VISUAL INFORMATION PROCESSING

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CONSIDERATIONS OF SOME PROBLEMS OF COMPREHENSION

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Since 1957 (Chomsky, 1957), the area of language has received increasing attention from psychologists. Linguistic characterizations of sentence structure have played important roles in formulating theories of sentence perception, comprehension and memory. The emphasis on characterization of the linguistic system has tended to overshadow another problem, however, namely that a language is a symbol system that is used by individuals. A consideration of the individual's contributions to the processes of creating, comprehending and remembering linguistic utterances may thus involve principles beyond those necessary for characterizing the linguistic system *per se*.

The purpose of the present paper is to investigate some of the contributions made by listeners while comprehending and remembering, and to demonstrate that the ability to understand linguistic symbols is based not only on the comprehender's knowledge of his language, but also on his general knowledge of the world. Much of the extra-linguistic knowledge affecting comprehension and memory may come from visually presented information (e.g., perceptual context), hence the present conference's concern with visual processing can have important implications for theories dealing with the comprehension and memory of linguistic events.

The paper is divided into four major sections. The first three present a number of studies which illustrate some of the interplay between linguistic inputs and extra-linguistic knowledge. In the fourth

section we attempt to highlight various implications of these studies with respect to the problem of characterizing the thought processes involved in comprehending language, and of characterizing the role of comprehension factors in learning and memory.

Comprehension as a Process of Creating Semantic Products

The studies in this section were designed to allow some initial inferences about the comprehension process based on the nature of the information available to a subject following comprehension. If understanding involves relating input information to general knowledge, the semantic product resulting from this process should often include more information than that directly expressed in the input. In the following experiments, the basic research strategy was to ask whether subjects would falsely recognize information that could only be available to them by inference.

Inferring Spatial Relations Among Objects

Consider the following set of sentences:

1. Three turtles rested *beside* a floating log and a fish swam beneath them.

2. Three turtles rested *on* a floating log and a fish swam beneath them.

These two sentences differ only in the lexical items *on* or *beside*. Both sentences include information about a fish swimming beneath the turtles. The critical difference is that in sentence (2), since the turtles are on the log and the fish swam beneath them, it follows that the fish swam beneath the log as well. This information (that the fish swam beneath the log) is not supplied by the linguistic input, but

is based on knowledge of spatial relations. Likewise, a knowledge of spatial relations allows the conclusion that the fish did not necessarily swim beneath the log in sentence (1).

Bransford, Barclay and Franks (in press) used sets of sentences like those above in the acquisition phase of a memory task. For example, an individual subject's acquisition list included either sentence (1) or sentence (2). Later, subjects were given a recognition test. Recognition items were presented successively and the subject's task was to indicate which sentences they had heard during acquisition and which they had not. In addition, they were asked to rate their confidence in each response. Of interest was the confidence with which subjects thought they had heard recognition items in which the final pronoun of the acquisition sentence was changed. For example, sentences (1') and (2') below are the recognition items corresponding to sentences (1) and (2), respectively:

1'. Three turtles rested beside a floating log and a fish swam beneath *it*.

2'. Three turtles rested on a floating log and a fish swam beneath *it*.

If subjects store only the linguistic information underlying the input sentence, subjects hearing either sentence (1) or (2) should be equally likely to detect the pronoun change in the recognition item. On the other hand, if subjects acquire information about a situation based on the information conveyed by the sentence in combination with their understanding of spatial relationships, a different pattern of results would be expected. Subjects hearing sentence (1) should reject the recognition item (1') since it is neither consonant with the actual input sentence nor with their understanding of the situation, whereas subjects hearing sentence (2) should be more

likely to think they heard the recognition item (2') since it is consonant with their understanding of the situation. As expected, subjects' confidence ratings indicated that they were not simply basing their judgments on the information expressed solely by the sentence. Rather, subjects were responding on the basis of whether or not a change in pronoun produced a sentence which was consistent with the overall spatial relationships among the objects that the input sentence implied.

Bransford, Barclay and Franks reported a similar finding in cases where sets of sentences were used to communicate an overall understanding of the spatial relationships among objects. For example, subjects heard several descriptions of the following type:

> There is a tree with a box beside it, and a chair is on top of the box. The box is to the right of the tree. The tree is green and extremely tall.

The reasoning was that subjects hearing such descriptions should know more than simply that information underlying the individual sentences in the description. For example, they should also know that *The chair is to the right of the tree* or *The tree is to the left of the chair*, even though this information was never presented. In a recognition task in which subjects were asked to choose which sentence they had actually heard from among a set of alternatives, subjects were much more likely to choose a sentence like *The tree is to the left of the chair* than they were to choose a sentence that violated the overall set of relationships, e.g., *The chair is to the left of the tree.*

Inferring Instruments Used to Carry Out Acts

Johnson, Bransford and Solomon (in press) investigated a class of items such as *The man was shot.*

Kintsch (in press) had earlier presented subjects with such sentences and asked them to indicate additional information that seemed to be true about the situations described. His subjects suggested that the man must be shot by something (i.e., there must be some *instrument* for carrying out the action, to use Fillmore's [1968] term), and most assumed that the instrument would be a gun. We asked whether subjects were likely to think they heard information based on such inferences.

The general design involved reading subjects a series of descriptive stories at acquisition and later giving them a recognition test in which they were to say Yes to sentences which were exactly like sentences in the stories and to say No to sentences which had been changed in any way. Subjects heard 20 stories in all, 6 of which are relevant to the present discussion. For the Experimental group, these stories were designed to suggest a particular inference regarding an instrument involved in the action described. For example,

> 1. John was trying to fix the bird house. He was *pounding* the nail when his father came out to watch him and to help him do the work.

For the Control group, the same story frames were used but in each case a verb was changed so that no object was implied or the implied object was different:

> 2. John was trying to fix the bird house. He was *looking for* the nail when his father came out to watch him and to help him do the work.

At recognition, both groups of subjects were presented with the same sentences. The critical Instrument-Inference item for the above story was:

John was using the *hammer* to fix the bird house when his father came out to watch him and to help him do the work.

The mean number of Yes responses are shown in Table 1. As can be seen in Table 1, Experimental and Control subjects did not differ in the mean number of Yes responses to Unrelated sentences (which conveyed information inconsistent with the stories of both groups) or to Old sentences (which were identical to sentences in the stories of both groups). However, the Experimental subjects were much more likely to say Yes to the critical Instrument-Inference items than were Control subjects.

Inferring Consequences of Input Events

In the study just described, we also investigated an additional class of items. In these items, the experimental version of each story suggested some probable consequence of the action described. In the corresponding control stories, verb or prepositional phrases were changed so that the probable consequence of the action was changed. Two examples of acquisition stories are given below, with the changes made for the control group given in parentheses and the corresponding Consequence-Inference recognition item given in italics.

Table 1. Mean Number of Yes Responses During Recognition

	Unrelated	Old	Inference	
			Instruments	Consequences
Number of Sentences	12	10	6	6
Experimental Group	.70	6.65	3.40	4.05
Control Group	.45	6.95	1.20	1.40

It was late at night when the phone rang and a a voice gave a frantic cry. The spy threw (pulled) the secret document into (from) the fireplace just in time since 30 seconds longer would have been too late. *The spy burned the secret document just in time since 30 seconds longer would have been too late.*

The river was narrow. A beaver hit the log that a turtle was sitting on (beside) and the log flipped over from the shock. The turtle was very surprised by the event. *A beaver hit the log and knocked the turtle into the water.*

As can be seen in Table 1, subjects hearing the experimental version of the story were more likely to think they had heard the critical recognition items than subjects hearing the control version.

Creating Situations that Justify the Relations Between Two Events

In collaboration with Nancy McCarrell, we have recently used a similar false recognition paradigm to investigate a class of items where the relations between two events have to be justified. For example, consider the sentence:

The floor was dirty *because* Sally used the mop.

Most people have little trouble understanding this sentence, but they usually assume additional information in order to do so. For example, many people assume that the mop was dirty. That is, people assume an antecedent condition that explains or justifies the relation between the two phrases. If the connective is changed--

The floor was dirty *so* Sally used the mop.

--the sentence seems relatively "self-contained;" at least understanding it does not seem to require any special assumptions about the state of the mop.

As another example, compare the following two sentences:

> John missed the bus *because* he knew he would have to walk to school.
>
> John missed the bus *so* he knew he would have to walk to school.

The relationship between the two phrases can be justified in the *because* version if, for example, one assumes that John wanted to walk to school. On the other hand, this assumption does not seem to play any part in understanding the *so* version of the sentence.

In the experiment, these types of sentences were embedded in short acquisition story frames. The experimental version of each sentence contained a *because* and the control version contained a *so*. The critical recognition items included the kind of information subjects were likely to infer given the experimental version of the story (e.g., that the mop was dirty or that John wanted to walk to school). The mean number of Yes responses to these critical recognition items was greater under the experimental than under the control condition. The data are given in Table 2.

