UNDERSTANDING PARAGRAPHS

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1. INTRODUCTION

Rieger's thesis (Rieger (1974)) claims that as a "reflex response" in memory, a large number of inferences are made from an input sentence. This number is so large as to make the process of understanding texts quite difficult. Tremendous numbers of inferences would be stored with each input sentence. The problem, it would seem, is to cut off the inference process in some non-arbitrary way. That is, ideally we would want to know that in certain situations only a small fraction of the possible set of inferences would have to be made. Such a resolution would be helpful for two reasons. First, we would have a theory of which inferences people are likely to remember in which circumstances. Second, we could limit the amount of storage space that would have to be assigned to an input sentence. This second goal, of course, would reduce the problem of understanding texts to a computationally manageable one.

One possible way to make this necessary reduction of the inference space is to examine sentences within the contexts that they appear. Processing a new sentence then, becomes partly the problem of relating it to other sentences that have occurred before it and partly the problem of understanding the new input in terms of the goals of the understander.

All understanding mechanisms to some extent bring to bear their prejudices and goals upon any new input. Thus, it is not really legitimate to ask how a human understands a text. But we can ask how, in principle, it is possible to relate the sentences of a text to each other. We would suspect that a certain amount of inference must be done in order to accomplish this task. If the process of relating together sentences in a text delimits the amount of inference that must be done then some important things will have happened. First, many of the inferences that might have been made for each individual sentence, might not be necessary for processing a text as a whole. This should save us computation time as well
as allowing for the processing of text in a more goal-oriented fashion. Second, if we know what a meaning representation for a text looks like, we will have an idea what the basic structure should be in memory after a text has been understood. This structure would be the basis for adding the inferences that individual differences and goals would cause to be made. Third, a representation for the meaning of a text should provide some idea of the relative importance of certain information in the text. This would be basic to any theory of paraphrase or summary of texts.

So we pose the question of exactly how units larger than the sentence are understood. That is, what would the resulting structure in memory look like after say six sentences which form a paragraph have been input? Obviously, there must be more stored than just the conceptual dependency representation for each of the six sentences, but we would rather not store all possible inferences for each of the six sentences. Ideally what we want is to store the six sentences in terms of the conceptualizations that underlie them as an interconnected chain. That is, we shall claim that the amount of inferencing that is needed to represent the meaning of a paragraph of six sentences in length is precisely as much as will allow for the creation of a causal chain between the original conceptualizations.

This would obviously have ramifications in units of discourse larger than the paragraph. A text then, would exist conceptually as a series of interconnected causal chains of conceptualizations.
II. GOALS AND BACKGROUND

What is the optimal representation for a text? The conditions that an acceptable answer must meet are these:

1) The representation should be unique and unambiguous.

2) The representation should not lose any of the information present in the text.

3) The representation should include any inferences that are necessary in order to join together the various pieces of the text.

4) The representation should focus on the items of major importance to the meaning of the text as a whole.

Points one and two are handled adequately by Conceptual Dependency theory (see Schank (1973a)), for individual sentences. We assume that a solution to point (3) that utilizes Conceptual Dependency will constitute a solution to points (1) and (2) for texts.

We will consider then how the sentences of a text are joined together. We shall do this assuming all the while that the conceptualizations underlying a text must necessarily be joined together in some fashion. Otherwise we would not have a coherent text. So, in addition to finding a conceptual representation for texts we should at the same time find a means of deciding when a text is not coherent. We shall have to create coherency rules in order to combine conceptualizations. When we cannot make these combinations we will have incoherent texts.

The work presented here will by no means totally solve the problem of text representation. At least two works are probably complementary to that presented here; that of Abelson (1973) and Charniak (1974). Both of these researchers have many useful things to say about how sentences relate to each other in texts. In addition Riesbeck (1974) and Rieger (1974)
have been concerned with computer implementations that read sequences of sentences and much of their work is assumed to be complimentary to what we will say here.

We shall also touch on the problem of paraphrase as an obvious ramification of a solution to the above. Goldman and Riesbeck (1973) have had a paraphrase program that functions very well for semantic paraphrases of individual sentences. Some examples of the power of their program are given below:

**INPUT:** John killed Mary by choking Mary.

**OUTPUT1:** John strangled Mary.

**OUTPUT2:** John choked Mary and she died because she could not breathe.

**OUTPUT3:** Mary died because she was unable to inhale some air and she was unable to inhale some air because John grabbed her neck.

**INPUT:** John prevented Bill from giving a banana to Mary by selling a banana to Rita.

**OUTPUT1:** Bill was unable to give a banana to Mary because Rita traded John some money for a banana.

**OUTPUT2:** Mary could not get a banana from Bill because Rita bought a banana from John.

In considering the problem of paraphrase of texts we shall assume the results of the above program essentially solve the sentence to sentence paraphrase problem.

