ON-LINE PROCESSING OF PRAGMATIC INFERENCES

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Cognitive science researchers have proposed a wide variety of inferences and inference mechanisms that may be used in comprehending stories. Inferences are concepts, or links between concepts, which are not explicitly stated in a text but which are present in the final memory representation. Many previous psychological experiments on inferences have been unable to distinguish between inferences that are generated during comprehension (on-line) and those that are constructed later (for example, during summarization or question answering). The experiments presented here contrast four types of pragmatic inferences to determine whether they are usually generated on-line.

Pragmatic inferences are a class of inferences that result from the application of world knowledge to information in a text. Knowledge structures typically employed in the production of pragmatic inferences (especially for narratives) are goal structures, planning mechanisms, and scripts (Schank & Abelson, 1977; Wilensky, 1978). A number of psychological experiments have demonstrated the use of individual schematic structures in producing pragmatic inferences (e.g. Bower, Black & Turner, 1979; Graesser, Gordon, & Sawyer, 1979; Smith & Collins, 1981), but have not shown the on-line operation of a combination of knowledge structures involved in pragmatic inference generation. In the two studies discussed here, we will present evidence that 1) knowledge-based inferences about goals, plans, and actions are made during reading and 2) inferences about consequent or associated states of the world are not made during reading. We will also give indirect evidence for on-line forward inferencing of plans from goals.

Knowledge of goals and plans organizes otherwise disconnected text elements, and thus it is important that they be inferred early in the comprehension process (Owens, Bower, & Black, 1979; Smith & Collins, 1981). Lower level inference types, like story actions, are used to fill in information specified by already active schemata (Bower, Black & Turner, 1979). State information, however, while potentially inferable, is not predicted to be generated as part of the comprehension process. There is considerable evidence that physical states that are antecedents or consequences of actions are not a central part of narrative representations (Black, 1980; Graesser, 1981; Kemper, 1982; Lehnert, Robertson, & Black, in press; Robertson, Lehnert, & Black, 1981). For example, when someone sits down in a restaurant, information about the position of tables and chairs is not typically accessed.

To test for on-line inferences of the specified types, we measured subjects' reading times for target sentences which *required* a pragmatic inference for coherence. In the first experiment we wrote sixteen short (17 line) stories each containing a goal, a plan for achieving that goal, a set of connected actions, and associated states. Eight of the stories were *script based* (e.g. going to a restaurant, going to the movies), the other eight were *plan based* (e.g. robbing a store, getting directions). Each story included *inference-statements* which explicitly described the goal, the plan, an act, and a state. Following each of these statements was an eight-syllable *target-statement* which required the preceding information to be inferred if it was not already present in memory. For example, sentence 2 when read alone requires that the goal stated in sentence 1 be inferred; sentence 3 requires an inference of the plan stated in sentence 2; sentence 6 may require an action inference (sentence 4) but not a state inference (sentence 5). (Our stories were not as compact as this example suggests.)

1. John was hungry.
2. John hurried to a restaurant.
3. John ordered the special dinner.
4. The waitress brought the food.
5. John had silverware.
6. John ate his meal in a hurry.

Target-statements (e.g. sentence 3) were presented with their associated inference-statements (e.g. sentence 2) either present or absent. Each subject received stories with goal, plan, act, and state inference-statements absent, but within any one story a subject had only one high level inference type (goal or plan) and one low level inference type (act or state) left out. Subjects read the stories one line at a time from a CRT screen and their reading times for the target-statements were recorded. It was assumed that inference generation would be evident in increased reading times for the target-statements in the inference-statement absent conditions. After the reading task and a short intervening task, the subjects were given a recognition test (1-7 scale) which included the inference-statements. High recognition ratings for absent inference-statements indicates the presence of the inferences in the final story representations.

Table 1 shows the mean reading times for target-statements and mean recognition ratings for inference-statements of the different types in the present and absent conditions. The analysis of reading times showed that goal and action targets took longer to read when their inference-statements were absent, but this was not the case for plans or states. Recognition results showed a specific interaction in which states were not falsely recognized when they are left out of the stories while the other types of inference-statements were. The reading time data and recognition data together support the view that goals and actions are inferred on-line whereas states are not. Plans proved problematic and were investigated further in a second experiment.

	Target RT		Inference Recognition	
Type of Inference	Inference Absent	Present	Inference Absent	Present
Goal	* 1.660	1.559	4.89	5.81
Plan	1.626	1.601	4.95	6.09
State	1.538	1.487	* 3.62	5.82
Act	* 1.595	1.448	4.75	6.06

Table 1. Mean reading times (sec.) and recognition ratings for the different inference types.

Though the reading time difference for plans was not significant in the first experiment, the high recognition rating for absent plans suggests that they were inferred at some point. A closer look at the materials revealed a possible explanation: knowledge of the goals in stories where the plan inference-statements were left out may have allowed subjects to infer the plans before their target-statements were read. For example, knowledge of the goal "John was hungry," may lead to a prototypical plan expectation, i.e. "going to a restaurant." If a prototypical plan is inferred when a goal in read, the presence or absence of the plan inference-statement would not have made any difference.

In a second experiment, prototypical plans in our materials were changed to less typical plans to minimize forward inferencing from the goals. In addition, some story titles were changed to decrease the chances of inferring a goal prior to reading the goal target-statements. Also, action inferences were not included in the second experiment since this effect had already been clearly demonstrated.

The results of the modified experiment are shown in Table 2. The reading time differences for goal and plan inferences increased and plans now became significant. We again failed to find evidence for on-line state inferences. The recognition data remained consistent with these results, showing a high false alarm rate for goals and plans, but not for states.

	Target RT		Inference Recognition	
Type of Inference	Inference Absent	Present	Inference Absent	Present
Goal	* 1.764	1.613	5.28	5.94
Plan	* 1.720	1.626	5.69	6.27
State	1.536	1.490	* 3.97	5.56

Table 2. Mean reading times (sec.) and recognition ratings for the different inference types.

Taken together, these experiments support the view that some pragmatic inferences, specifically goals, plans, and actions, are made during reading while others, specifically low level states, are not. It is especially important to note that high level inferences about goals and plans are made on-line. This result is congruent with models of language comprehension that incorporate strong *top down* uses of pragmatic knowledge during understanding. Active goal and plan schemata serve *during reading* to organize otherwise disconnected concepts in the text. We also obtained indirect evidence for on-line forward inferencing of prototypical plans from goals since we were only able to demonstrate that plans were inferred in a backward manner from plan inference-statements when they were non-prototypical of an active goal.

In terms of low level actions, the results support the view that script and plan completion inferences (remember that we had both script-based and plan-based stories) found in the representation after reading are not reconstructed at test time, but are built during reading. On the other hand, there was no evidence that inferences about states of the world occur during comprehension, even though we know that they are available after comprehension and even during comprehension in response to question probes (Graesser, 1981). Of course, some types of states may be very important and reliably inferred in some texts (Owens, Bower, & Black, 1979); however, the theoretical claim is that low level states *in general* are inferred on-line less often than the other types of inferences studied.

This "fine tuning" of data about the types of inferences made on-line provides important constraints on inference models. Since pragmatic inferences are probable rather than necessary, and since there is so much inferential material available at any given time from world knowledge, direct measures are needed to tell when inferences are made and which types are made. Although most models of language comprehension include an inferencing component, it is important to examine how different classes of knowledge are differentially utilized by the comprehension process.

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