Table 2. Mean Number of Yes Responses During Recognition

	Version During Acquisition	
	Because	So
Number of Sentences	3	3
Critical Justifications Recognition Items	1.54	.32

We think that the results of the studies in the present section are consistent with the notion that a subject's understanding depends not only on what he hears, but on the implications of this information in light of his prior knowledge.[1] Therefore, the subject's performance (e.g., in a recognition memory task) will be not only a function of what he heard, but of what he knows. These processes of making inferences and creating justifications probably occur quite frequently in the normal course of comprehending. Generally, we may not be aware of them. Sometimes, however, processes like justification can be quite elaborate. Our favorite example of this is to ask people to comprehend the sentence, *Bill is able to come to the party tonight because his car broke down*. As we have noted elsewhere (Bransford and Johnson, 1971), people generally indicate that they can comprehend this sentence *via* a process of fabricating a situation in which it makes sense. Most people come up with something like the following:

> Bill was originally going to leave town, but now he could not leave because his car broke down. Since he could not leave he could come to the party since the party was in town.

This act of creating an elaborate situation in order to understand the sentence is a far cry from merely interpreting the meanings of the phrases, "Bill is able to come to the party tonight" and "his car broke down." In some sense the *because* structure of the sentence acts as a cue to create a situation that

[1] Reaction time studies--in conjunction with false recognition data--might help distinguish between cases where inferences occur during acquisition and those where inferences are made during recognition. For some initial studies in this question, see Potts, 1971.

brings the two phrases into a meaningful relation. A listener is confronted with a problem-solving task of creating some situation in which the *because* structure makes sense. The studies in the next section indicate what happens if a listener fails in such problem-solving tasks.

Semantic Prerequisites for Comprehension

A description of the output of the comprehension process as a joint product of input information and prior knowledge allows for the possibility that a person *first* comprehends an input and *then* elaborates on its implications. However, the studies in the present section indicate that, under certain circumstances, this is not an accurate characterization of the comprehension process. Rather, there are cases in which certain knowledge may constitute a semantic prerequisite for comprehension; that is, where sentences presuppose knowledge of relevant information.[2] In the experiments presented below, the availability of prior knowledge is manipulated in order to assess its role in comprehending and remembering information.

Novel Contexts

One way to manipulate the information available to a listener is in terms of the contexts surrounding a message. As an example of how context can determine whether or not one can comprehend, consider the following passage:

> If the balloons popped the sound wouldn't be able to carry since everything would be too far away from the correct floor. A closed window would also present the sound from carrying, since most buildings tend

[2]For linguistic discussions of presuppositions see, for example, Fillmore and Langendoen, 1971.

> to be well insulated. Since the whole operation depends on a steady flow of electricity, a break in the middle of the wire would also cause problems. Of course, the fellow could shout, but the human voice is not loud enough to carry that far. An additional problem is that a string could break on the instrument. Then there could be no accompaniment to the message. It is clear that the best situation would involve less distance. Then there would be fewer potential problems. With face to face contact, the least number of things could go wrong.

In one experiment (Bransford and Johnson, in press), subjects in the No Context (1) condition were instructed to listen carefully to this passage and to try to comprehend and remember it. They were informed that they would later be asked to recall the passage as accurately as possible. They then heard the passage once and were asked to rate it on 7-point comprehension scale (where 1 indicated "very hard" to comprehend and 7 indicated "very easy"). The rating task was followed by a recall task in which subjects were encouraged to write down as many ideas from the passage as they could.[3] The No Context (1) subjects

[3]We have adopted the following standard procedure for scoring recall protocols of sentence materials or prose passages: idea units are designated *a priori* and correspond either to individual sentences, basic semantic propositions, or phrases. Maximum possible scores for the materials used in the experiments presented here are given in the appropriate tables. The protocols, which cannot be identified as to condition, are scored independently by two judges against the list of idea units. Paraphrases are allowed. Interjudge reliability measures have been $\geq .91$. Any differences in the assignment of scores to subjects are resolved by a third judge. These adjusted scores are then used in the final analysis of the data.

gave the passages very low comprehension ratings and recalled very few ideas. In contrast, subjects who were given 30 seconds to look at the picture in Figure 1 before hearing the passage (Context Before subjects) rated it as much more comprehensible and recalled twice as many ideas.

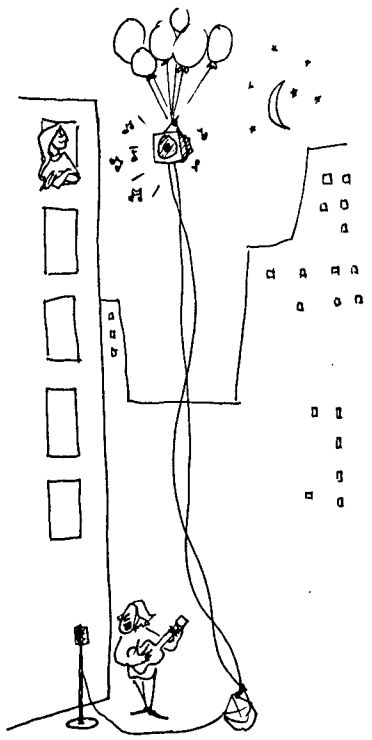

Fig. 1. Appropriate Context for the *balloon* passage.

There were three additional conditions in the study. Comprehension ratings and recall scores for all conditions are given in Table 3. No Context (2) subjects heard the passage twice in succession before the rating and recall tasks. A comparison between the No Context (2) group and the Context Before group indicates that subjects were actually better off in the present situation spending time looking at the picture (and then transferring to the to-be-learned items) than they were spending even more time on an additional study trial of the to-be-remembered material. This presents even stronger evidence that the picture constituted a prerequisite setting for comprehending the passage.

The other two conditions (Context After and Partial Context) were included to control for possible alternative explanations of the expected difference in recall between the Context Before and No Context conditions. Context After subjects saw the picture in Figure 1 after they heard the passage and before the comprehension rating and recall tasks. This did not seem to help them since they also rated the passage as quite incomprehensible and their recall scores were no better than those of subjects in the No Context group. The absence of a Context After effect suggests that subjects in the Context Before condition were not obtaining higher recall scores by simply generating ideas consonant with the picture. In fact, it is important to note that the passage did not simply describe the picture, but instead discussed events that could happen given the context as a conceptual base.

Table 3. Mean Comprehension Ratings and Mean Number of Ideas Recalled (Balloon Passage)

	No Context 1	No Context 2	Context After	Partial Context	Context Before	Maximum Score
Comprehension	2.30	3.60	3.30	3.70	6.10	7.00
Recall	3.60	3.80	3.60	4.00	8.00	14.00

As an alternative to the generation hypothesis, one might argue that the Context Before group benefited from a more available set of retrieval cues (i.e., the elements of the picture--balloons, wire, window, etc.) relative to the No Context groups. There are data to suggest that retrieval cues are important for recall and that it is important that these cues be present at input (e.g., Tulving & Osler, 1968). Therefore, Partial Context subjects saw the picture in Fig. 2 before hearing the passage. The partial context picture contained all of the objects represented in the appropriate picture, but

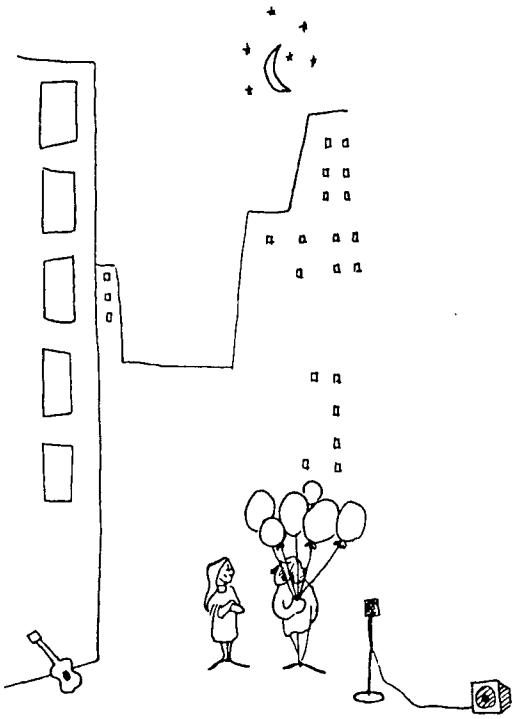

Fig. 2. Partial Context for the *balloon* passage.

the objects were rearranged. Partial Context subjects were clearly inferior to Context Before subjects in both comprehension ratings and recall.