Our goal is to combine input sentences that are part of a paragraph into one or more connected structures that represent the meaning of the paragraph as a whole. While doing this we want to bear in mind the following:

1) A good paraphrase of a paragraph may be longer or shorter (in terms of the number of sentences in it) than the original.

2) Humans have little trouble picking out the main "theme" of the paragraph.

3) Knowing what is non-essential or readily inferable from the sentences of a paragraph is crucial in paraphrasing it as well as parsing it.
III. NECESSARY CONDITIONS

Consider the following three paragraphs constructed from a base paragraph. The base paragraph is:

BP: John began to mow his lawn. Suddenly his toe started bleeding. He turned off the motor and went inside to get a bandage. When he cleaned off his foot, he discovered that he had stepped in tomato sauce.

Paragraph I is: It was a warm June day. (followed by) BP.
Paragraph II is: It was a cold December day. (followed by) BP.
Paragraph III is: John was eating a pizza outside on his lawn. He noticed the grass was very long so he got out his lawn mower. (followed by) BP.

Within the context of a paragraph, a sentence has a dual role. It has the usual role of imparting information or giving a meaning. But, in addition, it also serves to set up the conditions by which sentences that follow it in the paragraph can exist. Thus in order for sentence Y to follow sentence X in a paragraph, the conditions for Y must have been set up. Often these conditions will have been set up by X, but this is by no means necessarily the case. The conditions for Y might be generally understood, that is, part of everyday knowledge, so that they need not be set up at all.

By a necessary condition, we mean a state (in Conceptual Dependency terms) that enables an ACT. Thus, one cannot play baseball unless one has access to a ball, a bat, a field to play on etc. The conditions that are necessary in order to do a given ACT must be present before that ACT can occur.

It is thus necessary, in order to understand that a given ACT has occurred, to satisfy oneself that its necessary conditions have been met. Often this requires finding a causal chain that would lead to that condition being present. That is, if we can't establish that John has a bat, but we can
establish that he had some money and was in a department store, we can infer that he bought one there if we know that he has one now. Obviously there are many possible ways to establish the validity of a necessary condition. Often, it is all right just to assume that it is "normally" the case that this condition holds. (Rieger (1974) makes extensive use of this kind of assumption in his inference program). Establishing or proving necessary conditions is an important part of tying diverse sentences together in a story (John wanted to play baseball on Saturday. He went to the department store.) It is also, as we shall see, an important part of knowing when a paragraph doesn't make sense.

Thus, the problem of representing a paragraph conceptually is at least in part the problem of tying together the conditions set up by sentences with the sentences that required those conditions to be set up. In the Base Paragraph (BP) no conditions have been set up under which tomato sauce could reasonably be considered to be present. Thus BP does not hang together very well as a paragraph. However, in paragraph III the conditions for tomato sauce being present are set up and the last sentence of BP can be tied to those conditions. Thus III is an integral paragraph. We should note again that normality considerations serve to eliminate the necessity for setting up conditions. Thus, there is no need to set up "bandage's" existence in BP since people can normally be assumed to have a bandage in their house. However if the third sentence of BP were replaced by: "He took a bandage off of his lawn mower," there would be problems. That is it is the normality conditions set up by being in one's house (and presumably in the bathroom) that suffice for bandage's existence.

What we are seeking to explain then, is what the entire conceptual representation of a paragraph must be. It can be seen from the above that in our representation of BP, it might well be argued that "bathroom" and "medicine cabinet" are rightfully part of the representation. That is, a paragraph is a great deal more than the sum of its parts conceptu-
ally. The conceptual representation of a paragraph is a combination of the conceptualizations underlying the individual sentences of the paragraph plus the inferences about the necessary conditions that tie one conceptualization to another or to a given normality condition.

Let us consider the connectivity relationships in paragraph I. We shall do this by looking at the necessary conditions required for each conceptualization and established by that conceptualization for subsequent conceptualizations.

Sentence 1, (It was a warm June day) (henceforth S1), consists of two details. One is that the time of some unspecified conceptualization was a day in June. The other is that the temperature for that day was warm (or to be more precise greater than the norm for that season). These two states can be considered to be setting up all warm weather activities. It is not the case that these consitions must be set up in order to input a piece of new information input that involves such events (i.e. a warm weather activity).

What is the case is this: 1) The set up conditions invalidate any activities for which contradictory conditions would be necessary. 2) If these conditions are not explicitly stated, we can assume that if new input information required them, they or something like them, will have to be inferred.

Less abstractly we have the following. Suppose S1 were followed by an S2 such as:

S2.1 John put on his overcoat.
S2.2 John began to build a snowman.
S2.3 John decided to rake the leaves.

The fact that people would find such two sentence sequences bothersome, if not absurd, indicates that part of the process of understanding is the tying together of necessary conditions and established conditions. Necessary conditions are backward looking inferences that must be generated for each input conceptualization. For S2.1 we would have something like--"check to see if the necessary condition for this action (coldness) has been established. If it has not been, then infer it
unless a contradictory condition has been established in which case there is an anomaly".

