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ABSTRACT

Two experiments were conducted to test the hypotheses that the ability to draw inferences from a text about an unstated agent is based on the quality of information available to the reader, and that the quality of the information is itself based on the unique nature of cues embedded in the text and on the relevance of prior knowledge held by the reader. In the first experiment, 20 second and 20 fourth grade students listened to stories that contained a helpful (unique) or unhelpful (nonunique) clue and then drew inferences. In the second experiment, 28 third and 28 fourth grade students listened to stories with clues that varied as in the first experiment. In addition, half of the students first received a relevant prior knowledge and half received an irrelevant prior knowledge treatment. Both experiments confirmed that the unique nature of an embedded clue was directly related to the ease of drawing an inference. In addition, relevant prior knowledge was shown to enhance inference making in an additive, linear fashion. No grade differences were found. (Stories used in the experiments are included.) (FL)

Children's Ability to Draw Inferences from Text

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Abstract

Drawing an inference about an agent, unstated in a text, is hypothesized to be based, in large measure on the quality of information available to the comprehender. The quality of information, in turn, is based on the uniqueness of cues embedded in the text and the relevance of prior knowledge held by the individual. Two experiments were conducted to test these ideas in second through fourth grade children. In experiment 1, children listened to stories which contained a helpful (unique) or unhelpful (non-unique) clue and then drew inferences. In experiment 2, children listened to stories whose clues varied as before. But, in addition, half of the children first received a relevant prior knowledge treatment, while half received an irrelevant prior knowledge treatment. Both experiments confirmed that the uniqueness of an embedded clue is directly related to the ease of drawing an inference. In addition, relevant prior knowledge was shown to enhance inference making in an additive, linear, fashion. There were no grade differences found.

Recently, Schmidt and Paris (1983) proposed a general model of how children draw inferences while reading or listening to connected discourse. A key feature of the model is that children form hypotheses about unstated and to-be-inferred propositions, using whatever clues are available in the text. The clues, in turn, are used to eliminate improbable hypotheses and to focus in, progressively on more plausible ones. In a series of three experiments, Schmidt and Paris (1983) tested their model with elementary school children, by reading stories to children and asking children to draw an inference about an unstated action , agent, or object. For example, one story mentioned that a boy rode to school, but didn't indicate the means of conveyance. The children, then, had to decide how the boy rode to school (e.g., by bicycle, in a car, on a bus, in a hot air ballon, etc.). In the experiments, the investigators manipulated the number of clues embedded in a story which might, in turn, help the children to determine which inference is correct. Sometimes children received one clue; other times they received three. A major finding was that despite age changes in the overall performance of children in correctly drawing inferences, at all grades children did better when they had three clues than when only one was provided. The implication of the finding is that the more information is available, bearing on the unstated proposition, the easier it will be to infer what it is.

In the present paper we offer evidence for a complementary view of the inference process. We argue that, strictly speaking, it is not the amount of information that is crucial in determining the child's success at drawing the correct inference. Rather, what is crucial is the value or quality of the information. The value or quality, in turn, is related

to at least two factors-the prior knowledge the child can bring to bear on the clue and the specificity of the clue itself in directing the comprehender to a unique alternative.

Following a pilot study to examine some of the properties of the stories and clues used by Schmidt and Paris, we conducted a similar small scale pilot study with several narratives and clues crafted by us. Then, we conducted two formal experiments to test the prediction that a clue's informational value is critical in determining a child's success at drawing inferences. In experiment 1, the focus was on providing children with more or less unique clues (we call them helpful and unhelpful clues, respectively) and gauging performance.

In experiment 2, we combined an examination of the impact of the uniqueness of available clues with an experimental treatment providing children with specific relevant or irrelevant prior knowledge. The prior knowledge was introduced just before children listened and responded to each narrative passage. It was expected that the unique clues and relevant prior knowledge would combine to produce the most powerful aid to inferential comprehension. As a secondary feature, the second experiment also called upon children to judge the impact of having particular prior knowledge on their ease of drawing the appropriate inferences. This was to assess their metacognitive awareness of the ease or difficulty of the inferential process.

