the major burden of communication in our language, so the choice (of study) had to be made between them. Of these two, verbs are by all odds the most challenging. A considerable amount of work has already been done with nouns... and various principles of nominal classification are already known. Verbs, on the other hand, seem to be the real motor behind the critically important process of predication, and several theoretical discussions of the syntactic role of the verb have generated hypotheses worthy of the more extensive exploration. Therefore, we chose verbs because the rewards, as well as the risks, seemed higher (p. 338).

Empirical support for Miller's contention arises from several sources. Klemp (1974) and Abelson and Kanouse (1966) examined different types of verbs (e.g., manifest action and subjective state) and discovered that the structure of verbs plays a crucial role in subjects' perceptions of meaning. Specifically, manifest verbs (e.g., produce) allow for greater acceptance of generic assertions than subjective state verbs (e.g., avoid) when decisions are based on information like that in sentences (39)-(42) and the subject is

(39) Altogether there are three kinds of
magazines, weeklies, monthlies and
quarterlies

(40) Sailors buy weeklies

(41) Sailors do not buy monthlies

(42) Sailors buy quarterlies

(43) Do sailors buy magazines?

quizzed on (43). The nouns accompanying the verbs showed no influence in acceptance or rejection of the questions. Klemp (1974) notes that "the subjective use of verbal evidence depends to some extent on operations carried out at the lexical level. Inherent characteristics

of verbs have a sizeable effect on whether or not an assertion is accepted at its face value" (p. 363).

Heider (1958) also provides indirect testimony to the effect of verbs in his "naive analysis of action." In a structure that anticipates Schank's (1972) by 14 years, Heider specifies ten concepts underlying the perception of action. (He deals with interpersonal interactions, not with psycholinguistics or semantics per se, so his approach takes a different tack than Schank's. In any case, his underlying concepts, akin to Schank's ACTs, are subjective environment, perceiving, affect, causation, can (and may), trying, sentiments, wanting, belonging, and ought.) Presumably, Heider's analysis applies not only to observation of action, but also to the displacement of these actions, i.e., writing.

When an act is performed, the locus of causation is seen to differ depending on circumstances. In A verbs B, A is seen as responsible only if A voluntarily verbs B. If there is coercion, some unspecified (here) C is considered responsible. Using these notions, in the present terminology, if a given action is specified by a complex verb, then the overt stimulus, the sentence, can be seen as implying more than one idea or proposition. Thus, if a subject learns that (44) is true, that subject could consider easily the teacher to have ordered

(44) The janitor obeyed the teacher

or requested that the janitor perform some action for which the latter has no responsibility. Such a complex train of thought matches Heider's early notions and Schank's later ideas. Heider gives a small amount of empirical data that subjects actually do construct perceptions and inferences not actually present in an objective analysis

of a situation. "As is usual with attribution, in the attribution of an induced action, the whole causal structure is taken into account and not merely the proximal conditions" (1958, p. 247).

Obviously, though, verbs do not give meaning to sentences by themselves. In fact, HAM and ACT seem to play down any special qualities of verbs, or at least no focus is placed on them. The mechanisms and structures suggested in the associative models, however, are of questionable generality. The first study reported here indicated that the present methodology can generate results in accord with a strict associative model. The current procedure matched the type generally employed by the associative theorists. All stimuli are presented more or less independently of the others. To be sure, some sentences were related by common actors, but no coherent structure emerged from the sentence set. When the items are given together with the actors associated with consistent locations, something new and non-associative appears. Subjects seem to organize the input with great memorial emphasis on the locations. Search does not resemble the parallel processing from all nodes simultaneously, but in a serial fashion from a single node, as HAM outlines. Two likely alternatives emerge. First, the subject might search for a subject-location link in order to match information that has been consistently clustered. If a match occurs, the subject would proceed to a predicate search to match the subject and location. A second alternative would involve a close relationship of location to the the subject-predicate link as a whole, which could be represented

by L(S-V-O). The latter suggestion seems more likely. In Experiment 2, the verification times were shorter and error rates lower for negative probes whose grammatical subjects were associated with two rather than one location. A more tightly knit context seems to have obtained with the two location references, such that violations of the action-location context were spotted so quickly. The first alternative loses further appeal given that HAM would expect lengthening of verification times as greater numbers of locations must be searched. ACT predicts this effect, but it occurs only with negative items.

Another datum suggesting that contextual information engenders coherent rather than independent sentence processing is that when subjects learn sentences with appended locations, if the locations are absent at testing, subjects have difficulty verifying test sentences. However, they benefit from prior practice with items with locations. Moreover, location items derive no benefit from prior practice with no location items. The reason underlying this latter effect may be that performance asymptotes quickly for location items or that subjects do not make use of context in their prior verification of no location items, thus the subsequent location items show no VT decrement.