Established conditions are forward looking inferences. These are states that are inferable from an input conceptualization. Often established conditions are input directly and need not be inferred at all. Thus S1 consists of two established conditions. Neither of these conditions are called into play until a request for their existence is received from a following new input conceptualization.

Now the actual S2 in paragraph I is "John began to mow his lawn". S2 sends out requests for the appropriate necessary conditions for S2 to be satisfied. Some of these are: (a) John has a lawn; (b) John has a lawn mower; (c) John's lawn has grown to a length such that it might be mowed; (d) It is a pleasant day for being outside.

It can be seen from these four conditions that they are not all equal. That is (a) and (b) are of the class of necessary conditions that we shall call "absolutely necessary conditions" (ANC's). An ANC is a state that must be present in order to enable a given ACT to take place. If an ANC is violated a sentence sequence is construed to be anomalous. Conditions (c) and (d) however are the more interesting. They are what we shall call "reasonable necessary conditions" (RNC's). An RNC is a state that is usually a prerequisite for a given ACT. If an RNC is violated, the story sequence is not interrupted. Rather a peculiarity marking is made. These peculiarity markings turn out to be a crucial part of story understanding because they are predictive. That is, the sequence "It was a cold December day. John walked outside in his bathing suit," predicts a to-be-related consequence that is likely the point of the story. What makes this prediction is the peculiarity marking that would be generated from the established violation of the RNC involving warm weather necessary for walking outside scantily clad.

For S2, if S1 had been "It was a cold December day" a violation of an RNC would result if the information that lawns
don't grow in December were present in memory and it were accessed. The resultant peculiarity marking (PM) would predict either that this action had an interesting consequence that was the point of the story, or that John was a bit odd.

Necessary conditions are thus a subset of the set of possible inferences. They are precisely the set that is commonly used to connect isolated conceptualizations together. Necessary conditions are checked by means of establishing whether there exist records of them in memory. First, there is an attempt to tie them to information already present from previous sentences. This is done by use of the general facts in memory (e.g. about warm weather and lawns). If such facts are formed an enable causation link is established between the previously input or inferred state and the new input conceptualization.

If no such information can be found, memory is checked to see if this information is present from some other source. If this connection cannot be made, then normality conditions (see Rieger (1974)) are examined. That is, it is quite usual for people to possess lawns and lawnmowers so the fact that nobody told us this about John isn't upsetting. (Of course, if we knew that John lived in an apartment then an ANC would be violated and there would be trouble.) If the connection can be established from normality information, then the new states involving this normality information are inferred as being the case in this particular instance (i.e. John has a lawn is inferred). When none of this can be done, a severe problem in the cohesion of the story (for the listener) exists.

Continuing with paragraph 1, after checking the necessary conditions for S2, the next problem is to infer the set of states that will serve as the necessary conditions for S3 or subsequent sentences. Obviously to guess what the required necessary conditions will be for subsequent sentences is foolish indeed. Rather it is more reasonable to wait to see what necessary conditions will be required. For example, for S2, the following are some of the established conditions that one
could infer:

    Blades are rotating.
    John is walking.
    John's arms are in a horizontal position.
    Grass is lying, newly cut, on the ground.

The interesting part of paragraph connectivity comes when we examine S3 (Suddenly his toe started bleeding).

How can we connect S3 to previous information? In fact humans do it with little trouble. The main problem is to realize that for something to happen, an event that can cause that happening must have occurred. So the question is generated, "what can cause bleeding in people?" There are, of course, many possible answers to this question. The easiest procedure is to couple the former question with an inquiry as to whether the established conditions demandable from any previous information in the text can have results that might be "a human bleeding" under the right circumstances. Working in both directions at once, we can establish a chain from "blades turning" to "toe bleeding" if we hypothesize contact between blade and toe. The syntax for causality in this chain follows exactly the same lines as proposed in Schank (1973b).

The procedure is as follows: we are looking for an ACT that can cause a state change (to cut) which can enable the ACT that we were told about (toe bleed). We know that mowing a lawn includes having blades moving and that this is a candidate for such an ACT. Thus we have established a chain "ACT result STATE enable ACT" which is the basic causal chain discussed in Schank (1973b). The chain can be verified if there is reason to believe that the PROPEL ACT involved in lawn mowing could have had as object John's toe. This must be proved before the chain can be considered plausible.

The kind of inference outlined above has been considered in some detail (including programming some examples on the order of complexity shown here) by Rieger (1974). We shall have no more to say here about the process of tying together these causal chains since both of the above mentioned papers
expend considerable time on that problem.