Pilot Work

As a first step, we examined the properties of clues and stories utilized in the Schmidt & Paris study. In our examination, we undertook a microscopic look at the clues. In a series of procedures with second and fourth graders, it appeared that it was the nature of the specific clues utilized, rather than their number, which was most important in engendering appropriate inferences. More specifically, students (in both age-groups) as easily derived correct inferences based on one clue, as they did based on three clues inserted in the text.

In addition these results called our attention to the stories' content which was based on very familiar situations of children's daily life (such as ride to school, or getting a pet as a present for birthday). The results showed that children could made an accurate inference about the stories (for instance, how one can ride to school, or what kind of pet one may get as a present) based on their general knowledge, and thus it was difficult to separate the relative contribution of the clues and the children's general knowledge in the process of making correct inferences.

Experiment 1

Experiment 1 was conducted in order to clarify the relationship between helpful and unhelpful clues and the general knowledge of subjects which was not based on very familiar situations.

Subjects

A total of 40 children, 20 each from second and fourth grade levels, were drawn from two parochial schools in Madison, Wisconsin. The average age of the second graders was 8.4 years, and the average age of the fourth graders was 10.6 years.

Materials

A few stories were written in content areas which were conceived as partially familiar to the subjects. In addition one helpful clue and one unhelpful clue were written for each story. A helpful clue was considered to evoke the direct prior-knowledge which is needed to answer the question correctly. In contrast, an unhelpful clue was ambiguous and did not aggregate the specific prior knowledge needed to answer the question. After a pilot study was conducted with adults, second and fourth graders, four stories were selected and the helpful clues and unhelpful clues were defined too. An example of the stories is shown in Table 3.

Insert Table 3 here

The four topics of the stories were: 1) a description of different kinds of animals in a jungle, 2) a description of different instruments in an orchestra, 3) a historical description of the development of flying machines, and 4) a description of hunting activities of Eskimos. Each story was associated with an inference question which referred to one part of the stories.

Design

All subjects were tested with all four stories. There were two conditions in the study created by manipulating the helpful and the unhelpful clues.

In condition 1: first two of the stories included the helpful clue in the texts were presented, followed by the presentation of two stories with unhelpful clues. In condition 2, first the two stories with the

Table 3

Story-Example

Exposition: Nouvat, the Eskimo boy went hunting with his father. His father hunted the animal very skillfully. Together they put the hunted animal on the snow carriage which was pulled by dogs.

Clue 1* The animal was big and white and seemed strong and dangerous even after it was hunted.

Nouvat's father seemed very tired after the hard hunting. They both know that they would have enough food for the long winter. Nouvat was very proud of his brave father.

Question: What animal did Nouvat's father hunt?

Clue 3*-He admired his father using the spear so well and fast.

*Clue 1 is a helpful clue and clue 3 is an unhelpful clue.

unhelpful clue, inserted in the texts, were presented followed by the two stories with the helpful clue. The order of the clues was randomized for each story, and children were assigned in a random order in starting the task with one of the two conditions. Each subject heard two stories of condition I, and other two stories of condition 2.

Procedure

All students were tested individually. In the general instructions all subjects were told that after each story they would answer one question about it. Then, they would hear an additional information, and they would have to decide whether to change their answer of the question or not, based upon the new information. According to this procedure we explored the subjects' sensitivity to the different potential of the clue throughout their actual performance.

Each child listened to four stories recorded on a tape recorder, the first clue in each condition was already inserted in the story. Then the subject had to answer a question which was presented by the experimenter. Following the answer, the subject listened to the additional information (i.e. the other clue) from the tape recorder, and the inference question was presented again. The experimenter did not give any feedback after the first answer. In addition each subject was told that s/he had to decide whether or not to change the original answer.

Results and Discussion

The results of the inference questions based on the two kinds of clues is presented in Table 4.