The question of differential retrievability of information was investigated in a different way in a study conducted by Stanley Nyberg and John Cleary in our laboratory at Stony Brook. Subjects in No Context (1), Context Before, and Context After conditions were asked to recall the *balloon* passage either with or without key words as retrieval cues. The retrieval cues were the following words selected from the passage: balloons, window, wire, human voice, instrument, contact. Providing retrieval cues did not diminish the differences between the Context Before subjects and those in the other two groups, despite the fact that the Context Before subjects had less room to improve (see Table 4).

The results of the preceding studies indicate that context has a marked effect on memory. We are not, however, suggesting that there is a one-to-one correspondence between comprehension and recall. A subject may remember (or learn with repeated exposures) material that he has not understood. Conversely, a subject will not invariably remember all the material that he has comprehended. Although considerable research is needed to assess the relative contributions of comprehension and retrieval processes to remembering, our results do indicate that the absence of an appropriate semantic context can under some conditions seriously affect the acquisition process.

Table 4. Mean Number of Ideas Recalled (Balloon Passage)

	No Context	Context After	Context Before	Maximum Score
No Cues	3.92	4.33	7.33	14.00
Key Word Cues	4.00	3.75	8.50	14.00

Several colleagues have suggested that one way in which the absence of an appropriate context may retard the acquisition process is that subjects in No Context conditions are not using their study time efficiently. Rather than trying to memorize the input, subjects are trying to figure out a context for it in order to understand the meaning of the information. Indeed, many subjects in the experiments above who were not provided with the appropriate picture prior to hearing the passage did report that they actively searched for a situation that the passage might be about. It is possible that subjects who are relieved of the problem of finding a context (Context Before subjects) can devote more time to applying strategies for learning the input materials. On the other hand, subjects in No Context conditions have to share their time between looking for contexts and trying to memorize.

A study by Elizabeth Cole and the present writers attempted to evaluate the above time-sharing notion. The *balloon* passage was used and Context Before and No Context (1) conditions were included. In addition, subjects received either comprehension instructions or memorization instructions. Comprehension instructions were essentially equivalent to those used in the prior studies. The memorization instructions emphasized that the subjects should not spend any time or effort trying to understand the passage they were about to hear. Instead, they should attempt to memorize as much of it as possible. The time-sharing hypothesis predicts that No Context subjects under instructions to memorize should do better than No Context subjects who received comprehension instructions. In addition, if the time-sharing variable completely accounts for the memory deficit, No Context memorization subjects should perform as well as subjects in Context Before groups. The instructional manipulation should have little effect in the Context Before conditions since both comprehension and memorization groups are free of the problem of finding or creating a context and the

comprehension subjects are presumably devoting their time to memorizing the input.

The results of the experiment are given in Fig. 3. They did not provide any support for the time-sharing notion. In fact, the No Context subjects recalled slightly (though not significantly) more under instructions to comprehend than under instructions to memorize, and No Context Memorization subjects were far below subjects in the Context Before groups. Insofar as the instructional manipulation influenced the subjects' activities, these data indicate that those activities related to comprehending may also be those most conducive to learning prose materials. Of course, it should be possible to train subjects in better memorizing strategies than they presumably used in the present experiment. However, it is doubtful whether a good learning strategy will completely overcome the disadvantages arising from the problem of poor comprehension. We shall return to the question of how the context aids comprehension

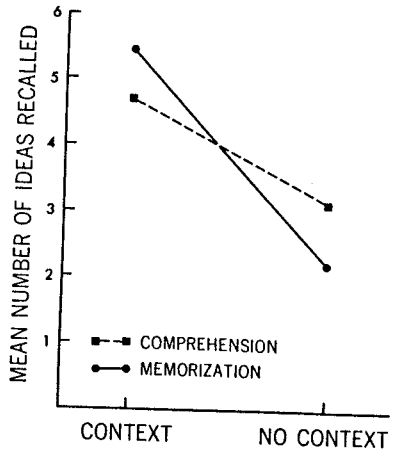

Fig. 3. Mean number of ideas recalled as a function of comprehension vs memorization instructions (*balloon* passage).

later in the paper. First we shall consider some additional studies that investigate the relation between prior knowledge, comprehension and recall.

Familiar Contexts

The *balloon* passage was constructed so that it would be very unlikely that the prerequisite semantic information would be part of the preexperimental knowledge of the subjects. The basic points made above, however, are applicable to situations where the semantic prerequisites are available from the subject's prior knowledge. Consider, for example, the following passage:

> The procedure is actually quite simple. First you arrange things into different groups. Of course, one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is the next step, otherwise you are pretty well set. It is important not to overdo things. That is, it is better to do too few things at once than too many. In the short run this may not seem important but complications can easily arise. A mistake can be expensive as well. At first the whole procedure will seem complicated. Soon, however, it will become just another facet of life. It is difficult to foresee any end to the necessity for this task in the immediate future, but then one never can tell. After the procedure is completed one arranges the materials into different groups again. Then they can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is part of life.

Now consider the same passage again, but this time with the knowledge that the topic of the passage is *washing clothes*.

Comprehension ratings and recall scores from two different experiments (one using the above passage and one using a slightly different version of the above passage) are presented in Table 5. The procedure in these experiments was similar to that used in the initial *balloon* passage experiment outlined above. Subjects in the No Topic group produced low comprehension and recall scores, as did subjects who received information that the passage was about washing clothes after hearing the passage. Subjects in the Topic Before conditions showed higher comprehension and recall scores.

Dooling and Lachman (1971) recently reported a similar recall advantage for Topic Before subjects vs No Topic subjects. Their materials were metaphorical passages about *Christopher Columbus Discovering America* and *The First Space Trip to the Moon*. With Nancy Fenrick, we replicated the Dooling and Lachman

Table 5. Mean Comprehension Ratings and Mean Number of Ideas Recalled (Washing Clothes)

	Experiment A			
	No Topic	Topic After	Topic Before	Maximum Score
Comprehension	2.29	2.12	4.50	7.00
Recall	2.82	2.65	5.83	18.00
	Experiment B			
		Topic After	Topic Before	Maximum Score
Comprehension		3.40	5.27	7.00
Recall		3.30	7.00	20.00

experiment with the addition of a Topic After condition. The words of the passage were presented successively *via* a carousel projector and protocols were scored for the number of correct words from the passage recalled. The mean number of words recalled in Topic Before, No Topic and Topic After conditions (collapsed across the two passages) were 22.6, 16.4 and 16.0, respectively. Again, Topic After did not augment recall.

These Topic After conditions seem particularly important in situations where the materials to-be-recalled convey information about familiar topics. The notion that subjects in Topic Before conditions achieve higher recall scores relative to No Topic subjects because they can generate (or reconstruct) ideas that are consistent with the topic and, coincidentally, with the passage, is much more persuasive in cases where the topics are familiar (as compared, for example, to the *balloon* passage). However, the results of the studies in the present section strongly indicate that, although generation of preexperimentally acquired ideas may sometimes operate in the recall of prose about familiar topics, this process alone cannot account for the large advantage of Topic Before subjects.[4]

In general, the results indicate that simply having relevant preexperimental knowledge is not sufficient to insure comprehension. This knowledge must be activated during the ongoing process of comprehension in order for it to be maximally useful.

[4]On the acquisition side, it has been suggested to us that providing a context makes it easier for the subject to image the input information (e.g., see Paivio, 1971; Bower, 1969, on the role of imagery in recall) or for the subject to organize the input information into a limited set of chunks or subjective units that may mediate efficient "storage" and subsequent recall (e.g., see Miller, 1956; Tulving, 1968; Mandler, 1967). For example, materials like the *balloon* and *washing clothes* passages become intuitively more imagable when they become more comprehensible (i.e., in the context or topic before conditions). Likewise, when these passages are comprehensible, the number of cohesive ideas, and consequently organizational units, seems to be more circumscribed. However, from our point of view, images and subjective units are potential outputs of active comprehension processes but do not by themselves constitute a full analysis of such processes.

Contexts and Sentence Acquisition

It seems reasonable to assume that had the No Context subjects in the above experiments thought of a relevant context during acquisition, their comprehension and recall scores would have improved. Therefore the present study, conducted in conjunction with Nancy McCarrell, explored the hypothesis that the difficulty of to-be-learned material is related to the likelihood that subjects will generate relevant contextual information. In order to have more than a single recall test as an index of the subjects' level of learning, the acquisition procedure involved three study-test trials. The materials consisted of a list of unrelated sentences and to minimize retrieval factors, cues for each sentence were provided on test trials.

The sentences were similar in form to the *because* sentences used earlier in the false recognition study (e.g., *John missed the bus because he knew he would have to walk to school*). On the basis of our intuitions we generated two classes of items: easy and hard. Easy sentences were those for which subjects should be able to find justifications for the relations between the two phrases with little difficulty. Hard sentences were designed to be ultimately comprehensible, but difficult to understand without help from the experimenter. For example:

Easy: The account was low because Sally went to the bank.
The car was moved because he had no change.

Hard: The notes were sour because the seam was split.
The haystack was important because the cloth ripped.

