A QUESTION ANSWERING METHOD OF EXPLORING PROSE COMPREHENSION: AN OVERVIEW

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When individuals comprehend prose, they construct a large number of inferences and expectations. Where do these inferences and expectations come from? It is believed that generic schemas provide the background knowledge that is needed to generate inferences and expectations. The schemas correspond to different knowledge domains and levels of structure. There are schemas for objects, actors, event sequences, goal oriented activities, and so on. During comprehension the comprehender identifies a variety of schemas. When a schema is identified, it guides the interpretation of explicit input as well as the construction of inferences and expectations.

There are several schema-based models in psychology and other disciplines in cognitive science. Psychologists have typically investigated global issues regarding schemas in comprehension. They have rarely specified detailed representations and symbolic procedures. However, during the last four years the Cognitive Research Group at Cal State Fullerton has ventured into a detailed and very time-consuming project. We set out to explore the following problems:

(1) To identify the inferences and expectations that comprehenders generate when a passage is comprehended.

(2) To trace the constructive history of specific inferences and expectations when a passage is comprehended on-line.

(3) To formulate a system for representing knowledge.

(4) To map out the content and structure of schemas which are invoked when a passage is comprehended.

(5) To examine how conceptualizations in generic schemas are passed to the representation of a specific passage.

(6) To assess whether behavioral data can be explained by properties of passage representations and the process of constructing these representations. The behavioral tasks include question answering, recall, and inference verification.

We have analyzed both narrative and expository passages. However, the most extensive analyses have been on short narrative passages such as the following:

The Czar and His Daughters

Once there was a Czar who had three lovely daughters. One day the three daughters went walking in the woods. They were enjoying themselves so much that they forgot the time and stayed too long. A dragon kidnapped the three daughters. As they were being dragged off, they cried for help. Three heroes heard the cries and set off to rescue the daughters. The heroes came and fought the dragon and rescued the maidens. Then the heroes returned the daughters to their palace. When the Czar heard of the rescue, he rewarded the heroes.

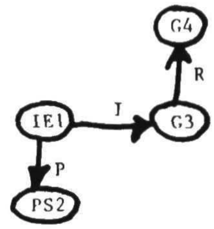
Conceptual Graph Structures

It is believed that knowledge can be represented in the form of conceptual graph structures. A graph structure is constructed when an individual comprehends a passage such as the Czar story. Both explicit statements and inferences are structurally interrelated in a graph structure. Similarly, the content of generic schemas are represented as conceptual graph structures.

In our representational system, a graph structure is a set of labeled statement nodes which are interrelated by labeled, directed arcs. A statement node is roughly a proposition. Each statement node is assigned to one of six node categories: Physical State, Physical Event, Internal State, Internal Event, Goal (which includes actions), and Style. For example, three heroes heard the cries and set off to rescue the daughters has the following four statement nodes:

(1)Internal Event: heroes heard cries
(2)Physical State: there were three heroes
(3)Goal: heroes set off
(4)Goal: heroes rescue daughters

There are five categories of labeled, directed arcs: Reason(R), Initiate(I), Manner(M), Consequence(C), and Property(P). These arcs interrelate the nodes. The above four statements would be interrelated as follows:



For a more complete description of this representational system, see Graesser (1981) and Graesser, Robertson, and Anderson (1981).

One distinctive feature of this representation is that it captures differences between goal-oriented structures (with Goal nodes, Reason arcs, and Initiate arcs) and causally-oriented structures (with Event nodes, State nodes, and Consequence arcs).

A Question Answering Method of Exposing Implicit Nodes

A question answering (Q/A) method has been used to expose inferences and expectations. After comprehenders read a passage, they answer why, how, and what-happened-next (WHN) questions about each explicit statement in the text. The answers include a large number of implicit nodes. An implicit node is analyzed if it is produced as an answer by at least two comprehenders. Thus, the ideosyncratic answers are eliminated.

When comprehenders are probed with questions after reading a passage, the inferences in the Q/A protocols are classified as preserved nodes. There is a large number of preserved nodes in a short passage such as the Czar story. In our analyses, there were 189 preserved nodes. Therefore, there were 10 unique inference nodes for every explicit node. Conceptual graph structures were composed from the set of explicit nodes and inference nodes.

Constructing Graph Structures On-line

It is possible to trace the constructive history of each node in a passage structure. This is accomplished by manipulating the amount of passage context that a comprehender receives before a statement is probed with questions. In a No Context condition, passage statements are probed out of context. The inferences generated in this condition are classified as statement-driven (SD). In a Prior Context condition, passage statements are probed on-line; the comprehender reads only the passage content up through the target statement and then the statement is probed. Inferences in this condition are classified as prior-context-driven (PCD) if they are not SD. In a Full Context condition, the comprehender reads the entire passage before the passage statements are probed. Inferences in this condition are subsequent-context-driven (SCD) if they are neither SD nor PCD.