Insert Table 4 here

Table 4

Means and Standard Deviations for the Four Stories and Presentation Condition of the Clues

Presentation	Grade			
	Second		Fourth	
	$\bar{X}$	SD	$\bar{X}$	SD
Condition 1:				
Helpful Clue (first)	0.49	0.52	0.58	0.50
Unhelpful Clue (second)	0.43	0.51	0.60	0.49
Condition 2:				
Unhelpful Clue (first)	0.13	0.32	0.20	0.40
Helpful Clue (second)	0.56	0.51	0.68	0.48

Note: Each mean is based upon 40 observations (10 subjects x 4 stories each). Scores could range from 0-1.

The findings show that helpful clues contributed more than the unhelpful clue across the two conditions of the story. More students corrected their answers when the helpful clue was presented after the unhelpful clue (condition 2). This trend was consistent in both second and fourth grade classes. When a helpful clue was presented in the story, followed by an unhelpful clue (condition 1), most students did not change their correct answers. This trend appeared in both grade levels. Nevertheless, we found that in two out of the four stories ("Jungle" and "Orchestra") even the helpful clue did not produce an optimal or ceiling level or performance-there was still room for improvement. These findings showed that subjects had at least partial knowledge about the likely set of agents from which to draw an inference (i.e. select an answer) in the stories, and there was a need for providing the subjects with an informative clue to help them narrow down the possibilities. This pattern of findings led us to experiment 2, where we were able to manipulate the clue's value separately from the prior knowledge of the children about the set of inferential possibilities. In experiment 1, prior knowledge for the content of the stories and the associated set of inferential possibilities was not carefully controlled.

Experiment 2

In order to control for the contribution of prior knowledge separately from a clue's value, experiment 2 was conducted. The assumption was that children would draw inferences, partly on the basis of their prior knowledge, and partly on the basis of the clue's value. Thus, the present investigation seeks to show that what is most important in drawing an inference is the relation between a potential clue and the prior knowledge the reader acquires about the topic of the discourse on which the clue may bear.

Subjects

A new group of 56 children was drawn from a public school in Madison, Wisconsin. Half of the group was drawn from third grade and half from fourth grade. The average age of the third graders was 9.1 years, and the average age of the fourth graders was 10.3 years. There was no expectation of a grade difference in performance.

Materials

Two stories previously used in experiment 1 were employed in the study. For both of them, it appeared that both second and fourth graders still had room for better inferential performance (i.e. there was no earlier ceiling effect)-the expected outcomes of the optimal condition in the present design. The same clues were used as in the earlier study. To manipulate prior knowledge, two pairs of passages were written, one of which was read to the children before the target stories. One pair of passages

contained information about specific agents that would be relevant to drawing the correct inference in the story heard later-we call these the relevant prior knowledge passages. The other pair of passages contained information about specific agents irrelevant to drawing the correct inference in the story heard later-we call these the irrelevant prior knowledge passages. Examples appear in Table 5.

Insert Table 5 Here

An inference question was associated with each target story.

For the later judgment task, a five point scale was given to subjects to answer how helpful it had been to answer the inference questions in each of the target stories, based on the relevant prior knowledge or the irrelevant prior knowledge passages.

Design

There were four conditions created by crossing the two kinds of clues, helpful and unhelpful, that were inserted in the two target stories, with the presentation of prior knowledge or control passages. Hence, there were four groups: (1) relevant prior knowledge with a helpful clue, (2) relevant prior knowledge with an unhelpful clue, (3) irrelevant prior knowledge with a helpful clue, and (4) irrelevant prior knowledge with an unhelpful clue. In each condition subjects read the same two target stories.

Procedure

All subjects were tested individually. Each subject was randomly assigned to one of the four conditions. (Seven children of each grade level.) At the beginning of the session, children were told that they would

Table 5

The Orchestra/Relevant Prior Knowledge Passage

The orchestra is a group of people who play many kinds of musical instruments together. Some of the brass instruments like the trumpet make a very loud sound when you blow into them. The flute makes a very soft and sweet sound and can be made either of silver or of wood. Other instruments, like the violin, are played by moving a bow across their strings. Their sound can be very quiet or loud. The harp is a very large instrument with strings that is played with the fingers. It makes a very delicate sound. Drums are usually made of metal and leather and their sounds are produced by striking the instrument. Drums can be very noisy.