When one considers the effect of reference usage (Experiment 1) and the data on number of locations per form of reference, and the effects of practice items (Experiment 2), one sees that two types of search strategies are possible. The first involves a HAM-like subject-then-verb-then-object search (with permutations or order) with little context effect. The second requires a search which involves an assessment of the (subject-predicate)location match, with much emphasis placed on the location.

These comments on search strategy imply some specific underlying storage mechanisms. On the basis of the above arguments, a parsimonious model of storage would posit that one retains a coherent semantic construction based on a sentence from which one can retrieve a general meaning of the sentence or individual elements, such as subject, verb or object, in a verification task. Search in a model having HAM's and ACT's nonemergent properties could not handle the effects generated by addition of the locative.

In some sense, then, subjects seem to "add information" to form an idea that contains more than just the subject-verb-object relations.

Smith, Adams and Schorr (1978) have in fact documented such integration of information in several studies. They gave their subjects groups of sentences that were either semantically coordinated or unrelated. With the coordinated information, subjects were quicker to spot new sentences (distractors) as such. Smith et al. suggest that subjects may construct contexts for sentence sets and can reject implausible intruders easily. This fits well with the present suggestion that with the locative, subjects develop contexts for memory and are able to process test items more efficiently when those probes included the same context as the learning items did.

In the second of the present verification time studies, subjects made effective use of action-location consistencies, almost as if they clustered all actions in a given location with the same actor and spotted any intruders quickly. Compelling evidence for a coherent storage mechanisms with different types of search is that no-location items (without practice) seem to function quite differently than location items. When subjects are tested on items with locations, the de-

scription provides easier access to memory than the name. This holds true for inferences as well. On the other hand, with no-location items, the pattern reverses itself--names show little effect with inferences and descriptions require longer times for verification. In both cases the subject has the same memory store and structure, but search takes on a different aspect depending on the form of test items. Suppose that a subject must verify sentence (44).

(44) Dave Grant kicked the dog

(45) The banker kicked the dog

Dave Grant has few associations attached to it and may, in the absence of context, provide easy access to memory. Since the banker in (45) could possibly link with many other concepts, when little context exists, the subject may need more time to identify this particular person. With context (i.e., location), the more familiar form of reference in a certain context shows an advantage in terms of access to memory, while the novel reference seems not to derive any advantage in being associated with a context.

When one considers the arguments concerning storage mode in conjunction with those on search strategies, it is obvious that a HAM-like model of storage or the specific storage suggestions Anderson and Hastie assume simply do not suffice to capture the complexity of memory. What Anderson and Hastie take to be differential storage of names and descriptions here seems to be differential search mechanisms.

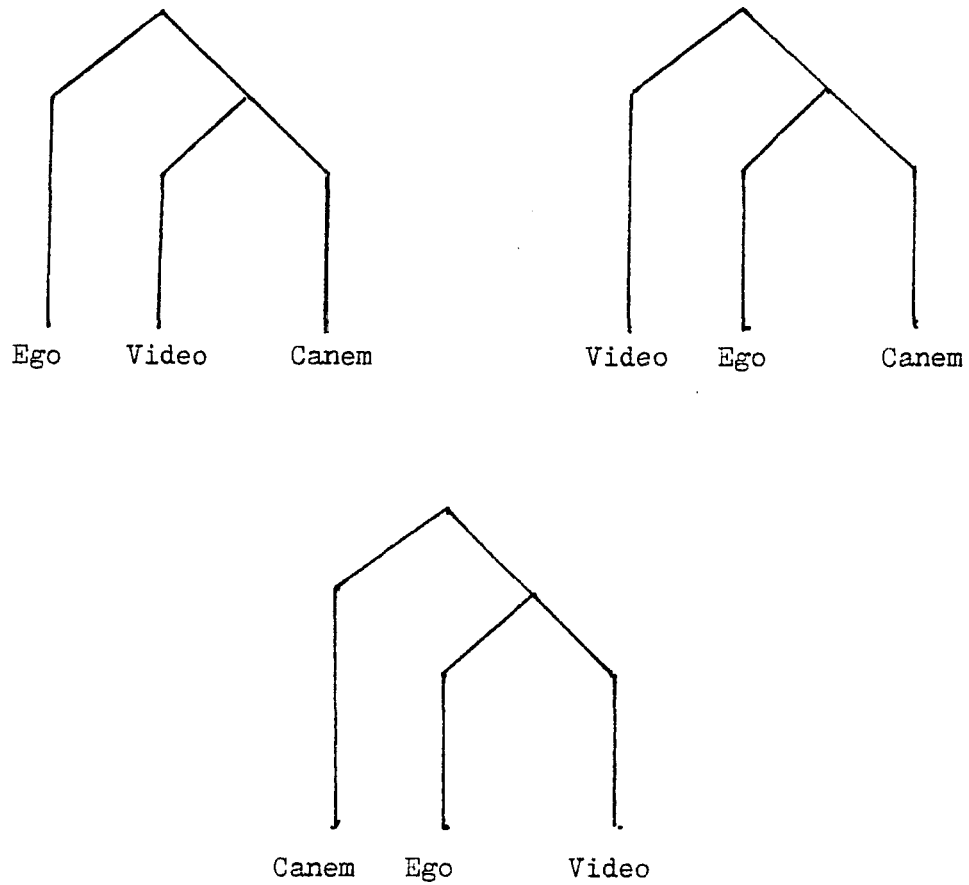
In fact, looking at the nature of the stimuli in Experiments 4 and 5, one might suggest that encoding strategies might complicate the picture. That is, with a sentence holding many implications, a subject might learn a sentence by encoding the gist, establishing a context in which