On the basis of these context manipulations we traced the constructive history of each inference node (answer to why or how question) and expectation node (answer to WHN question). Each implicit node was classified on the basis of the first explicit node in the passage which activated the implicit node. Of the preserved inference nodes, 61% were SD, 34% were PCD, and only 5% were SCD. Consequently, the on-line representation of a target statement accounts for 95% of the inferences associated with the statement; subsequent context adds very little.

Sometimes implicit nodes are generated sometime during comprehension , but are later disconfirmed. There were 108 disconfirmed nodes in the Czar story. Erroneous SD nodes were usually disconfirmed by subsequent context, rather than being blocked by prior context.

We traced the entire evolution of the conceptual graph structures as passage statements are interpreted incrementally, statement by statement. This analysis included both preserved nodes and inference nodes. The analysis of the Czar story revealed that established conceptualizations are rarely restructured as new information is received. New nodes were rarely inserted inbetween old nodes; erroneous old nodes were rarely removed from chains of old nodes that end up being preserved. Instead, new nodes were appended to old nodes; erroneous nodes and node chains were pruned from old structures. A pruning+appending mechanism explained much of the on-line construction of graph structures for narrative.

Schema Content and Structure

A free generation plus Q/A method has been used to map out the content and structure of schemas. Consider a DAUGHTER schema. Individuals in a free generation group write down typical actions and attributes of daughters. Free generation nodes include all statements that are produced by two or more individuals. A second group of individuals participate in a Q/A task. Each of the free generation nodes are probed with a why and a how question. The final set of nodes include all statements produced by at least two individuals. Conceptual graph structures are then prepared for schemas such as the DAUGHTER schema.

We have identified 31 schemas that are relevant to the Czar story. The content of these schemas has been analyzed using the free generation plus Q/A method. Twenty of these schemas were classified as microstructure schemas because they referred to explicitly mentioned actors, objects, actions, or properties (e.g., HERO, PALACE, KIDNAP, ATTRACTIVENESS). There were 11 macrostructure schemas which were derived from the text on the basis of our intuitions (e.g., GOODNESS, FAIRYTALE, RETURNING FAVOR). The number of nodes per schema varied from 32 to 187 with a mean of 93 nodes. The number of free generation nodes varied from 3 to 22 with a mean of 13. Therefore, the Q/A task exposed most of the schema content.

Passing Schema Nodes to Passage Representations

Among the 31 schemas relevant to the Czar story, there were 2883 nodes. Only 362 of these generic nodes matched an inference node in the passage. There were three types of matches between inference nodes and schema nodes. Exact matches accounted for 9% of the matches. Most of the matches (86%) involved an argument substitution, as shown below:

Schema node: person get exercise
Inference node: daughters get exercise

Some matches (5%) were more complex. Since only 13% of the schema nodes were passed to the conceptual graph structure for the passage, a substantial number of schema nodes are somehow eliminated. We are presently examining symbolic mechanisms that might explain which generic nodes are passed to the passage structure.

The schemas accounted for most of the nodes in the Czar story structure. For 79% of the implicit passage . nodes, there was a match with a node in at least one schema. For 74% of the inference nodes, there was a match with a node in at least one microstructure schema; there was a match with a node in at least one macrostructure schema for 31% of the inference nodes. On the average, an inference node had a match with 1.7 schemas. We are presently examining how schema structures are synchronized with structures of passage excerpts--as passage statements are comprehended on-line.

Question Answering, Recall, and Verification Ratings

Do the conceptual graph structures correspond closely to human conceptualizations? One way to assess this is to examine whether the structures explain behavioral data. We have extensively examined patterns of data in three tasks: question answering, recall of explicit information, and verification of nodes in the graph structures (see Graesser, 1981; Graesser et al., 1981). The results of these analyses have been encouraging.

We assumed that specific symbolic procedures are invoked in any given behavioral task. Most of the symbolic procedures were written in the form of a production system. A production system operates on a conceptual graph structure and thereby generates expected output. Hopefully, the expected output would match closely to the obtained behavioral output. For example, we formulated production systems for specific types of questions. The production system for one type of question follows different paths of arcs and nodes than does that of another type of question; the expected answers would therefore be different for the two types of questions. The production systems and graph structures have together accounted for 90% of the specific answers to specific questions.

Final Comments

We have been impressed with the Q/A method as an empirical technique for exploring comprehension. The method can be used to drag out the implicit knowledge that is part of passage representations and schemas. The method can also be used to trace the process of constructing structures while passages are comprehended on-line. Our research has uncovered dozens of informative trends which have important implications. However, it is beyond the scope of this presentation to report many of the interesting observations (see Graesser, 1981). It suffices to say that the data are sufficiently rich and distinctive to discover new pieces to the puzzles of comprehension.

References

Graesser, A.C. Prose comprehension beyond the word. New York: Springer-Verlag, 1981.

Graesser, A.C., Robertson, S.P., & Anderson, P.A. Incorporating inferences into narrative representations: A study of how and why. Cognitive Psychology, 1981, 13, 1-26.