Two groups of subjects were run in the study. One group (No Context) received a list consisting of eight easy and eight hard sentences, randomly intermixed. On study trials, each sentence was preceded by the subject noun (e.g., the account, the car, the notes, the haystack). On the free-recall test trials, the subject nouns were available as retrieval cues. For this condition we expected easy sentences to be better remembered than hard sentences, since the latter should seem anomalous (see Marks & Miller, 1964, for memory for anomalous vs. non-anomalous sentences). Figure 4 shows that there was a marked difference in the level of recall of the easy and hard items, with the advantage of the easy items persisting over three study-test trials.

The second group (Context) received conditions identical to those of the first group except that each sentence was preceded by a context cue rather than a subject noun on study trials. The contexts for the four sentences above were *withdrawal*, *parking meter*, *bagpipes*, and *parachute*, respectively. The retrieval cues on the recall tests were the subject nouns. As can be seen in Fig. 4, the presentation of context cues significantly reduced the difference between easy and hard sentences. The differential difficulty of easy and hard items was therefore not simply a function of the sentences *per se*, but rather was a function of the ease with which subjects could find solutions to the comprehension problems they presented. For the Context subjects, all sentences were presumably easy to comprehend; consequently subjects were learning instances

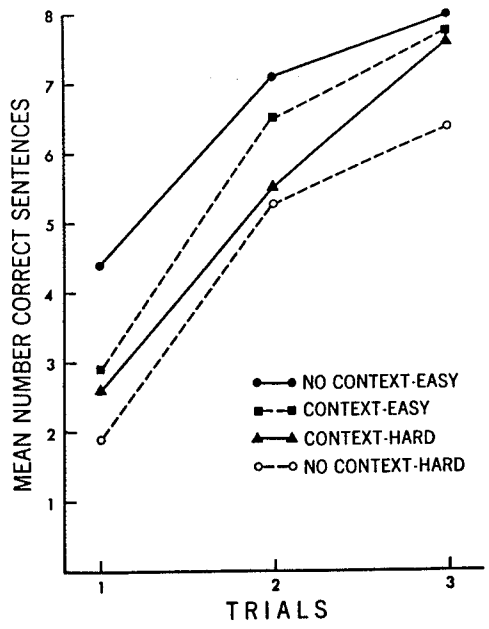

Fig. 4. Mean number of sentences recalled on successive learning trials (easy vs. hard *because* sentences.

of both classes of sentences rather than concentrating on only "easy" items (as seemed to be the case with subjects in the No Context group).

The results of the present study are consistent with the notion that context cues affected the degree to which hard sentences could be comprehended and that comprehension, in turn, affected the degree to which the individual sentences were learned and recalled. The results also support the notion that semantic anomaly is largely a function of the degree to which one can relate a sentence to some relevant aspect of his knowledge of the world (Olson, 1970).

Situations in which Prior Activation of Relevant Information Fails to Augment Comprehension or Recall

A specification of the information that must be available in order for a subject to arrive at a particular semantic product would involve a clarification of the conditions under which the prior presentation of relevant information does and does not augment comprehension and recall. The two studies in the present section suggest some of the factors that may be important in determining whether or not providing subjects with relevant information before a comprehension task will improve their performance. One study indicates that the prior presentation of a relevant topic for a passage may not be sufficient to activate the critical features of the prerequisite semantic context. The second shows that the effects of presenting a topic will depend on the availability of contextual cues within the passage itself.

In the first study, the *balloon* passage mentioned earlier was used. One group of subjects received the topic *Possible breakdowns in communication during a serenade* before hearing the passage. A second group did not receive any information before the passage was presented. Table 6 shows that providing a topic did not augment comprehension ratings and recall scores relative to the No Topic condition. Presumably, information about the specific structure of the serenade (which is supplied in the context picture in Fig. 1) is necessary for understanding the balloon passage. Knowledge of a relevant topic alone was not

Table 6. Mean Comprehension Ratings and Mean Number of Ideas Recalled (Balloon Passage)

	No Topic	Topic After	Topic Before	Maximum Score
Comprehension	2.78	2.33	3.10	7.00
Recall	3.78	3.56	3.90	14.00

sufficient to increase comprehension and recall scores. From prior studies it is clear that subjects do not need any advance information about the topic in order for the context picture to greatly facilitate comprehension and recall. In addition, the picture does not "contain" the topic in that various passages (with different topics) could be built around the picture. Given that this is the case, it is possible that subjects might derive additional benefit from a condition in which the topic is provided along with the context picture. However, since the topic may be inferred from the content of the passage (in combination, of course, with the picture), providing it ahead of time may contribute little additional information. Although we have not run this topic-plus-context condition, the next study is relevant to this issue.

In conjunction with Carol Raye, we conducted a study designed to assess the role of prior activation of topics in two situations, one in which the passage in isolation was relatively incomprehensible, the other in which the passage in isolation was comprehensible. Two versions of the same passage were prepared for this experiment, one abstract and one concrete. The abstract version was similar to the *washing clothes* passage presented earlier. For the concrete version, concrete words were substituted for more abstract words in the passage. Two of the 11 substitutions were *clothes* for *items* and *laundromat* for *somewhere else*. Four groups of subjects were run in the experiment: Topic Before-Concrete, Topic Before-Abstract, No Topic-Concrete, No Topic-Abstract. The topic was *washing clothes*.

From previous studies we expected the topic-before manipulation to have a large effect on comprehension and recall scores for subjects receiving the abstract passage. One primary question was whether the prior information about the topic would augment performance in the concrete case, where the passage itself included many cues to the appropriate context. An additional point of interest was the degree to which the Topic Before-Abstract subjects' performance would approximate that of subjects in the concrete group.

Table 7 shows the comprehension ratings and mean number of ideas recalled for the four conditions. The maximum score was 17; therefore, the groups were all well below ceiling. Recall scores for the concrete version of the passage were not affected by the topic variable. As in previous results, the topic increased comprehension and recall scores for subjects receiving the abstract version of the passage. In addition, the Topic Before-Abstract group remained significantly below the corresponding concrete condition.

We think that this residual advantage of the concrete passage can be attributed to the fact that substituting concrete words did help make some of the individual sentences in the passage more comprehensible. Therefore, although both Concrete subjects and Abstract-plus-Topic subjects had relevant semantic information activated, concrete words probably had greater cue value for specific details of the meaning of the passage than did abstract words. The fact that subjects in the Topic Before-Abstract group produced significantly lower comprehension ratings than subjects in the concrete groups supports this point of view.[5]

Table 7. Mean Comprehension Ratings and Mean Number of Ideas Recalled

	Comprehension[a]		Recall[b]	
	Abstract	Concrete	Abstract	Concrete
Topic	6.00	6.89	9.00	11.67
No Topic	3.67	6.67	4.87	10.56

[a]Scale from 0-7

[b]Maximum Score = 17

[5]Concreteness and comprehensibility are, in fact, confounded in many experiments. See, for example, Johnson, Bransford, Nyberg and Cleary's (in press) analysis of Begg and Paivio's (1969) study of memory for abstract versus concrete sentences.

Situations in which Prior Activation of Certain Information Retards Comprehension and Recall

The experiments above indicate that relating information to relevant aspects of prior knowledge is a critical part of the comprehension process. Presenting subjects with a context or, more generally, a cue to a context) made relatively incomprehensible materials much more comprehensible. Postexperimental interviews indicated that, when left to their own devices (no context, no topic or no cue conditions), many subjects attempted to find or generate information that would make sense of the materials. Occasionally they appeared to be somewhat successful in making parts of the input idiosyncratically meaningful. In this section, we will consider what happens when subjects are specifically misdirected in their attempts to find a useful context for difficult material. Although we do not have a great deal of evidence on this point, the data below suggest that subjects may be better off creating their own context than attempting to find relationships between an input and the wrong context.

One indication that wrong contexts might retard performance was obtained in our replication (mentioned above) of the Dooling and Lachman experiment. In addition to the conditions previously discussed, this study included a condition in which subjects were presented with irrelevant topics just prior to acquisition. The irrelevant topics were *Writing a letter to a Friend* and *Reading a Magazine at Lunch* for the *Christopher Columbus Discovering America* and *The First Space Trip to the Moon* passages, respectively. As can be seen in Table 8, there was a slight

Table 8. Mean Number of Words Recalled (Columbus and Moon Passages Combined)

No Topic	Topic After	Irrelevant Topic	Topic Before	Maximum Score
16.40	16.05	15.25	22.65	77.00

detrimental effect on recall as a consequence of presenting the irrelevant topics, but the difference between irrelevant and no topic conditions was not significant.

