

Sometimes the bridge, that is, the number of inferences involved in making a connection, can be longer than in the above examples. From the set of sentences "John is a Republican. Mary is slightly daft, too," the implications would be that all Republicans are slightly daft; therefore, John is slightly daft. (Some people also infer that Mary is Republican, although that implication is less clear.) Those are both needed as antecedents to the "given information" that someone other than Mary is slightly daft. The number of inferences the listener assumes should be made to bridge the sentences is the *minimal number*. There are, undoubtedly, a large number of paths of inferences that could connect two sentences. The comprehender must use the rule of finding the shortest path; otherwise, comprehension would take a long time, and there would not be a unique set of antecedents for a sentence that could be intended by the speaker.

There have been a number of experiments which support the notion that the time to comprehend a sentence is affected by the number of inferences that need to be drawn to do so. (Clark & Haviland, 1976; Clark, Note 11). Some sentences that subjects read were preceded by a direct antecedent; others by an indirect antecedent. Comprehension of the identical sentence was faster when preceded by the direct antecedent. For example, subjects were faster to comprehend the second sentence in "Fran took the beer out of the car. The beer was warm," than in "Fran took the picnic supplies out of the car. The beer was warm," or in "Fran likes beer. The beer was warm," (the last being a control for the word "beer").

Clark also makes the important distinction between *backward* and *forward* inferences and *authorized* and *unauthorized* inferences. Forward inferences are unauthorized (not demanded by the speaker) and are indeterminate in number (i.e., there is no minimal number rule). These are elaborations or embellishments of the input in the text. Backward inferences that are authorized and follow the minimal number rule are the bridges described above. Unauthorized, backward inferences follow from statements such as Nixon's "I am not a crook." In this case, the speaker did not intend the implication that there is reason to consider that he might be a crook.

Schank's Model for Drawing Inferences

Clark writes as if there were very few and often only one backward inference to be made per sentence. However, Schank's model for sentence comprehension and for paragraph comprehension (Schank, 1972, 1973, 1975b) suggests that many such inferences are made. These backward inferences tend to concern presupposition and enabling conditions. The fact that a large number of inferences needs to be made has always seemed to be one of the weakest aspects of these models. Schank (1972, 1973) asserted, in his papers on conceptual dependence (sentence parsing), that during comprehension, the verb is decomposed into its semantic primitives. Decomposition includes inferring the instrument of action when the verb is one that "takes" an instrument. Even in sentences where the instrument is explicitly stated, more implicit instruments may need to be inferred, recursively. For example, the conceptual dependency representation of the instrument in "Fred hit Bill with a stick" would be that "Fred did something with a stick," and the instrument for that would be that

"Fred grabbed the stick" which implies that "Fred moved his hand toward the stick," and so on.⁷

In a similar vein, Rieger (Note 13), a student of Schank, developed a scheme in which a seemingly limitless number of "real world inferences" would be made during comprehension. As he states,

When the current CM (Conceptual Memory) is turned loose, it will often generate upwards of 100 inferences from a fairly banal stimulus such as "John gave Mary the book." (p. 31)

Rieger described a large number of classes of inferences (16) which include specification, resultative, causative, motivational, enabling, knowledge propagation (inferring what other knowledge an actor must know), and normative inferences. He believes there are even more classes he did not identify and that all these classes generate spontaneous inferences seeking out relevant context. Rieger gives certain notions about how the proliferation of inferences will be cut off, but these are not worked out.

Schank (1975b) used many of these same inference classes in a paper on paragraph comprehension. One motivation for Schank's decision to develop representations for paragraphs was that sentence comprehension involved the generation of too many inferences; embedding a sentence in a paragraph limits the number of relevant inferences. He felt that in paragraph comprehension, one only needs to generate those inferences that will connect sentences of the story together; one must find enabling conditions, that is, causal chains that allow an event to occur. He distinguishes between absolutely and reasonably necessary conditions (ANC's and RNC's respectively). Examples of ANC's for the phrase "John began to mow his lawn" would be John having a lawn, possessing a lawn mower, John being alive, etc. Reasonably necessary conditions would be that it is not cold, nor rainy, nor is there any snow on the ground, etc. None of these conditions needs to be stated in the paragraph that includes the phrase. All these statements could be satisfied by "normality assumptions." If the ANC's can be satisfied by normality assumptions, one only checks to be sure that none of these assumptions is violated by some other assertion in the paragraph.

Scripts, Plans, and Goals

Schank and Abelson (Abelson, 1975; Schank & Abelson, 1977, Note 9) proposed that people utilize situation-specific knowledge, called scripts, in order to make inferences and determine if something seems plausible or reasonable in a particular context. Normality assumptions will vary from context to context (or script to script). The model that uses scripts is implemented in a computer program that summarizes, paraphrases, and translates stories (Schank, Note 15). It can also answer questions

⁷ At a Sloan-sponsored workshop at Yale in June, 1978, Schank indicated that his position on decomposition has been modified. He now believes there exist "primitives" at many different levels. One need not unpack a verb down to the original "primitive acts" postulated by Schank. I find the notion of different levels of primitives somewhat disconcerting. Perhaps primitives now mean "concepts."