However, we do wish to point out an additional feature. The syntax of causality discussed in Schank (1973b) is in fact useful far beyond the level of analyzing sentences that have some causal word in them. In fact, the entire problem of the representation of paragraphs is dependent upon the causal chains presented in the above mentioned paper. That is, a paragraph can be considered to be a series of conceptualizations that must be joined into a complete causal chain conceptually by means of inferring the states that result from these conceptualizations that enable the other conceptualizations in the paragraph to take place.

Let us now consider what the final representation of paragraph I should be.

(In our representation we shall use a simplified Conceptual Dependency diagram, consisting of a parenthesized expression in the order: (ACTOR ACTION OBJECT X) where X is any other relevant case that we choose to include. State diagrams are written: (OBJECT NEWSTATE). Causals are as used in Schank (1973b): r=result; IR=an MBUILD action that is a reason; E=enable. Necessary conditions are abbreviated as ANC's or RNC's. S's designate input sentences. INF's designate inferences needed to complete causal chains. The time of an event or state is relative to the others around it. That is, higher on the page equals earlier, lower later.

Appendix I lists the information on ACTs in Conceptual Dependency necessary to understand the rest of this paper. Appendix II lists the causal information explained in Schank (1973b).
The above is the final representation of the paragraph except for the following:

1) Normally the IR causation (located around $S_4$) would have to be expanded. In this case there would have to be a belief about what bandages had to do with bleeding body parts. This belief would be part of the MBUILD structure that supplied the reason for the rest of $S_4$.

2) All the ANC's would have to be accounted for. This would be done as the paragraph was being processed.

The ANC's for the above paragraph are as follows:

$\text{ANC}_1$, $\text{ANC}_2$, ...: These specify that John has a lawn and a lawn mower and can push it, etc.

$\text{ANC}_3$: John has a toe and he wasn't wearing shoes, etc.

$\text{ANC}_4$: John has a house, it's nearby and he can get in, etc.

$\text{ANC}_5$: John has a bandage in his house, and he can find and get it.

$\text{ANC}_6$: This is provided by $S_5$. Thus the entire structure causally related to $\text{ANC}_6$ establishes another chain apart from the actual story.

$\text{ANC}_7$: This is specified by the next part of $S_5$.

$\text{ANC}_8$: This is the condition that tomato sauce be in a place where John might have stepped in it.

Two important things follow from an examination of the representation of paragraph I:

1) Conceptually, a paragraph is essentially a set of causal chains, some leading to dead ends and at least one carrying on the theme and point of the story.

2) As long as required necessary conditions can be
established and inferences necessary to complete causal chains can be resolved, a paragraph is coherent and understandable. When these processes are too difficult or impossible problems result.

In paragraph I, of course, the main problem is that while ANC's 1 through 5 are easily satisfied by everyday normality conditions, ANC_8 is unresolvable in this way. There is thus no way to make sense of paragraph I because there is no way of inferring ANC_8.

Now, in paragraph III on the other hand, ANC_8, when it is discovered, is easily resolvable. (PIZZA LOC (LAWN)) is a possible result of the first sentence (John was eating a pizza outside on his lawn). If the problem of knowing that a pizza contains tomato sauce is resolvable, then so is ANC_8. In that case, an ANC would be resolved from within the given paragraph as was done for ANC_6 and ANC_7 in paragraph I.

Some additional comments that can be made about the representation of paragraph I are:

1) INF_1 is a deadend. Short grass may be the condition for something, but this story does not tell us nor make use of it. Deadend paths in a story indicate items of less importance in the story. This information is crucial in the problem of paraphrase of paragraphs since it tells you what you can leave out.

2) INF_3 is one of the most important inferences in the story. It comes from the information provided by S_3 which yields INF_2. Basically INF_3 is a subpart (denoted by |) of S_2. That is, it is the identical action to S_2. It is just a different viewpoint on the same action. This different viewpoint can be considered to have different inferences and results that follow from it.
3) The information about turning the lawnmower off is another deadend. In fact, there was no reason for this information to be in the story at all.

4) INF₄, INF₅ and INF₆ are crucial to a story that has not been told. What has happened is that the attempted resolution of ANC₆ has interrupted the flow of the story. Inside the resolution of ANC₆ we have had to resolve ANC₈ which causes us to quit.

Diagrammatically we can view the story as follows:

That is, from various sources of information we can construct a path that sets up C₃. One of the inferences from C₃ is fruitful in that it provides a chain to C₇. Two paths come from C₇, one is fruitful in leading us to C₁₀ (whose conditions can be explained by ANC₄). On our way to C₁₅, we try to establish ANC₆. Doing so leads to a direct path to C₁₆. However, in order to prove the conditions for C₁₆ we need ANC₇ (which is part of S₅) which needs ANC₈ which cannot be determined.
IV. REMEMBERING

We have established in the previous section some basic principles regarding what we would expect to be the result in memory after a paragraph has been input.

1) The conceptual dependency representation of each input sentence is included.

2) All sentences should be, in principle possible to be connected to each other.

3) The basic means of connecting the conceptualizations underlying the input sentences to each other is the causal chain.