to embed it, then encode the context as well. Both Thorndyke (1976) and Smith et al. (1978) have suggested this type of processing. It seems likely that in recall, one could access the most expedient mode of retrieval.

Does this mean that Schank's suggestions also receive support, with verbs being "unpacked" into their primitives?³ Obviously, any such breakdown would ultimately enhance the integration of ideas related in discourse, much as Heider (1958) speculated that individuals put together separate components of interpersonal interaction into a coherent schema. Unfortunately for Schank's CDT, the data do not indicate that verbs of great underlying complexity are remembered less well than those of simpler structure.

One final point to be made in the search-storage area involves the results of Experiment 5. Subjects were able to make effective use of subject cues with sentences whose subjects determined verb meaning: they used objects effectively in object-oriented sentences. These results suggest that the search mechanisms focus on salient elements, wherever they lie in the sentences. It is possible that this search mechanisms belies an object-dominant storage structure. Any theory could handle a search alteration with relative ease. However, no model has posited mechanisms for storage other than logical-subject, verb, logical-object. Fortunately, history has provided us with some consideration of the matter. In Die Sprache, Wundt (cited in Blumenthan, 1970) suggested that the focus of a sentence need not be any predetermined element, and that whatever the focus is, it can be stored as a very salient point, as shown in Figure 5. In that figure, the free word order of Latin allows sentence structuring to take any cognitive

Figure 5. A schematic representation of Wundt's ideas of representing a single sentence differently depending on the emphasis intended by the speaker. Sentence: Ego video canem.



order. In fact, one can presume that Wundt's comments on word order also apply to cognitive salience since he specifies that inner linguistic structure resembles the surface features of language.

Where there is free word ordering the principle of positioning is simply a special application of the general psychological principle of the successive apperception of aspects of a whole according to their proportionate effect on cognition (original italics, cited in Blumenthal, 1970, p. 29).

As Wundt's comments relate to the structure of sentences in Experiment 5, the meaning imparting element might link closely with the verb. Although he addressed a different point than the one at hand, the underlying principles apply. And although Wundt's figures strongly resemble modern associative psycholinguistic structures, there is no need to limit his ideas to the purely associative realm.

In summary, the data reported here suggest that one stores input in a coherent or unitized fashion rather than item by item as a simple neo-associationist account would have it. Contextually based input engenders on the part of the subject a "deeper" type of processing that includes not only simple grammatical relations but also the more complex functional relations that one takes for granted in life. When the restrictions placed by context on an action or predication are violated, the discrepancy is quickly noted. Storage of the simple grammatical relations would not allow one the benefits of these contextual constraints, only a step-by-step plodding through a maze of labelled but functionally independent relations and nodes.

At this point, what remains is to explain why certain sentences and sentential elements attained the salience they did. This will

involve invocation of initial encoding instead of search and storage features.

As mentioned before, certain sentences were more salient than others, leading to greater recall or faster verification times for them. In two studies, Experiments 4 and 5, no group of sentences showed systematically more recall than any others. However, the cues which produced best recall differed markedly from one sentence group to another. Obviously, one question here is whether one can differentiate among storage and retrieval mechanisms. The foregoing analysis of verb breakdowns implies the realm of storage structures although the name-description differences, initially suggesting storage processes, here appear to involve search strategies instead. In the case of differential access to sentences in memory, it would seem that storage rather than simply search mechanisms account for the differences across groups. In fact, if semantic primitives or implications are derived from verbs, the differences obtained would be a virtual necessity following from the verb structures.