The Orchestra/Irrelevant Prior Knowledge Passage

Eskimos live in areas which are very cold and covered by snow. Many months of the year the sea is frozen. Dogs pull the Eskimo across the frozen sea in sleds, so that the Eskimo can hunt.

Some animals like the white fox are caught by a trap containing a piece of meat to attract the animal. The large seals are hunted with a long spear. Sometimes fish can be caught with a hook, through a hole in the frozen sea.

The white bear is very strong and dangerous so the Eskimo shoot it from a distance.

Target story

Exposition: The big hall was silent. Ann was sitting with her parents and then the orchestra began to play. Ann recognized most of the instruments and she like the sound of the instrument she used to play at home the best.

Clue 1 - The sound of the silver instrument was sweet and gentle. Ann enjoyed listening to all the instruments playing together. The conductor gave the orchestra many directions and the pleasant sound of her favoriet instrument was clear and vivid.

The question: What is the instrument Ann plays at home?

hear four stories, and then they would be asked several questions. In addition, they were told that each pair of two stories might be related to one another and that sometimes the first story (i.e. the relevant or irrelevant prior knowledge passage) would be helpful and sometimes it wouldn't in answering the question of the second story (i.e. the target story). In each condition a different random order of presenting the two taget stories was used for each child; however its associated prior knowledge passage was always presented first. All subjects were given the same instructions.

In each condition, subjects were told about the main topic of the prior knowledge passage and that a memory test would be given after they listened to it. The memory test included five questions, one per underlined agent in the passage. Each child heard the prior knowledge passage on a tape recorder, followed by five questions given orally by the experimenter. The presentation of the prior knowledge passage and the memory test was repeated until a criterion of all 5 correct answers was achieved. This insured that subjects were primed to consider 5 specific alternatives when later asked to draw on inference about the target passage. And, as can be seen from the example, one of the alternatives turned out to be correct in the relevant prior knowledge treatment. In the irrelevant prior knowledge treatment, by contrast none of the alternatives was germane.

After completing the memory test, subjects listened to the target story (also recorded on a tape recorder) followed by an inference question that was given by the experimenter. After the inference question, subjects were asked to judge how much the prior knowledge

passage helped them to answer the inference question. The subject had to indicate on a five point scale, just how helpful it had been.

Results and Discussion

In the memory test associated with the prior knowledge passages, none of the groups differed in the average number of trials required to achieve the criterion level of performance (the average was from 2.11 to 2.32 trials.)

The children's levels of answering the inference questions correctly in the four conditions are summarized in Table 6. In each condition the scores of the third and fourth graders were computed together as one group, since an informal inspection of the means revealed no grade differences.

Insert Table 6 Here

A series of four X^2 comparisons were conducted among the means, setting the α level at .01. The students who received the target stories with the helpful clues did better than students who received the target stories with the unhelpful clues, both in the case of relevant prior knowledge considered separately ($\chi^2 = 9.52$, df = 1, $P < .01$) and in the case of irrelevant prior knowledge considered alone, ($\chi^2 = 15.24$, df = 1, $p < .01$). Considering the effect of prior knowledge, the group which received relevant information outperformed the group which received irrelevant information, both for the case of the helpful clue ($\chi^2 = 8.12$, df = 1, $p < .01$).

Table 6

Means and Standard Deviations for Drawing the Correct Inferences in Target Stories Across the Two 'Clues' and 'Prior Knowledge' Conditions

Clue		Relevant Prior Knowledge	Irrelevant Prior Knowledge
Helpful			
	$\overline{X}$	0.93	0.61
	SD	0.26	0.50
Unhelpful			
	$\overline{X}$	0.57	0.11
	SD	0.50	0.31

Note: Each mean is based on 28 observations (14 subjects x 2 stories each). scores could ranged from 0 to 1.

and the unhelpful one (χ^2 = 13.46, df = 1, $p < .01$).