4) Inferences from the input conceptualizations are part of the representation of the total paragraph if they are used in order to connect input conceptualizations into a causal chain.

5) The necessary conditions must be satisfied for every represented conceptualization. This is done by inferring facts both from inside and outside the paragraph. Inferences made from outside the paragraph proper are still part of the representation of the total paragraph.

6) Stories can be viewed as the joining together of various causal chains that culminate in the "point" of the story. Dead end paths that lead away from the main flow of the story can thus be considered to be of lesser importance.

From the point of view of paraphrasing tasks or the problem of remembering, the things most likely to be left out in a recall task are: the dead end paths; the easily satisfied necessary conditions, whether they were explicit in the original paragraph or not; and, the inferences that make up the causal chain that are "obvious" and easy to recover at any time.
In order to better examine the validity of our predictions about memory and the usefulness of our representation for stories, we shall now attempt to diagram the well known "The War of the Ghosts" a story used by Bartlett (1932) for experiments in memory. We are not interested here in all the facets of memory that Bartlett considered. But some of the problems that he concerned himself with can be handled more easily using our representation.

The story is:

One night two young men from Egulac went down to the river to hunt seals, and while they were there it became foggy and calm. Then they heard war-cries, and they thought: "Maybe this is a war-party". They escaped to the shore, and hid behind a log. Now canoes came up, and they heard the noise of paddles, and saw one canoe coming up to them. There were five men in the canoe, and they said:

"What do you think? We wish to take you along."

We are going up the river to make war on the people".

One of the young men said: "I have no arrows".

"Arrows are in the canoe", they said.

"I will not go along. I might be killed. My relatives do not know where I have gone. But you", he said, turning to the other, "may go with them."

So one of the young men went, but the other returned home.

And the warriors went on up the river to a town on the other side of Kalama. The people came down to the water, and they began to fight, and many were killed. But presently the young man heard one of the warriors say: "Quick, let us go home: that Indian has been hit". Now he thought: "Oh, they are ghosts". He did not feel sick, but they said he had been shot.

So the canoes went back to Egulac, and the young man went ashore to his house, and made a fire. And he told everybody and said: "Behold I accompanied the ghosts, and we went to fight. Many of our fellows were killed, and many of those who attacked us were killed. They said I was hit, and I did not feel sick".

He told it all, and then he became quiet. When the sun rose he fell down. Something black came out of his mouth. His face became contorted. The people jumped up and cried.

He was dead.

We now present the representation for that story, using the principles expounded above. We shall make use of causal
abbreviations to save space only. That is, what people make up to fill in missing causals is obviously an important part of the problem of paragraph representation. However, when the task of filling in the causal chain is obvious and unambiguous, we shall abbreviate. Thus, RE will be used when the resultant change that is enabled is obvious and unimportant. IR will be used when the thought that was MBUILDeed is reasonably obvious and straightforward. For simplicity we shall leave out the necessary conditions that are an uninteresting part of the understanding of the story (e.g. that there were seals in the river for $S_1$).
C30: (nMEN \_2 LOC TOWN (NEAR KALAMA))

C31: (PEOPLE \_3 ATTEND EYES 6MEN \_2)

C32: (PEOPLE PTRANS PEOPLE \_3 WATER)

C33: (PEOPLE DO)

C34: (1PEOPLE \_3 DEAD)

C35: (1MEN \_1 HURT)

C36: (1MEN \_2 MTRANS)

C37: (1MEN \_1 MBUILD)

C38: (1MEN \_1 HEALTH (SICK))

C39: NOT (1MEN \_1 MBUILD C38)

C40: (1PEOPLE \_3 PROPEL ARROW 1MEN \_1)

C41: (1MEN \_2 MTRANS C40 1MEN \_1)

C42: (1MEN \_2 PTRANS 1MEN \_2 EGULAC)

C43: (1MEN \_1 PTRANS 1MEN \_1 HOUSE (1MEN \_1))

C44: (mMEN \_1 DO)

C45: go to C48
C45: (SOMETHING BURN)

C46: (1MEN₁ WARM)

C48: (1MEN₁ MTRANS C29-C39 PEOPLE₄)

C49: NOT (1MEN₁ SPEAK)

C50: (SUN PROPEL SUN UP)

C51: (PROPEL 1MEN₁ GROUND)

C52: (1MEN₁ EXPEL SOMETHING MOUTH)

C53: (SOMETHING COLOR BLACK)

C54: (FACE (1MEN₁ CONTORTED

C55: (PEOPLE₄ EXPEL TEARS)

C56: (1MEN₁ DEAD)

C40

C47: (PEOPLE₄ PTRANS PEOPLE₄ HOUSE)
In this diagram the following facts should be pointed out:

1) The fact that nothing follows from C2 indicates that it can be easily forgotten.
2) C4-C6 are less important than the flow to C7 that leads to the basic story. No use is ever made again of C4-C6.
3) This occurs again when C12 leads directly to C18 indicating that C16 and C17 are unimportant filler.
4) Two separate events C12 and C13 lead to C18 indicating C18 to be of major importance.
5) The causal chain between C22 and C23 involves an unstated MBUILD that is important in understanding C23-C25. Namely, the first man doesn't want to go on the trip. This fact however, turns out to be unimportant for the story as a whole.
6) Two events enable a third, (C30 and C32 enable C33) indicating that the third is very important.
7) We can infer that C33 leads to C35, but later we are told about C40 which is an instantiation of C33. It is C40 that really leads to C35. Nonetheless the double connection again denotes importance.
8) According to the logic of MBUILDing presented in Schank (1973b) this MBUILD comes from nowhere and is illogical. The fact that C37 leads to nothing indicates that it is probably unimportant to the story but a PM must be generated that might dispute this. The function of the PM here could possibly be to use C37 to explain the disjointed text that follows much later.
9) Again C44-C46 are irrelevant to the text.
10) C47 can be connected to C48 when it is recognized as an ANC.
11) The fact that no ANC is present for C52 leaves the "something black" to be explained. Another PM is generated.

12) C49-C55 are disconnected and therefore confusing. No one seems to relate to any other causally. That is, the conditions set up by one are irrelevant for another in each case.

13) C56 is understandable because the conditions for it are set up by C40.
The general form of this story is as follows:
In subsequent rememberences or paraphrases of this story we can expect that certain rules that depend on the nature of the flow diagram will be followed:

1) Dead end chains will be forgotten.
2) Sequential flows (correct chains) may be shortened.
3) Disconnected pieces will be either connected correctly or forgotten.
4) Pieces that have many connections are crucial.

Thus for "The War of the Ghosts", a potential diagram for paraphrases would be:

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    C1
   /  \
 C7-12 C13-14
   /    \
C18-33
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A realization of such a paraphrase would be:

- C1 Two men went to the river.
- C7-12 While they were there they heard some noises and hid.
- C13-14 Some men approached them in canoes.
- C18-33 They asked them if they would go on a war party with them. One man went.
- C35/C40 He got shot.
- C42-43 The men took him home.
- C48-56 He told the people what happened and then he died.

The reasonableness of this paraphrase suggests that the above procedural outline for paragraph paraphrase is a good one. The rough spot in it is the paraphrase of C18-C33 which is very long. My paraphrase of that section followed the following sub-rules:

1) The first link in a chain is the most important.
2) Resolution of questions or problems is important.
If one compares our paraphrase with the output of Bartlett's subjects, one discovers a number of things. First, the two conceptualizations missing necessary conditions are present in his subjects' output. We hypothesized in section II that peculiarity markings would be generated for violation of NC's. C37 and C52 ("They are ghosts" and "Something black came out of his mouth.") would have generated peculiarity markings. If Bartlett's output is examined, it can be seen that his subjects handled these PM's in various ways. They were hardly ever forgotten. Rather, they were made part of the causal chain in entirely different ways for each speaker.

Of course, Bartlett was interested in many different facets of memory than we are dealing with here. We have chosen to use Bartlett's story because it is both familiar and problematical. Furthermore, there exist records of subjects' attempts to paraphrase the story. Our results at codifying a paraphrase procedure jibe quite well with the output recorded by Bartlett's subjects. His subjects tended to remember the same basic flow of the story that is described by the structural diagram. Different individuals, of course, embellish the story in different ways. Furthermore, we were trying to shorten the story in the paraphrase we created, something Bartlett's subjects were explicitly not doing. Nevertheless interesting parallels exist between the results of the paraphrase procedure based on the structural diagram and the output of Bartlett's subjects.
V. PARAPHRASE

The problem of the paraphrasing and summarizing of texts would seem to be based on the problem of isolating the most important information in the text. Often which information is important can only be known by using a highly sophisticated memory model. This would be the case whenever the information that is the crux of the text is important because of its un-usualness. There is little we can say about handling that kind of problem here. Paraphrase based upon the recognition of important information depends on a more sophisticated goal-oriented memory model than we now have. However, paraphrases and summaries that are based on the structure of the meaning of the text can be handled by using the method outlined above.

The important points about that method are:

1) Texts are treated as complex causal chains. Whatever inferences must be made to complete causal chains between input conceptualizations are made by memory before the text as a whole is processed.

2) Inferences are indistinguishable from input conceptualizations in the final representation of a text in memory.

3) All necessary conditions must be proven for each input conceptualization. Any unproven ones cause special problems.

4) A structural diagram that is devoid of the content of the text can be produced from the meaning representation of the text in memory. This diagram can be used to detect which conceptualizations are of importance to the story being related in the text.