Another condition, one in which the search mechanisms could well belie the storage structure, concerns the verbs of varying complexity in Experiment 4. Here, subjects show dramatically different patterns of recall, depending on cue type. The complex verbs represent the connector of different and superficially unrelated propositions. That is, A obeyed B means that A issued a request and B performed some action. These two items are not related except for the concept of obeying that links them. As a result, finding a request in memory does not guarantee knowing how that request interacts with other propositions. However, if the verb is cued or is recalled when

some other cue is also remembered, then the likelihood of the entire sentence being recalled should be greater, and it is.

With simple sentences, verbs contribute little information and accordingly serve as poor cues. To be sure they help impose a meaning structure on a sentence, but they do not connect ideas coherent in their own right, but only single concepts linked in some simple fashion. This is why the object cue generated more subject recall, while the verb was either recalled as part of an entire sentence or not at all.

Causative sentences tend to confuse the question of the verb role. One might expect the verb to play a large role in memory access here since one action is performed and some emotional or physical state is entered into consequently--two propositions. The verb was as ineffective as for the simple sentences, however. It seems to be stored quite abstractly, serving as a poor cue for recall and seldom being recalled except as part of an entire sentence. With partial recall, the pair that showed tight links was the subject and object. This might indicate the lack of a psychological mechanisms for causatives, or the psychological simplicity of causative verb structures.

This pattern of results does severe damage to the plausibility of Schank's CDT. First of all, recall should have suffered as the complexity of the verbs increased. It did not. Secondly, the causative verbs should have shown more breakdown than simple verbs, and a concomitant increase in storage complexity, which they did not. The special structure of the causatives was given little support here. If these mechanisms do not appear psychologically real, then Schank's theory reduces to a model resembling HAM. In fact, probably the

single most important difference between the two was the status of the verb.

What now remains is to figure out what theory might handle these data best. HAM has been shown by Kintsch (1974) to differ in its structure of some stimuli from Kintsch's own model, specifically with respect to multiargument sentences. While the stimuli used in the present studies do not fall into that category, some can be conveniently broken down into multiproposition stimuli by making use of implications. If complex sentences are treated as multipropositional items, then the verb, as a copular, should effectively serve as a recall cue. HAM and ACT would not provide for this treatment, and would expect no differential efficacy of cues across sentence groups. Kintsch's theory, with no semantic primitives, but with a verb-based implicational theory, handles these data best.

With regard to the notion of psychological salience of a sentence, no theory at present has posited mechanisms for this purpose. The data in Experiment 5, for instance, do not consistently differ across groups in terms of number of arguments or propositions, complexity of verbs or case structure of sentences. Yet striking differences in recall emerge. There is no explicit storage mechanisms in any theory to handle this to date, although they are consistent with the notion of depth of processing. Moore (1972) has suggested that one processes a subject-verb-object sentence in two parts, subject-verb and verb-object. In the present work (Experiment 5), such processing would not always be successful in generating the meaning of a sentence the first time through the sentence. Success would occur with a subject-oriented sentence with a dominant verb meaning. The subject would assess

the subject-verb link, hypothesize as to the meaning, and then go to the verb-object unit for completion. Since the grammatical subject dictates meaning in this case, and since the verb has a dominant denotation, comprehension goes smoothly. If the verb meaning is less dominant, or if one must process the object before the sentence meaning is apparent, one would need to reassess the subject-verb and possibly verb-object meanings, and the subsequent subject-verb-object triplet for total comprehension of the sentence. In the latter cases, one should show better sentence memory since there has been deeper processing of the relations among sentential elements, in addition to the simple processing of the content words. Further, the efficacy of the verb as a cue for object-oriented sentences over subject-oriented indicates that subjects may have had to reassess the verb's underlying structure, giving it greater depth of processing, thus a higher level of salience. Finally, the element which determines the verb meaning should act as a very good cue for recall since it has an especially strong psychological link with the verb. In fact, this happens although only for dominant verb senses.

The picture one sees based on these data is the comprehension of sentences that, not surprisingly, involves two special realms of encoding and processing. Initially, one utilizes the simple subject-verb-object structure of input and attempts to assess the meaning of that sentence. Once one has left the rote learning mode, the processing does not stop at surface features. Rather, one plunges to the level of implication and inference.

After all, meaning consists of more than a compilation of simple items. One can, at will, draw inferences at encoding as well as

retrieval, understand subtle shades of meaning and tend not to remember where the physical input ended and our added "perceptions" begin. This structuring enables one to show considerable flexibility of processing and the ability to retain enormous amounts of related information with very little effort.