With different materials and procedure, a subsequent experiment (Doll, Lapinsky, Bransford, & Johnson, in preparation) resulted in a much more marked effect of irrelevant information on recall. The subjects were presented with 16 sentences for three study-test trials. The sentences were relatively short, and seemingly anomalous in isolation (e.g., *The streak blocked the light; The man saw his face in the body*). The design consisted of three cue conditions combined factorially with two acquisition rates and for the present purposes the data are collapsed across this latter factor. For No Cue subjects, each sentence was preceded by the word ready during acquisition. For Cue subjects, each sentence was preceded by a context cue; for example, the cues corresponding to the sentences above were *a window* and *new car*, respectively. For the Irrelevant Cue condition, these cues were randomly paired with the sentences. Subjects in the Cue and Irrelevant Cue conditions were told that the cues might help them remember the sentences, but that the cues themselves would never have to be recalled. A free recall test procedure was used and no cues were provided on test trials.

The mean number of sentences recalled on each of the three trials is shown in Fig. 5. As expected, the Cue subjects were at a considerable advantage. More important for the present discussion, the performance of the Irrelevant Cue subjects was significantly worse than that of the No Cue subjects. It seems likely that many of the No Cue subjects were able to find contexts for some of the sentences. On the other hand, providing irrelevant cues hurt the subjects' performance presumably because they were attempting to understand the sentences in light of the presented contexts and therefore were not as likely to discover better contexts of their own.

The sentences used above were difficult to understand in isolation, but even basically comprehensible information can be rendered incomprehensible by an inappropriate context. A sentence that can be understood in isolation is presumably one that provides sufficient cues so that the comprehender can make whichever semantic contributions are necessary. However, from the present point of view, comprehension problems should arise with such sentences when the context active at the time of input is inappropriate or when the subject cannot create a relationship between the sentence and the context. To test this notion, we used the following passage.[6] The passage was read once at a

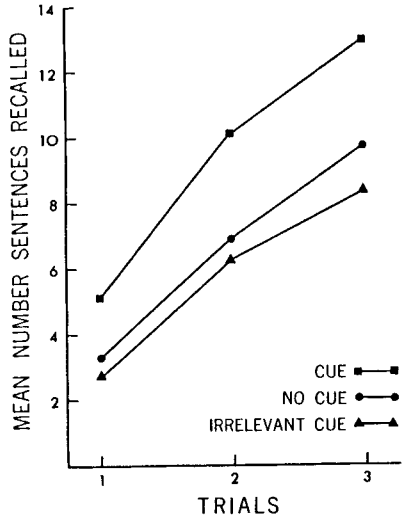

Fig. 5. Mean number of sentences recalled on successive learning trials under three input cueing conditions (Cue, Irrelevant Cue, and No Cue).

[6]This study grew out of an undergraduate project conducted by Paula M. Mintzies. We are indebted to her for her interest and her work.

normal rate, so the subjects did not have time to linger over any particular sentence. The subjects were instructed that they would later be asked to recall as much as they could.

Watching a Peace March from the 40th Floor

> The view was breathtaking. From the window one could see the crowd below. Everything looked extremely small from such a distance, but the colorful costumes could still be seen. Everyone seemed to be moving in one direction in an orderly fashion and there seemed to be little children as well as adults. The landing was gentle, and luckily the atmosphere was such that no special suits had to be worn. At first there was a great deal of activity. Later, when the speeches started, the crowd quieted down. The man with the television camera took many shots of the setting and the crowd. Everyone was very friendly and seemed glad when the music started.

The conditions of the experiment and the recall data will be presented below. For the moment, consider some informally gathered introspective reports. People are generally able to understand this passage quite easily until they hear the sentence, "The landing was gentle and luckily the atmosphere was such that no special suits had to be worn." At this point they usually become confused or surprised. A few people come up with a "rationale" for the sentence. For example, that a helicopter landed in the middle of the parade to control the crowds, that the peace march moved to the airport to meet someone, or that the "landing" referred to a platform outside the hotel-room window and that the "atmosphere" part of the sentence referred to the fact that the weather was warm. These reports represent the most creative attempts to incorporate the sentence into the ongoing context suggested by the title

and the rest of the passage. Most people report that they could not figure out what the sentence meant.

Now consider the same passage again and assume that the title has been changed to *A Space Trip to an Inhabited Planet*. Under this title condition, people generally do not have any special trouble with the *landing* sentence.

There were four conditions in the actual experiment using this passage. Two conditions (one with each title above) were included to make sure that the *Space Trip* title did not simply activate a better overall context for the passage. Therefore, in these conditions, the *landing* sentence was deleted; otherwise the passage was the same as above. With the *landing* sentence deleted, recall was not influenced by the title manipulation. For the other two conditions, the passage contained the *landing* sentence. In this case, overall recall under the *Space Trip* title was slightly (but not significantly) greater than under the *Peace March* title. Therefore, the presence of the critical sentence did not appreciably disrupt the overall performance of the subjects in the *Peace March* condition.

Of primary interest were the recall scores on the *landing* sentence as a function of the title condition. As can be seen in Table 9, a significantly greater number of subjects in the *Space Trip* than in the *Peace March* condition recalled at least one of the two critical idea units (landing gentle; atmosphere did not require suits) from the *landing* sentence. To assess whether this expected difference in recall was due simply to subjects' tendency to recall only ideas consistent with their respective topics, the subjects received a second type of retention test immediately following the free recall test. They were provided with a printed "cue outline" of the passage in which many words were deleted (similar to a "cloze" technique). The subject's task was to fill in the missing parts of the passage. The scores for the frame, "Luckily the landing _____ and the atmosphere _____" are also included in Table 9. As is apparent, the cued recall procedure did not reduce the advantage of the subjects in the *Space Trip* title condition.

Table 9. Recall Scores with The *Landing* Sentence Deleted or Present

	Mean Number of Ideas Recalled	
	Landing Sentence Deleted	with *Landing* Sentence
Space Trip	5.57	7.41
Peace March	5.86	5.82
Number of Subjects per Condition	14	17
Maximum Score	16	18

	Number of Subjects Recalling at least One Idea from *Landing* Sentence	
	Uncued	Cued
Space Trip	9	14
Peace March	3	5
Number of Subjects per Condition	17	17
Maximum Score	17	17

Taken together, the studies presented in this section indicate that potentially meaningful material can remain relatively incomprehensible when subjects do not have prerequisite semantic information activated at the time of input. In addition, it is possible to impede the subjects' ability to find useful relations between an input and what he already knows by presenting him with an irrelevant context. A logical inference from these results is that the meaning of an input cannot be determined independently of the context into which an individual is trying to assimilate it. For example, the *Peace March/Space Trip* passage is a message whose meaning varies depending on the cognitive orientation from which it is viewed.

Alternative Contexts

Meaning as a Function of Context

In the present section, we would like to mention briefly some further implications of the notion that what is understood from a message depends on the activated semantic context. The studies above indicate that comprehension ratings and recall measures are quite sensitive to the presence or absence of an appropriate context. However, the general orientation suggested by the above studies should be applicable to situations where material is readily comprehensible without additional cues but where alternative contexts yield different semantic products. In these cases, differences in semantic products will not always be reflected in the number or objective characteristics of the ideas recalled. Nevertheless, the characteristics of the semantic product should vary with different contexts and these differences should have consequences for subsequent tasks.

As an example of the influence of alternative contexts, and of how their activation may depend on minimal changes in the input, consider the following passage:

> The man stood before the mirror and combed his hair. He checked his face carefully for any places he might have missed shaving and then put on the conservative tie he had decided to wear. At breakfast, he studied the newspaper carefully and, over coffee, discussed the possibility of buying a new washing machine with his wife. Then he made several phone calls. As he was leaving the house he thought about the fact that his children would probably want to go to that private camp again this summer. When the car didn't start, he got out, slammed the door, and walked down to the bus stop in a very angry mood. Now he would be late.

Now consider the passage again, but assume that it includes an adjective that lets you know that the man is out of work: "The *unemployed* man stood before the mirror...."

Intuitively it seems that adding this single adjective changes the characteristics of what is understood about the passage. For example, the events described in the passage (e.g., reading a paper, making phone calls, putting on a conservative tie, etc.) might be structured into a semantic product that not only includes information *that* certain things took place, but also inferences about *why* they took place. An individual may be likely to infer that the unemployed man is getting ready for a job interview, that he studied the want ads over breakfast, and that he probably cannot afford to buy the washing machine or send his children to camp. Different contexts allow different types of inferences. For example, if *stockbroker* is substituted for *unemployed man*, the individual should be more likely to conclude that the man was getting ready for work, that he studied the financial page over breakfast, and that he probably could afford to buy the washing machine and send his children to camp. These differences in understanding should have empirical consequences for subsequent performance. For example, question answering should reflect the meanings understood in light of the context (e.g., what section of the paper do you think the man was reading?), and the kinds of cues that will remind one of aspects of a story or seem consonant with that story should be determined by the way that it was initially understood (e.g., see Light & Carter-Sobell, 1970; Tulving & Osler, 1968; Tulving & Thomson, 1971).