5) Paraphrases can be generated from meaning representations of text by procedures that read out the conceptualizations that are central to the flow of the diagram. Paraphrases longer than the original text would be generated by realizing all the con-
ceptualizations in the final meaning representation. Paraphrases shorter than the text would be generated by various means. Among these are: a) leaving out dead end paths, b) only realizing conceptualizations that have more than two pointers to them in the text, c) reading out only starting and ending points of the subchains in a text. Summaries would be developed in similar ways.

We have not taken the time here to present detailed rules for paraphrasing texts. We would imagine that working out the actual details will be tricky. The crucial point is that chains such as we have been describing can be used in conjunction with various heuristics for determining what indicates that a given node is important.

The main problem in building a computer program to do paraphrases is, at this point, not the generation aspect, but the problem of actually being able to make the crucial inferences that connect texts together. In BP in section III, the inferences that the lawnmower may have cut John's toe is difficult to make. In "The War of the Ghosts" the crucial inference is even too hard for a human to make. However, a look at the diagram indicates that somehow C37 ought to connect to the unrelated chain of C52-C56. That is, the fact that men were ghosts should somehow explain the other mysterious happenings.

So we are left with the problem of how can a program actually make the connections that we have said are crucial to this task? The answer, we suspect, is a complex issue hidden within a single word--prediction. It is necessary to be making predictions in the actual processing of text. These predictions are about what we expect to follow given what we have just encountered. When we can accurately predict the causal chains that will occur, then we can recognize new input as the elements of those causal chains.
Several of my students have begun work on seemingly distinct tasks and have ended up working on the prediction problem for the processing in those tasks. Published accounts of these works are available in Riesbeck (1974) (for predicting word senses based on context) and Rieger (1974) (for predicting belief structures applicable for inferencing). Work on this latter task by David Levy has further refined the notion of prediction to delimit inferencing. In addition, Peggy Karp has been using the prediction to understand dialogues for the game of Diplomacy.

All of this leads us to believe that future work will force us to concentrate on the practicalities of making and using predictions in order to wholly understand natural language texts. This, coupled with the ideas presented here, should facilitate the paraphrasing and summarizing of texts.
REFERENCES


APPENDIX I

CONCEPTUAL DEPENDENCY

We regard language as being a multi-leveled system, and the problem of understanding as being the process of mapping linear strings of words into well formed conceptual structures. A conceptual structure is defined as a network of concepts, where certain classes of concepts can be related to other classes of concepts. The rules by which classes of concepts combine are called the conceptual syntax rules. Since the conceptual level is considered to underlie language it is also considered to be apart from language. Thus, the conceptual syntax rules are organizing rules of thought as opposed to rules of a language.

Crucial to all this is the notion of category of a concept. We allow the following categories:

PP- a conceptual nominal, restricted to physical objects only
PA- a state which together with a value for that state described a PP
ACT- something that a PP can do to another PP (or conceptualization for mental ACTs)
LOC- a location in the coordinates of the universe
T- a time on the time line of eternity, either a point or a segment on the line or relative to some other point or segment on the line
AA- a modification of some aspect of an ACT
VAL- a value for a state

We have required of our representation that if two sentences, whether in the same or different languages, are agreed to have the same meaning, they must have identical representations. That requirement, together with the requirement that ACTs can only be things that animate objects can do to physical objects severely restricts what can be an ACT in this representation. We have found that it is possible to build an adequate system, (that is, one that functions on a
computer for a general class of sentences and that has no obvious deficiencies in hand analysis) using only eleven ACTs.

In Conceptual Dependency, a Conceptualization consists of an actor (an animate PP), an ACT, an object (a PP or another conceptualization in the case of three mental ACTs) a direction or a recipient (two PP's indicating the old and new possessors or two LOC's indicating the old and new directions (often PP's are used to denote LOC's in which case the LOC of that PP is what is meant) and an instrument (defined as a conceptualization itself). A conceptualization can also be an object and a value for an attribute of that object. Conceptualizations can relate in certain causality relations.

In this paper we write conceptualizations in the following format:

(\text{RECIPIENT} \quad \text{DIRECTION})

\text{actor action object}

or

\text{actor state}

The eleven ACTs that are used are:

\text{ATRANS} \quad \text{The transfer of an abstract relationship such as possession, ownership or control. Thus, one sense of give is: ATRANS something to someone else; a sense of take is: ATRANS something to oneself. "Buy" is made up of two conceptualizations that cause each other, one an ATRANS of money the other an ATRANS of the object being bought.}

\text{PTRANS} \quad \text{The transfer of the physical location of an object. Thus, go is PTRANS oneself to a place, put is PTRANS of an object to a place. Certain words only infer PTRANS. Thus, throw will be referred to as PROPEL below, but most things that are PROPELed are also PTRANSed. Deciding whether PTRANS is true for these is the job of the inference program.}

\text{PROPEL} \quad \text{The application of a physical force to an object. PROPEL is used whenever any force is applied regardless of whether a movement (PTRANS) took place. In English, push, pull, throw, kick, have PROPEL as part of them. "John pushed the table to the wall"}
is a PROPEL that causes a PTRANS. "John threw the ball" is a PROPEL that involves an ending of a GRASP ACT at the same time. Often words that do not necessarily mean PROPEL can probably infer PROPEL. Thus, break means to DO something that causes a change in physical state of a specific sort (where DO indicates an unknown ACT). Most of the time the ACT that fills in the DO is PROPEL although this is certainly not necessarily the case.