When one remembers the meaning, the exact wording often lies by the wayside, just as simple subject-verb-object links do. What remains is a detailed cognitive map of the environment, with more stored there than could ever be placed in a single sentence. That is why with lax scoring in the cued recall studies, several effects appear that would not show up with strict scoring. In the VT studies, subjects showed considerable advantage for items with locations--their memories were more accurate and their responses faster when more context was embedded. When a subject is given the opportunity to integrate knowledge, the subject simplifies his task by adding information and inferences, even if the total memory network is more complex, and the integrity of the original input merged with the subject's own cognitions.

The present data suggest this pattern of learning, and much recent data hints that the storage of verbs and relations in sentences is abstract. That is, nouns can exist more or less independent of verbs, but the latter need embedding relationships. Predications do not exist as strings of elements, but concrete concepts linked by defining relations. These relations hold meaning together even though they show little evidence of existence on their own, other than through their immediate physical existence at input.

However, it would be simplistic to suggest that one stores

contextually based information with subject and object standing side by side with only a linking relationship. Rather, the subject will weave a complex mental representation such that a violation of contextual constraints will make its presence known immediately.

How do the theories fare?

In general, Schank's CDT has not fared well in the experiments reported here. The major verb structures outlined here have not been captured in the data. Those features of CDT that resemble HAM have also not been borne out in Experiments 1 and 2. Thus, the intuitive appeal of Schank's theory with its semantic primitives does not seem to reflect the type of processing one carries out, at least not in these studies.

Experiment was designed to assess some of Schank's mechanisms, based on earlier work by Thorndyke (1975) which showed that imagery was responsible for differential recall of different structures. The present work, by controlling for the imagery factor, has shown, like Thorndyke's, that Schank's postulates suffer from a lack of psychological reality. Using a longer study period than Thorndyke's, this experiment does generate noticeable effects of verb type, even when they do not accord with Schank's notions.

The role of implications, though, plays a large part in one's retrieval of information. Access to the memory structure is most efficient when the element most salient to a given sentence is probed. In this case, the salience is determined by pragmatic factors and concepts which are seen to underlie a given sentence.

As mentioned before, Schank's CDT begins to look more and more like ACT as Schank's mechanisms fall to disuse. But how successful

has ACT been in characterizing the data? Unfortunately, its utility has run hot and cold. In some situations, context-free clusters of sentences have taken on the appearance of being stored as ACT specifies. But the generality seems limited since the addition of the locative produces recall that seems at variance with ACT in many cases. The fact that both configural or implicational patterns and associative mechanisms emerge suggests that the effects that were obtained depended on the type of search used. To attain this effect of the locatives, ACT would need to be amended considerably. However, a configural model would allow both types of search since it allows construction of implications as well as retrieval of simple elements. One might opt for dual storage of the sentences, as did Garrod and Trabasso (1973), although the effects of practice on no-location sentences suggests that after practice with informative locative items the subject simply modifies search from a given storehouse of information rather than looking elsewhere. This same strategy change manifests itself with the proper name primacy with no location items and the description primacy with location items.

In some senses, these discrepancies can be handled by strategy-free components in that one can use various encoding techniques and devices to restructure input, which ultimately winds up in simple labelled relational network of ACT. However, a configural model would predict the effects found while HAM would only lend uncertainty to the pre-storage processing.

Finally, Kintsch's (1974) theory remains. Although it is verb-based and implicational, it does not utilize semantic primitives or features. Important, however, it emphasizes the pragmatics of

meaning. Thus, although the verb to cook embodies specific meanings, to saute, to fry, to bake, etc. the initial verb is not broken into semantic primitives. It only gains refinement by virtue of the company and context it keeps.

The results of Experiments 1, 2 and 5 do not necessarily support Kintsch, nor do they refute him. With respect to the verification time studies, Kintsch might claim that the repeated location would create a consistency across predications already linked by a common actor. As such, one might expect the strongest advantage with four predications (i.e., one location) for a given form of reference, rather than it lying with two predications with each location for a given form of reference (as it did). However, since a given character in the study had two forms of reference, it can be said that subjects made use of the fact that with two locations for a given form of reference, there was no need to assess a new locative when the alternate form of reference was invoked. Thus if Dave Grant were associated with only one form of reference and the banker a different one, although (46) would be easy to verify,

(46) Dave Grant kicked the dog in the park

(47) The banker kicked the dog in the park

(47) would be difficult due both to its inferential nature and to the new location involved with the banker. This being the case, subjects may have in fact made good use of redundant location information. Thus, the findings obtained neither directly support nor refute Kintsch. For Experiment 5, the way in which one processes the focus of a sentence will influence recall, regardless of its assigned case. Kintsch says nothing about this type of cue effect, so the

phenomenon has little bearing on a test of a theory. Rather, it addresses the more general idea of where sentential elements go as they are encoded and after they are processed.