Restructuring Information in Retrospect

As we can ask whether the activation of various contexts results in different meanings for the same or similar passages, we can ask whether a change in context *after* an initial understanding has been obtained will allow an individual to retrospectively comprehend

(recomprehend). A pilot study, conducted with Nancy Fenrick, provides some information about this question. It involved reading subjects a passage and providing them with "inference cues" that might remind them of aspects of the story. These cues were designed to be effective for subjects hearing the story from an "appropriate topic" perspective, but not for subjects hearing it from its "natural" (i.e., no topic) perspective. The passage is provided below:

> It was 5:30 in the morning and the sun was not yet up. The man got up quietly so as not to awaken anyone and silently got dressed. It was Saturday--a day he had long been looking forward to--and he was glad it had arrived. Once outside he walked along the fence for a while until he came to the break that formed an opening. There he headed for the forest that he so loved.
>
> Since it was spring there was lots of foliage, so the forest was quite dense. He walked for quite a while and enjoyed the view. After some time he thought he heard voices. He looked around but could not see anyone else.
>
> The man came to a clearing in the forest. It was muddy because of the previous day's rain, and his boots sank in deeply. When he came to a little stream he walked up it for quite a while before crossing to the other side.
>
> In front of him darted a rabbit. At first he had an urge to shoot it, but then decided to let it be.
>
> When he finally came to the lake he found his little boat that was moored among the rushes. He had spent many childhood days fishing from this craft, and it was still quite seaworthy. He rowed out to the little island where he and his brother had built their shack for hunting. Everything was as

they had left it the last time. Once inside he took off his shirt and put on his long-loved lumber jacket. It felt much more comfortable than his other clothes, and he liked the looks much better too.

The man turned on his radio to catch a glimpse of what was happening in civilization, and then relaxed with his pipe.

His brother should arrive shortly, and together they would follow the lakes even more deeply into the wilderness, and follow trails where few men had gone before.

Examples of "inference cues" are as follows:

Evidence of pursuers
A concern with the trail and a way to eliminate it
Worry about the sound
A desire to eliminate old identifying factors

From prior experience we knew that most subjects in the No Topic conditions would assume that the above passage was either about a hunter or a man walking through the forest, and we did not expect the above cues to suggest ideas from the information yielded by these points of view. Topic Before subjects, however, were told that the story was about an *escaped convict*. For these subjects, we anticipated a higher probability of the cues mapping into the meanings they had acquired (e.g., that evidence of pursuers referred to the man hearing voices, that a way to eliminate the trail referred to his walking up the river for awhile, that a desire to eliminate old identifying factors referred to his changing out of his prison shirt, etc.).

After all subjects recalled the passage, they were provided with "inference cues" like those mentioned above and told to use them to aid their recall of things they had forgotten. Then they were to answer some questions about the information value of the cues. The cues did not augment recall of the Topic

Before subjects. However, subjects' answers to questions about the information value of the cues suggest some interesting leads. Most subjects in the Topic Before condition (who knew that the passage was about an escaped convict) seemed to feel that the cues related to the story. Some felt that many of the cues made sense immediately, some felt that they had to think awhile before seeing their relevance, and some felt that the cues actually helped them understand the story better. Only one subject said that he failed to see a meaningful relation between the initial story and any of the cues. The responses of the No Topic subjects were quite different. Over half (56%) of the subjects wrote spontaneous comments indicating that the cues actually made them change their initial interpretation of the story or doubt that they had correctly understood the story when it had initially been read. For example, "After thinking about the cues for about 5 minutes I realized that this story was in fact about a man who had a hunting shack but was now using it as a hide-out from the police. I put the story sections I remembered together with the cues and it occurred to me to have a completely different story than the one I described (recalled) first."

Although they are difficult to classify, the subjective reports indicate that the above "information after" condition caused some of the subjects to recomprehend the story--to understand it from a different point of view. The No Topic subjects presumably tried to find some relationship between the cues and the story, and when they were unsuccessful they changed their interpretation of the story in order to accommodate the cues.

Note that this possibility for retrospective comprehension is in contrast to the results of previous studies. For example, there was little effect on comprehension ratings and recall for topic after conditions in the *balloon* or *washing clothes* passages. The lack of context or topic-after effects with these latter passages is probably due to the fact that, unlike the *hunter* passage, these stories were not comprehensible

in isolation; thus, subjects had a difficult time retaining much of what they heard. In order for information to be retrospectively comprehended it must somehow be available, which is unlikely with relatively long, incomprehensible passages after only one acquisition trial. With shorter materials retrospective comprehension is possible and seems to produce the subjective feeling of the "aha-experience" (Buhler, cf. Blumenthal, 1970, p. 51). For example, we have informally presented subjects with sentences like *The notes were sour because the seam was split* and after a few seconds' delay have presented them with relevant contextual information (e.g., bagpipes). The "insight" or "aha-experience" seemed to occur in a very sudden way. The "aha-experience" in the context of a single sentence seems to be a limiting case where non-comprehended information is temporarily available since the material in question is not long enough to tax the limits of short-term memory. Using longer passages, it would be interesting to assess the speed with which inputs may be retrospectively comprehended. In some cases, subjects probably have to recall mentally an initially comprehended story and, in effect, present themselves with a new comprehension trial with a new context in mind. In other cases, the retrospective process might be more abrupt with new information restructuring old information more or less all at once. Studies of the processes by which subjects retrospectively comprehend information should provide interesting hypotheses about some of the ways in which individuals can manipulate and modify what they already know.

Towards a Schematic Characterization of the Problem of Comprehension

The preceding studies, we think, implicate an approach to comprehension that focuses on the relation between input information and the general knowledge available to the subject. Their dominant theme is the reminder that a language is a symbol system that is generally used by individuals for the purpose of

communication, and that the effective use of this symbol system depends on other knowledge available to its users. One implication of this orientation is that an account of comprehension must concern itself not only with an analysis of the linguistic symbol system for communication, but also with a consideration of the knowledge structures to which the symbols are assumed to refer.

The basis for an approach to comprehension that focuses on the relation between input information and general knowledge was provided some time ago by Karl Buhler (cf. Blumenthal, 1971) who emphasized the interdependence between inputs and "fields." According to Blumenthal:

> Buhler's field concept was most important. Given two speakers of the same language, no matter how well one of them structures a sentence his utterance will fail if both parties do not share the same field to some degree. . . There are inner aspects of the field, such as an area of knowledge, or outer aspects, such as objects in the environment. Indeed, the field can be analyzed into many aspects. The total field (Umfeld) consists not only of the practical situation (Ziegfeld) in which an utterance occurs, but also the symbol field (Symbolfeld) which is the context of language segments preceding the segment under consideration. . . . The structure of any particular language is largely field-independent, being determined by its own particular conventional rules, but the field determines how the rules are applied . . . with a 'rich' external field less needs to be specified in the sentence (p. 56).[7]

[7]If the "field" is rich enough, a series of ideas can probably be communicated with minimal input cues and little processing time. For example, at Stony

The studies presented here seem quite compatible with Buhler's general framework. In the present section we shall further consider some theoretical implications of these studies. Although the following discussion is divided into sub-sections, the points discussed are all interrelated, differing more in emphasis than in kind.

Linguistic Inputs Presuppose Appropriate Knowledge of the World

The studies using the *balloon* and *washing clothes* passages were explicitly designed to investigate the consequences of a subject's failure to identify appropriate knowledge domains that were presupposed by input information. Such failures markedly reduced his recall of the material. Although No Context and No Topic subjects reported attempting to discover or generate circumstances that would render the materials meaningful, their lack of success was clearly reflected in the low comprehension ratings they gave the materials. These results suggest that comprehensibility (and presumably linguistic acceptability) is affected by extra-linguistic information. That is, a linguistic input may seem acceptable to one listener and unacceptable to another, depending on the contributions they are able to make from their past experience.[8]

Brook, Carol Ray has presented subjects with three successive lists like the following: Mailman, box, plastic, room, hose, sheet, cigarette, flood. Overall recall scores of subjects receiving an appropriate theme for each list (e.g., *new waterbed*) were higher than those of subjects in several other instructional conditions (e.g., method of loci). Additional pilot data suggest that increasing the presentation rate to 1.5 sec. (from 5.0 sec.) per item has much less of a detrimental effect on the performance of Theme subjects than on that of Method of Loci subjects.