MOVE The movement of a bodypart of an animal by that animal. MOVE is nearly always the ACT of an instrumental conceptualization for other ACTs. That is in order to throw, it is necessary to MOVE one's arm. Likewise MOVE foot is often the instrument of hand. MOVE is less frequently used noninstrumentally, but kiss, raise your hand, scratch are examples.

GRASP The grasping of an object by an actor. The verbs, hold, grab, let go, and throw involve GRASP or the ending of a GRASP.

INGEST The taking in of an object by an animal to the inside of that animal. Most commonly the semantics for the objects of INGEST (that is, what is usually INGESTed) are food, liquid, and gas. Thus, eat, drink, smoke, breathe, are common examples of INGEST.

EXPEL The expulsion of an object from the body of an animal into the physical world. Whatever is EXPELed is very likely to have been previously INGESTed. Words for excretion and secretion are described by EXPEL. Among them are sweat, spit, and cry.

MTRANS The transfer of mental information between animals or within an animal. We partition memory into three pieces: the CP (conscious processor where something is thought of), the LTM (where things are stored) and, IM (intermediate memory, where current
context is stored).
The various sense organs can also serve as the origin-
ators of an MTRANS. Thus, tell is MTRANS between
people, see is MTRANS from eyes to CP, remember is
MTRANS from LTM to CO, forget is the inability to
do that, learn is the MTRANSING of new information
to LTM.

MBUILD The construction by an animal of new information
from old information. Thus, decide, conclude, imagine,
consider, are common examples of MBUILD.

SPEAK The actions of producing sounds. Many objects can
SPEAK, human ones usually are SPEAKing as an in-
strument of MTRANSing. The words say, play music,
purr, scream involve SPEAK.

ATTEND The action of attending or focussing a sense organ
towards a stimulus. ATTEND ear is listen, ATTEND eye
is see and so on. ATTEND is nearly always referred
to in English as the instrument of MTRANS. Thus,
in Conceptual Dependency, see is treated as MTRANS
to CP from eye by instrument of ATTEND to eye to
object.

The states that are used in this paper are ad hoc. A
more adequate treatment can be found in Schank (in press).
APPENDIX II

CAUSAL TYPES

We allow four kinds of causality each occurring in the following conceptual syntactic arrangement:

Result Causation

A conceptualization involving an ACT (denoted \( \rightarrow \)) can have a result (\( \uparrow \)) that is a change in value of some state of an object.

Enable Causation

When a state change occurs, it can possibly complete sufficient conditions for an ACT to take place. This is called enable causation (\( \uparrow \rightarrow \)). Such state changes only enable potential ACTs (\( \rightarrow \downarrow \)).

A potential ACT is an abstraction that can be realized as an ACT if the actor so desires.

Initiation Causation

Whenever an ACT or a state change occurs, or whenever a state or a POT-ACT exists, it is possible that an actor may be made aware of it, and made to thing about it. This is called initiation causation (\( \uparrow \leftarrow \)). Initiation causation accounts for people thinking about things.

Reason Causation

\( \rightarrow \downarrow \) MBUILD
Once people have started thing about things, they are likely to decide to do something (MBUILD). Deciding to do something is the reason for doing it. This is reason causation (R).

Negatives Causing

A negated conceptualization cannot cause anything really. However, a non-event can initiate a thought as can anything else so we allow negatives to cause MBUILD's in initiation causation.

The above causal relations can have certain changes made to them that cause them to behave differently. Any causal can be stated as being potential. This is symbolized by a "c" on the causing conceptualization. A (c) B is considered to be "if A then B would occur".

In addition to this, enable causation can be negated (symbolized E). This means that a state change can remove the sufficient conditions for an ACT to take place. This, in effect, is another kind of causation (unenable causation); but since all the conditions and properties of enable causation are the same as unenable causation, we will treat them as being the same here.

It is not possible to place time modifications on causals themselves because causals are merely relations between conceptualizations. The conceptualizations denote events which themselves have times. Thus event 1 can be causally related to event 2 even if event 2 is a future event, and event 1 is a past event. In that case, the causality is hypothetical (will cause).

In order to simplify the diagrams we abbreviate causals by placing the letters denoting each causal together. This notation indicates that more than one causal occurred but we have not specifically written it down. Thus, means that C1 resulted in some state (usually readily inferable) which enabled C2. indicates that C3 initiated an MBUILD that decided that C4 should be done which was the reason why C4 was done.