How is a sentence represented?

So far no single theory has captured the essence of the memory structure. On the atomistic level, HAM can handle simple sets of input, with its subject-predicate distinction. Beyond that, it is not clear how effective HAM is since a tenable theory should handle encoding mechanisms as well as storage.

Kintsch and Schank have both been proffered as configural theorists with alternatives to HAM and ACT. The semantic primitives of Schank, though, do not appear viable. Only Kintsch's representation remains. Pragmatically speaking, how are sentences viewed according to Kintsch's model? The underlying structure of sentences need not resemble the surface structure. The crucial point is to isolate the implications that a subject realizes and see how they are stored. As Thorndyke (1976) pointed out, subjects fill in the gaps in discourse and often forget their own contributions, storing input and mental constructions together. This probably occurs even in sentences. That is, if a given item is read and considered for a reasonably long period, one has the opportunity to construct some meaningful presuppositions about the item. In the present work, the subject could either try to impose a context onto four apparently unrelated items (Experiments 1 and 2) or assess any complex relationships implied in a sentence (Experiments 4 and 5). The ultimate representation probably contains the rules for generating (approximately) the input, but as input gets more complex, the interweaving of

ideas dominates. When the verbs were examined, they seemed to have undergone considerable change. Their storage forms seem quite general, and they attain specific meaning only through interactions with sentential elements rather than on their own.

In summary, subjects seem to store sentences not as simple units in a subject-verb-object sentence frame, but they construct ideas within which the input sentences comfortably fit. The more detailed or specified the items are, the easier the input will fit into accompanying ideas. While the subject does not break the constituents down into primitives, they nonetheless appear to be the core around which sentence meaning is molded. As such, they do not maintain the stable existence of nouns. Instead they tend to funnel meaning into one direction or another, as befits the occasion. The product of these cognitions may not resemble the original input very much, but it will nonetheless contain the basic sentiment, pragmatically connected to the perceptual space of the comprehender.

FOOTNOTES

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2. The stimuli for all experiments and the F-values and mean square values for all experiments are presented in Appendices A-P.

3. Schank (1975) has listed eleven basic ACTs: 1) ATRANS, transfer of an abstract relationship such as possessives; 2) PTRANS, transfer of the physical location of an object; 3) PROPEL, the application of physical force to an object; 4) GRASP, the grasping of an object by an actor; 5) MOVE, movement of a body part of an animal by that animal; 6) INGEST, the taking in of an object by an animal; 7) EXPEL, the expulsion of an object from the body of an animal; 8) MTRANS, the transfer of mental information; 9) MBUILD, construction of new information from old, as with deduction; 10) SPEAK; 11) ATTEND, the action of attending or focusing a sense organ toward a stimulus.

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Appendix A. Stimuli for the first verification time study.

<u>Actors</u>	<u>Predicates</u>
The banker	killed a bug
Dave Grant	told a joke
	ran a race
The dentist	bought the paper
Art Stein	drove the car
	broke the vase
The teacher	heard the thunder
Herb Clark	mailed the letter
	kept his promise
The lawyer	cut his hand
Mike Collins	kicked the dog
	opened the door
	lost his temper
	kissed his wife
	found the key
	played the piano
	won the game
	ate the apple
	wrote a book
	hung the picture
	drank his coffee
	spread the rumor
	dropped his watch
	cleaned his glasses

Appendix B. ANOVA summary table for verification times for positive probes for Experiment I.

<u>Source of Variation</u>	<u>F^a</u>	<u>Mean Square Error</u>
Time of Learning (T)	2.49	0.989
Form of Reference (R)	3.04	1.479
Inference (I)	18.34	0.479
T x R	0.95	0.639
T x I	0.04	0.634
R x I	2.83	2.091
T x R x I	2.73	1.359

^adf = 1,19

Appendix C. ANOVA summary table for errors for positive probes for Experiment I.

<u>Source of variation</u>	<u>F^a</u>	<u>Mean Square Error</u>
Time of Learning (T)	1.67	0.242
Form of Reference (R)	19.27	0.157
Inference (I)	5.94	0.421
T x R	0.74	0.341
T x I	0.01	0.253
R x I	0.08	0.314
T x R x I	3.21	0.383

^adf = 1,19

Appendix D. ANOVA summary table for pattern of errors for items with 3 versus 6 noninference items.