[8]Many recent papers in linguistics discuss the notion that the acceptability of a sentence can be

The dependence between linguistic comprehensibility and general knowledge was also illustrated in the sentence acquisition studies (Figs. 4 and 5). Sentences such as *The house turned to water because the fire got too hot* become readily comprehensible (and were much better recalled) in light of additional information that helps specify referential situations (e.g., *igloo*). This sentence is difficult to comprehend and remember, not because it violates some syntactic constraint governing the use of the word *house*, but because it conflicts with the knowledge that houses do not usually turn to water. Identifying a kind of house that could turn to water, however, renders the sentence intelligible. A similar example is apparent from the sentence *The haystack was important because the cloth ripped*, which is more readily understood in combination with the cue *parachute*. Here the word *parachute* does not simply specify a reading for cloth. It also sets up conditions for realizing the relations between the cloth and the haystack, namely that the parachute was above the haystack when it ripped. These examples illustrate that the contributions that an individual must often make in order to comprehend include more than a specification of appropriate individual referents. He must also generate appropriate relations among entities as well.[9]

---

affected by knowledge from other sources (e.g., see Fillmore and Langedoen, 1971), and the false recognition data shown in Table 2 suggest that subjects often make extra-sentential assumptions in order to justify sentences. The notion that acceptability can be affected by extra-linguistic information implies that a sentence may be acceptable to one individual and unacceptable to another. Perhaps this helps explain why some examples of linguistic "clear-cases" and "non-cases" are not always convincing to everyone, and, more importantly, why one's intuitions about acceptability may change.

[9]The notion that subjects must often be able to specify rather precise conditions in order to comprehend an input suggests that it may be fruitful to view

The fact that information about presupposed knowledge structures may be prerequisite for comprehending inputs indicates that sentences are not always first understood as independent entities and then amalgamated with other information. Instead, there may be important dependencies between activated knowledge structures and comprehension of the inputs themselves.[10]

The Same Inputs Can Have Different Meanings Depending on the Knowledge Structures to which they are Referred

A related aspect of the dependency between activated knowledge structures and comprehension is that not only may such structures be prerequisite for comprehension, but the same inputs may have different meanings depending on the knowledge structures to which they are assumed to refer. The passages about the *Peach March/Space Trip* and *Man/Unemployed/Man* illustrate this point.

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words or phrases as providing cues to semantic structure. A sentence like *The man put the airplane in the envelope*, for example, may be more quickly comprehended if it contains the adjective *toy* (i.e., *The man put the toy plane in the envelope*). Similarly, the sentence *The man escaped from the ice cream cone* may be more readily understood when it includes an adjective that suggests relational aspects of the referential situation (i.e., *The man escaped from the falling ice cream cone*). In ordinary prose or conversation, of course, the referential situation is often given by preceding inputs. For example, a paragraph from a well-known study by Sachs (1967) contains the sentence *On the next night all were to the west*. The preceding sentences indicate that the sentence referred to Galileo looking at Jupiter's moons.

[10]Other studies showing that the situation to which an input refers can affect how easily it is understood include Slobin (1966); Huttenlocker, Eisenberg and Strauss (1968); Huttenlocker and Strauss (1968); Huttenlocker and Weiner (1971).

At first glance it may appear that examples such as these show only that sentences can be ambiguous, and that different knowledge structures may disambiguate sentences in different ways. We think that the relation between linguistic inputs and referential knowledge structures can be much more dynamic than is implied by the general notion of linguistic disambiguation, however. To illustrate with an example that is somewhat simpler than a whole passage, consider the sentence *The woman was worried that the rope might break* in light of the four situations (contexts) shown in Fig. 6. Each context suggests different reasons for worrying about the rope breaking: e.g., (a) because the mirror would fall (and might break); (b) because the lamp would fall (and maybe break the mirror); (c) because the clothes would fall; (d) because the man would fall. The availability of these reasons is based on perceived implications of the input (i.e., of the rope breaking) in light of each context.[11] In addition, the perceived implications of inputs may yield referential situations that are presupposed by subsequent inputs. For example, the sentences *The rope broke/The woman was angry about the mirror* are interrelated sentences from the perspective of the first two contexts (e.g., they could be connected by *so*) but not from the perspective of contexts (c) and (d). Thus, inputs modify structures and these modified structures are, in turn, referents for subsequent inputs. In general, the meaning derived from inputs should depend on their implications for the structures to which they are referred.

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[11]The following sentence is a similar example: *The man escaped from the situation.* If the situation in question is an airplane, *escape* may involve parachuting, whereas if the situation is a boat, *escape* may involve swimming. It might be profitable to consider word meanings as abstract constraints governing more precise specifications that occur in particular contexts. This would seem to allow for the possibility of variance as well as abstract invariance in meaning.

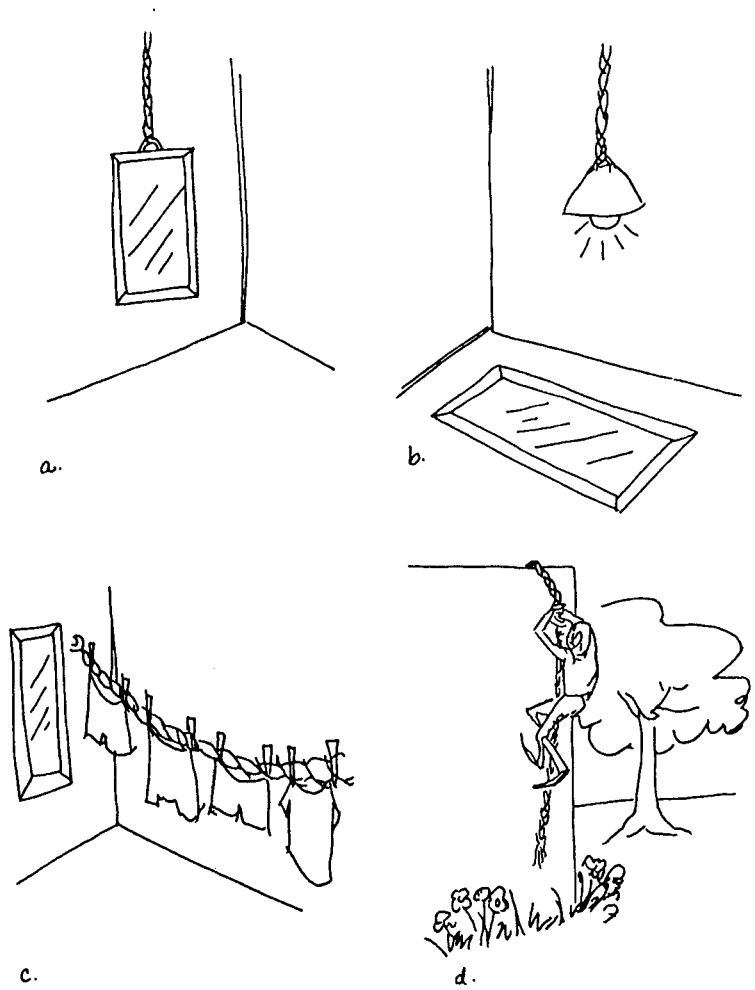

Fig. 6. Four contexts for *The woman was worried that the rope might break.*

A consideration of the dynamic interplay between inputs and knowledge structures suggests some speculations about why the appropriate context (Fig. 1) for the *balloon* passage aided comprehension but the partial context (Fig. 2) did not. Given either context, the subjects' initial assumption was probably that the sentences in the passage referred to the context provided. For the appropriate context, the first phrase of the passage (i.e., *If the balloons popped . . .*) had definite implications, namely that the speaker would fall. Since the distance between the ground and the girl was considerable, a possible consequence of the speaker falling was that the girl could no longer hear the boy's voice. The availability of the latter information thus allowed the subject to understand what was being referred to by the phrase *the sound could not carry* (which was the second phrase of the passage).

For the subjects receiving the partial context picture, the phrase *If the balloons popped* also had certain potential implications (e.g., that the balloons would no longer tug at the strings held by the boy) but none which could easily serve as a basis for relating *the sound could not carry* to the situation suggested by the initial phrase. Of course, given different information the partial context could serve as an adequate referential structure. In short, the notion of an "appropriate" context is relative to the input information that is to be processed.[12]

[12]It should be possible to develop experimental situations which are sensitive to the processes by which inputs are related to other knowledge structures. For example, if different structures require different amounts of modification in order to accommodate an input (or if different inputs require different amounts of modification of the same context), measures of comprehension time might reflect the number of implicational steps involved. Such a paradigm might provide more systematic information about the processes by which subjects amalgamate input information with other available knowledge.

Memory may Include Extra-Linguistic Information

Many theories of language processing tacitly assume that sentences are treated as self-contained objects. They thus assume that the semantic reading directly assigned to a sentence exhaustively characterizes what is understood and stored (e.g., Katz & Postal, 1964). Although it is possible, of course, for subjects to treat linguistic inputs as objects to be remembered, recent evidence from memory studies indicates that subjects often are not simply storing either the surface (Sachs, 1967) or the deep structures (Bransford, Barclay, & Franks, in press; Bransford & Franks, 1971) of individual sentences. For example, when related sentences are included in an acquisition list, the subjects' performance in a recognition task may be based on an integration of the ideas expressed by several sentences (Bransford & Franks, 1971). And input sentences may be amalgamated with previous knowledge to yield semantic products specifying more information than was expressed in the input. False recognition studies indicate that subjects are likely to make assumptions about spatial relations (Bransford, Barclay & Franks, in press), and about instruments (*John was using the hammer . . .*), consequences (*The spy burned the secret document . . .*) and antecedent conditions (*John wanted to walk to school . . .*).