Judgment

Subjects rated the contribution of the relevant or irrelevant prior knowledge to enabling them to correctly answer the inference question, for each target story. The results are summarized in Table 7.

Insert Table 7 Here

Four Wilcoxon (Mann-Whitney) two Sample Tests were employed. Each test was performed with the α level set at .01. Significant differences were revealed in the judgment between the relevant and irrelevant prior knowledge group, when both received the target stories with the helpful clues ($Z = 2.74$, $p < .01$) as well as when both received the target stories with the unhelpful clues ($Z = 3.82$, $p < .01$). Thus, having relevant prior knowledge was perceived as making the task of drawing the correct inference relatively easier as compared with having extraneous (irrelevant) information. There were no significant differences, however, in the perception of difficulty of drawing an inference based on the relative helpfulness of the available clues.

In summary, the results of Experiment 2 provided support for the hypothesis that, both the availability of unique clues and a body of discrete relevant prior knowledge combine to produce the optimal level of inferential comprehension. Children, also seemed to be aware of the helpfulness of a relevant general body of knowledge for drawing the correct inference.

Table 7

Means and Standard Deviations for the Perceived Helpfulness of Each Type of Prior Knowledge in Drawing on Inference For Each 'Clue' Condition

Clue		Relevant Prior Knowledge	Irrelevant Prior Prior Knowlege
Helpful			
	$\bar{X}$	2.07	3.04
	SD	0.85	0.93
Unhelpful			
	$\bar{X}$	1.93	3.32
	SD	0.58	0.85

Note: Scores could be ranged from 1-5.
The score 1 = very easy
2 = kind of easy
3 = not easy and not hard
4 = kind of hard
5 = very hard

Conclusions

The two experiments demonstrate quite clearly that the informativeness or uniqueness of an embedded clue is directly linked with children's success at drawing an inference about an unstated agent. In both experiments, the presence of a unique clue enhanced inference making relative to a condition in which a less unique (but, nevertheless, pertinent) clue was present. The effect was powerful and straightforward.

In addition, experiment 2 demonstrates the importance of prior knowledge. When children had a discrete set of agents described to them including the one needed for the correct inference, and these alternatives were guaranteed to be salient in memory when needed, children were more accurate in drawing inferences than when no such relevant information was available. Again, the effect was powerful and straightforward.

A comparison of the effects of 'clues' and 'prior knowledge' shows that each was of an approximately equal size-accounting for a mean increment in performance of about 40 to 50 percent of the whole inference item. When the 'clue' and 'prior knowledge' condition were combined, experimentally, the enhancing effect was additive and linear. We make no claims that other experimental operationalizations would result in the same precise effect sizes or in precise comparability of these two component variables. Nevertheless, it is noteworthy that without our consciously trying to equate the impact of these two variables, we nevertheless attained such an outcome. It suggests to us that caution is in order in accepting claims about the priority of bottom up ('clue driven') or top down ('prior knowledge driven') processing in comprehending,

generally, or drawing inferences, specifically.

Finally, we note that children were able to discern the relative benefit of having as opposed to not having relevant prior knowledge before they tried to draw the correct inference. The mean ratings on the judgment task support this conclusion and the finding is consistent with other research (e.g. Meyers and Paris, 1978) showing that children as young as second grade appreciate the advantage of knowing about a topic before being given some comprehension test dealing with it.

The demonstration offered in these two experiments suggests a range of further theoretical and empirical questions worthy of serious, future research effort. Among the provocative theoretical questions occuring to us is the matter of how children might draw on or withhold alternative sets of prior knowledge bearing on a topic at hand, when the sets of prior knowledge are more closely related to one another and to the comprehension problem faced by the child than the rather arbitrarily different prior knowledge sets we created. Are there developmental changes, for example in how well children might differentiate among and consciously utilize different prior knowledge bases to solve a comprehension problem when the knowledge bases differ only slightly from one another. Among the important empirical questions worthy of future attention is just how well the findings obtained here might generalize to other prose forms (expositions, essays, more complex narratives) and to other kinds of inference making. We have, admittedly, sampled only a small range of prose and inference types.

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