<u>Source of Variation</u>	<u>F^a</u>	<u>Mean Square Error</u>
Number of Noninferences (N)	3.35	0.8388
Inference Status (I)	6.45	0.8546
N x I	3.77	0.5598

^a all df = 1,19

Appendix E. ANOVA summary table for verification times for items with 3 versus 6 noninference items

<u>Source of Variation</u>	<u>F^a</u>	<u>Mean Square Error</u>
Number of Noninferences (N)	1.81	0.8165
Inference Status (I)	23.96	0.1410
N x I	0.64	0.7200

^a all df = 1,19

Appendix F. ANOVA summary table for comparison of verification times for positive and negative probes for Experiment 1.

<u>Source of Variation</u>	<u>F^a</u>	<u>Mean Square Error</u>
Truth Value (F)	0.39	0.9613
Form of Reference (R)	4.87	0.9544
Time of Learning (T)	4.16	0.7679
Correct or Error (E)	11.75	2.5465
F x R	1.44	0.8467
F x T	1.38	0.2676
R x T	0.81	0.4682
F x E	0.36	2.0315
R x E	1.79	1.4963
T x E	0.32	1.2337
F x R x T	5.24	0.3673
F x R x E	3.18	0.4834
F x T x E	0.04	0.5143
R x T x E	1.57	0.7154
F x R x T x E	0.02	0.5861

^a all df = 1,19

Appendix G. Stimuli for second verification time study.

<u>Actors</u>	<u>Predicates</u>	<u>Locations</u>
Dave Grant	tore the paper	the park
The banker	broke his shoelace	the office
	caught a cold	the car
Bob Shade	blew a bubble	the house
The lawyer	killed a bug	
	cut his hand	
Herb Clark	stole a wallet	
The teacher	hung a picture	
	teased a child	
Art Stein	found his key	
The dentist	earned the money	
	hummed a tune	
	cleaned his glasses	
	lost his temper	
	wrapped a gift	
	cracked a nut	
	wrote a letter	
	told a joke	
	licked the envelope	
	wiped his nose	
	ate his lunch	
	dropped his ring	
	kissed his wife	
	wound his watch	
	heard the game	
	spilled the coffee	
	planned the party	
	drank the milk	
	read a book	
	lit a cigar	
	combed his hair	
	watered the plants	

Appendix ANOVA summary table for verification times for positive probes in Experiment 2.

Source of Variation	F ^a	Mean Square Error
Presence of Location (L)	4.56	0.8034
Number of locations per reference (N)	0.21	11.0599
Order of test (O)	0.99	11.0599
Time of Learning (T)	0.06	0.5136
Form of Reference (R)	3.57	1.2961
Inference (I)	20.37	1.1366
L x N	2.02	0.8034
L x O	15.45	0.8034
N x O	0.11	11.0599
L x T	0.30	0.7143
N x T	3.05	0.5136
O x T	0.35	0.5136
L x R	0.07	0.7586
N x R	0.05	1.2961
O x R	1.26	1.2861
T x R	0.05	0.6774
L x I	0.66	1.0509
N x I	0.36	1.1366
O x I	0.01	1.1366
T x I	0.90	0.4199
R x I	1.76	0.8650
L x N x O	0.76	0.8034
L x N x T	0.67	0.7143
L x O x T	0.15	0.7143
N x O x T	0.08	0.5136
L x N x R	0.81	0.6163
L x O x R	2.67	0.7586
N x O x R	0.03	1.2961
L x T x R	1.02	0.5292
N x T x R	0.27	0.6774
O x T x R	0.51	0.6774
L x N x I	0.02	1.0509
L x O x I	11.14	1.0509
N x O x I	0.05	1.1366
L x T x I	0.12	0.5282
N x T x I	0.01	0.4199
O x T x I	0.10	0.4199
L x R x I	2.35	1.7899
N x R x I	1.72	0.8650
O x R x I	0.04	0.8650
T x R x I	0.1313	0.7215

^a all df = 1,28

Appendix K. ANOVA Summary Table for negative probes (errors) for Experiment 2.