The general pattern of these results indicates that subjects spontaneously make assumptions about extra-linguistic circumstances and draw on a wide range of prior knowledge in doing so. The subject's memory for a sentence or sets of sentences will therefore be a function of how he uses what he knows to interpret what he hears, and of how he uses this interpretation to modify what he already knows.[13]

[13]The view that subjects may treat sentences as cues to activate and modify general knowledge structures --rather than simply as information to be stored--may help in understanding the bases for some idiosyncratic distortions in recall. For example, subjects sometimes recall sentences which are related to input information

What is Understood and Remembered can Depend on the Uses to which Information is Put

In the preceding sections we have argued that what is understood and remembered about an input depends on the knowledge structures to which it is related. In the present section we shall consider implications of the fact that an input can be related to a particular knowledge structure in different ways. For example, an input may be judged true or false with respect to another source of information. Presumably this process of verification may proceed without significantly altering the referential knowledge structure. On the other hand, an input can be viewed as further information about some knowledge structure. The input may then cause a restructuring of (or an elaboration of) the old structure such that new information is acquired. The manner in which an input is related to a knowledge structure may thus influence the processes of knowledge acquisition. We think that this is demonstrated in the pilot study below.

In conjunction with Nancy McCarrell, we conducted an experiment designed to manipulate the manner in which inputs were related to a specific structure. All subjects were tested simultaneously and each subject received one of three sets of written instructions. All instructional conditions informed the subjects that they were in a two-part experiment and that during Part 1 they would hear a story. One group of subjects (Verification) was told that in Part 2 they would hear a series of statements and that their task was to decide (and to write down on an answer sheet) whether each statement was true or false with respect to the story.

but which cannot be said to be direct paraphrases of input information. Thus, a sentence like *The University President demanded that the barricades be removed immediately* might be recalled as *The University President demanded that the students immediately leave the occupied building.*

They were instructed that true referred to any reasonable paraphrase of events described in the story and that false meant that the statement contradicted information conveyed by the story. The other two instructional conditions will be described after the stimulus materials are presented. Parts 1 and 2 are given below (consider them in light of the above instructional condition):

Part 1

The man got into his pick-up truck and drove to the store in the nearby city. He knew that this was the last day of the special sale. He wanted to buy a hat and coat while the special prices were still in effect. The streets near the store were very crowded and there was no place to park. He drove round and round. After 10 minutes he returned to a dead-end alley he had noticed earlier. The alley was a couple of blocks away from the store. The man parked in the alley, got out of his truck and started walking. It began to drizzle and he worried whether the store was as close as he thought it was.

Part 2

The man returned to the alley/ The man got into his pickup truck and drove towards the the store/ After searching, the man finally saw a place to park/ The parking space was only a few feet from an entrance to the store/ The man was not worried about the rain/ The man bought a specially priced coat but not a hat/ The man was happy about the sale/

Subjects in the other two conditions, Acquisition (U/P) and Acquisition (Y/N), were informed that each statement in Part 2 represented a continuation of Part 1 in order to induce them to view the statements

as a potential source of further information about the man's activities. These two conditions differed with respect to the written rating task the subjects performed during Part 2. Acquisition (U/P) subjects were to decide whether each statement seemed pleasant or unpleasant given the initial story. Acquisition (Y/N) subjects were instructed to write "yes" if a statement in Part 2 represented a comprehensible extension of Part 1 and to write "no" if it did not.

One minute after the completion of the Part 2 task, all subjects were given a surprise recall test. They were informed that information in Part 2 really represented an extension of Part 1, and were asked to attempt to recall the information in order of presentation if they could, but were encouraged to recall in any order if they could not remember the exact order in which events occurred.

Following the recall test, all subjects were informed about the experiment and were told to listen to both Parts 1 and 2 as a single story. Subjects were then asked to indicate whether, during the actual experiment, they had been aware of the fact that information in Part 2 could have represented a continuation of Part 1. If subjects indicated that they had noticed this relationship, they were also asked to indicate whether they had noted a little, a moderate, or a lot. Of course, we expected subjects in the two Acquisition conditions to indicate that they had noticed the continuation since they had been led to expect it by instruction. Of primary interest was whether or not Verification subjects would detect the potential continuation relationship between Parts 1 and 2. As can be seen in Table 10, most subjects in the Verification

Table 10. Awareness Ratings

	Verification	Acquisition (U/P)	Acquisition (Y/N)
No	16	1	1
Yes			
A Little	8	1	4
Moderate	1	6	6
A Lot	0	18	14

condition were not aware that Part 2 could be an extension of Part 1. Further, most of the subjects who did respond "yes" were only slightly aware of the continuation.

The mean number of ideas recalled (scored for paraphrases and without regard for correct serial order) are given in Table 11. The three conditions exhibited equivalent Part 1 recall. In recalling Part 2, however, subjects in the verification condition were markedly inferior to subjects in the other two conditions.

The awareness data in combination with the recall data suggest that under conditions where all subjects are processing information semantically, the consequences of this processing may depend on the assumed relationship between an input and the presupposed referential structure. That is, with the same inputs, different things may be understood.[14]

Table 11. Mean Number of Ideas Recalled

	Verification	Acquisition (U/P)	Acquisition (Y/N)	Maximum Score
Part 1	9.36	9.08	8.80	11.00
Part 2	2.84	5.84	5.00	7.00

[14]Recent evidence (e.g., Bobrow & Bower, 1969; Hyde & Jenkins, 1969; Johnston & Jenkins, 1971) indicates that memory for words is better if subjects are asked to perform tasks during acquisition that presuppose semantic processing than if they are directed to perform tasks that require them to focus on more formal properties of the inputs. The results of the present pilot study suggest that even when subjects are presumably successfully processing the information semantically, the uses to which the information is put may influence its availability on a subsequent recall task.

Recently, many investigators have concentrated on processes involved in verifying the relation between sentences and knowledge structures (e.g., Chase & Clark, 1972; Clark, in press; Collins & Quillian, 1969, 1970; Trabasso, in press). Our experiments have generally involved situations where the subject is attempting to modify or acquire new information about knowledge structures. It would appear fruitful to compare more carefully the effects on comprehension of different task sets.[15]

Although additional research is needed, the above study also suggests the possibility of a very complex relation between comprehension and knowledge acquisition. Semantic processing may involve options such as whether or not to modify various knowledge structures, whether or not to create new ones, whether or not to judge the truth value of a statement or presuppose its truth value and see what its implications might be.[16] What is acquired from an input may thus depend on the ways in which it is related to existing knowledge domains.

[15]See Dooling (in press) for an example where comprehension times are affected by differences in task set.

[16]Different syntactic forms probably influence the way subjects react to various inputs. For example, we have asked subjects to write down their first response (from the set of responses *True*, *False*, *Comprehensible*) to each of a list of unrelated sentences. Sentences like *Girls wear dresses* and *Canaries eat cigarettes* generally are given True and False responses, respectively. In contrast, subjects tend to respond Comprehensible to sentences like *The girls wore dresses* and *The canaries ate the cigarettes*. In further investigating how subjects draw upon knowledge available from long-term memory in processing information (e.g., Collins & Quillian, 1969, 1972), it might be interesting to compare the time to verify sentences like *Sharks have large fins* and *Sharks have tough skin* with comprehension times for sentences like *The sharks had large fins* and *The sharks had tough skin*.

Concluding Comments

The present paper has been concerned with the question of linguistic comprehension. We have tried to show that one may not be able to process linguistic inputs effectively without access to a substrate of additional information. Such prerequisite information may be derived from non-linguistic experiences (e.g., visual inputs) as well as from prior sentences. Therefore, questions about linguistic processing cannot be completely separated from questions about the processing of other information.

The results of the studies reported here do not dictate a detailed model of comprehension, but they suggest to us a general orientation towards the problem of linguistic comprehension that places it squarely within the domain of cognitive psychology, and that generates questions for future research. We have emphasized that aspects of the comprehension process may involve mental operations on knowledge structures and the realization of the implications of these operations. In addition, we have argued that information about the consequences of such operations--rather than information only about the input itself--may be necessary for comprehending subsequent inputs and may be an important part of what is available in memory tasks. Hopefully, the development of paradigms to investigate comprehension as a function of the degree of modification of knowledge structures which is required, and of paradigms to determine the locus and time course of inferences, will clarify the thinking processes involved in comprehension and will clarify the relationship of understanding to the acquisition and retention of information.

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