<u>Source of Variation</u>	<u>F^a</u>	<u>Mean Square Error</u>
Number of locations per reference (N)	3.10	0.2467
Order of testing (O)	0.25	0.2467
Form of Reference (R)	6.95	0.1440
Location Match-Mismatch (L)	13.07	0.2020
Inference (I)	1.83	0.3069
N x O	3.10	0.2467
N x R	18.34	0.1440
O x R	0.43	0.1440
N x L	7.73	0.2020
O x L	1.93	0.2020
R x L	3.79	0.2020
N x I	4.12	0.3069
O x I	0.20	0.3069
N x I	1.89	0.2980
L x I	0.56	0.2533
N x O x R	0.11	0.1440
N x O x L	0.00	0.2020
N x L x R	7.74	0.2020
O x R x L	0.08	0.2020
N x O x I	2.49	0.3069
N x R x I	0.47	0.2980
O x R x I	0.21	0.2980
N x L x I	0.99	0.2533
O x L x I	5.00	0.2533
R x L x I	2.20	0.1774
N x O x R x L	1.24	0.2020
N x O x R x I	0.47	0.2980
N x O x L x I	0.00	0.2533
N x R x L x I	1.41	0.1774
O x R x L x I	10.66	0.1774
N x O x R x L x I	1.41	0.1774

^a all df = 1,28

Appendix L. ANOVA summary table for third verification time study involving judgments of meaningfulness.

<u>Source of Variation</u>	<u>F^a</u>	<u>Mean Square Error</u>
Order of Testing (O)	0.04	1.4880
Sentence Length (L)	26.87	0.1508
Form of Reference (R)	5.38	0.4329
O x L	10.37	0.1508
O x R	0.10	0.4239
L x R	0.16	0.2498
O x L x R	2.31	0.2498

^aall df = 1,14

Appendix M.

Subjects, predicates and objects used in Experiment 4. In this experiment, each subject was always paired with a single object. However, within each subgroup, a different verb was used.

SUBJECT-OBJECT PAIRS

janitor-teacher
 salesman-clown
 foreman-student
 reporter-artist
 carpenter-wife
 thief-child
 captain-troops
 actor-nurse
 jury-prostitute
 clerk-family
 waiter-daughter
 convict-guard
 hunter-printer
 grocer-friends
 speaker-workers
 detective-liar
 driver-cousin
 drunk-dentist

VERBSSimple

joined
 shot
 wrote
 followed
 watched
 called

Causative

bored
 fired
 surprised
 angered
 protected
 hurt

Complex

punished
 obeyed
 believed
 instructed
 employed
 trusted

Appendix N. Summary table for analysis of variance for the first cueing study, involving simple, complex and causative verbs.

Source of Variation	F	Mean Square Error
Delay (D)	25.54 *	0.4786
Verb Type (V)	1.03 **	0.8104
Cue Type (C)	3.67 **	1.1017
D x V	3.67 **	.2504
D x G	0.74 **	.2504
V x G	7.32 ***	1.0326
D x V x G	3.82 ***	0.1774

*df = 1,17

**df = 2,34

***df = 4,68

Appendix O. Sentences used in Experiment 5. Stimuli are classified according to their semantic dependency. Within each listing, the single word that orients a given sentence toward the monodominant meaning of the verb is given within the parentheses.

SUBJECTSPREDICATES

Subject-oriented

Teacher (artist)
lecturer (sculptor)
professor (painter)

covered the material

robber (visitor)
thief (tourist)
criminal (reporter)

took the picture

athlete (musician)
runner (singer)
swimmer (shopper)

broke the record

child (gambler)
carpenter (gangster)
father (criminal)

fixed the game

referee (drunk)
official (convict)
referee (gangster)

started the fight

doctor (clerk)
actress (bookkeeper)
cook (accountant)

reduced his (her) figure

Appendix O. (Continued).

Object-oriented

SUBJECTS

foreman
owner
tailor

swimmer
camper
runner

student
activist
teacher

tailor
worker
driver

carpenter
foreman
doctor

actor
doctor
carpenter

PREDICATES

fired the gun (worker)

caught the ball (cold)

planted the flowers (bomb)

made the pillow (money)

boarded the window (ship)

tipped his hat (the waitress)

Appendix P. Summary table for analysis of variance for the second cueing study, involving verb orientations and dominance.

<u>Source of Variation</u>	<u>F</u>	<u>Mean Square Error</u>
Delay (D)	0.01*	0.4437
Verb Type (V) (Dominance)	0.09*	1.2800
Verb Orientation (S) †	6.61*	1.1385
Cue Type (C)	0.52**	1.2357
D x V	0.11*	0.1973
D x S	0.01*	0.2964
V x S	0.01*	1.1169
D x C	1.56**	0.1347
V x C	1.91**	1.3879
S x C	2.61**	1.3002
D x V x S	1.38*	0.1735
D x V x C	1.72**	0.1735
D x S x C	1.62**	0.2237
V x S x C	0.47**	1.1304
D x V x S x C	8.37**	0.1016

*df = 1,17

**df = 2,34