

Reminding and Interpretation During Encoding¹

Gary L. Bradshaw

The Beckman Institute
405 N. Mathews Avenue
University of Illinois
Urbana, Illinois 61801
(217) 333-0925
bradshaw@speech6.cogsci.uiuc.edu

Brian H. Ross

The Beckman Institute
405 N. Mathews Avenue
University of Illinois
Urbana, Illinois 61801
(217) 333-8745
bross@s.psych.uiuc.edu

Abstract

To understand and act upon new experiences, people may draw on specific past experiences. Analogical transfer models suggest that past experiences are used following the encoding of the new information. Research on reminders suggests that specific experiences may be accessed during encoding, and text comprehension research suggests available information may be used to interpret incoming material. Together, these findings suggest a more dynamic organization of interpretation processes, where past experiences may be accessed and used during encoding.

This paper reports on two experiments that explore the relationship between reminding and interpretation. In particular, the question was whether reminders that occur early during encoding might bias later interpretation. The first experiment used a post-processing measure of interpretation, while the second measured on-line sentence reading times. In contrast to most contemporary models of analogical transfer, we found that reminders may influence interpretation during encoding.

Introduction

Upon encountering a complex body of material, such as a text passage, word problem, or diagram, people often draw on their past experiences to assist in the interpretation of the new material. These experiences may suggest embellishments and inferences that can be used to make the material more coherent and

memorable, or may suggest solutions to problems based on past successes.

Research on the influence of specific past experience has mostly appeared in the work examining reminding and analogical transfer. Some work focuses on factors that lead to retrieval of an earlier experience (e.g., Ross, 1984, Schank, 1982). Other work focuses on inferences made using analogical transfer, based on the similarity of memory structures (Gentner, 1989; Gick & Holyoak, 1980; Holyoak, 1985).

Analogical transfer provides a complete framework to understand the influence of specific past experience on interpretation. Transfer involves several component operations, including *encoding* the new target material, *noticing* the similarity between the target and previous source knowledge, *mapping* the structures from target and source against one another, and *producing inferences* based on the mapping (e.g., Gick & Holyoak, 1980).

Typical models of transfer organize the component processes in a strict sequence. First the target material is encoded, then relevant source knowledge is retrieved, followed by mapping, and finally transfer occurs². Presumably, the representation of the target material does not change until the final stage.

There are two reasons why the sequential view might be problematic. First, much evidence shows that reminders can be based on superficial features (Gentner, 1989; Holyoak, 1985; Ross, 1984). Such superficial-based reminders do not depend upon analyzing the target problem, so they can occur even very early during the encoding of the target. If an earlier problem is brought to mind during the encoding of the target, it is possible that it may affect the rest of the encoding.

The second reason why a sequential view may not be appropriate comes from research on text

¹The Institute of Aviation and the Cognitive Science/AI Steering Committee at the University of Illinois provided funds to support a sabbatical leave for Gary Bradshaw. Air Force Office of Scientific Research Grant 89-0447 funded the work of Brian Ross.

² Holyoak explicitly acknowledges the possibility that analogical processes may not operate in a rigid sequence (e.g., Holyoak, 1985, p. 68). In practice, his treatment has always been sequential.

comprehension. The text comprehension literature also includes a focus on how (general) knowledge may be used in understanding, but proposes a different view of how interpretation processes might be organized. For example, Kintsch's (1988) construction-integration model features concurrent operation of several interpretative processes during encoding. As each new proposition is considered by the model, it stimulates the retrieval of potentially relevant facts. Useful inferences are identified, and integrated into the developing representation of the text. Text comprehension models do not commonly provide a role for specific examples in interpretation, and so do not exhibit the kinds of effects of interest here. Yet they do suggest an alternative view, that analogical processes may act in a concurrent fashion.

The focus of the current investigation is to examine this possibility of a dynamic process organization that exploits specific past memories in interpretation. In particular, might a reminding shift the representation of information before it is fully encoded? To do so, we must induce a reminding early during the encoding of the target, which produces information that influences later encoding. Such a demonstration provides support that these processes can occur concurrently.

Thus, we sought to construct materials where a reminding that occurred early in the processing of a story could influence later interpretation. Our general procedure uses a cue to induce a reminding to a theme that is helpful in interpreting an ambiguous story. An example story, shown in Table 1, was adapted from Anderson et al. (1977). This text can be interpreted as either a story about a wrestler in a difficult match or a prisoner breaking out of jail.

The location of the reminding cue is indicated by <reading-material>. If the cue brings to mind wrestling, subjects may interpret later passages as statements about a wrestling match. If the cue brings to mind a jailbreak, subjects may interpret the same passages in quite a different way. Of course, the words that appeared in this location did not have any pre-experimental association to either theme: Subjects read either "some Shakespeare" or "the Delaware Daily." Instead, the interpretation was affected by

having had these reading materials connected to the different themes in earlier stories. Subjects had read stories that connected Shakespeare with wrestling and the Delaware Daily with a jailbreak (e.g., the main character in an earlier story enjoyed reading Shakespeare and watching wrestling on TV).

Such reminders by themselves are not presumed to affect interpretation--they only retrieve information that may help later interpretation. Another process must use remembered material as later information is processed. Our experiments rely on remembered connections to suggest a theme useful in interpretation. This does not require structural correspondences to be made between propositions in the initial story and the current ambiguous text, and so is quite different from the familiar analogical transfer. Instead, the interpretation is biased by *reminding-based cuing* of a relevant theme. Presumably thematic cuing can be done with little cognitive effort, and so need not disrupt ongoing processing of the ambiguous story.

Thematic cuing effects have been studied before by others, notably Bransford and R. Anderson. In these earlier studies, when themes were provided, they were given explicitly. For example, Bransford and Johnson (1972) provided titles to subjects that revealed the theme, while Pichert and Anderson (1977) gave subjects a "perspective" (e.g., burglar, home buyer) at recall that represents a theme. The major difference between these studies and the ones we report is the superficial nature of our cues. A phrase such as "some Shakespeare" or "the Delaware Daily" does not itself cue the theme of wrestling or jailbreak. Only if the cue produces a reminding to a specific past memory will the proper theme come to mind. This would demonstrate the interpretation is affected by the reminding and suggests a more dynamic view.

We will describe two experiments that measure reminding-appropriate interpretations in quite different ways. In the first experiment, we asked subjects about their final interpretation of the text. If the cue was sufficient to bias encoding, subjects should interpret the story as an episode about the reminded theme, which will be reflected in their final

Table 1: Ambiguous Wrestling/Jailbreak story

Although it was a big day for Johnny, he had tried to keep to his usual routine. As always, he had read <reading-material> and done his morning stretches. He knew that preparation was crucial, so he had prepared well. Now he would find out if he had prepared enough.

Johnny slowly pushed up, planning his move. Things were not going well. The lock that held him was strong, but he thought that he could break it. He knew, however, that his timing would have to be perfect. Johnny was aware that it was because of his early roughness that he had been penalized so severely. The reward system here seemed to work against people like him, but there was not much he could do about it. The situation was becoming frustrating and he was ready to make his move. He knew that his success or failure would depend on what he did in the next few seconds.

interpretation. To ensure the phenomenon occurred during encoding, the second experiment measured sentence-by-sentence reading times for all stories.

Experiment 1

Method

Materials. The materials consisted of 3 target stories, 6 source stories, and 1 filler story. The 3 target stories were each written to be consistent with two very different interpretations. Table 1 shows one of the stories that could be interpreted as a story either about a jailbreak or a wrestling match. The other two target stories were ambiguous about whether the woman was ill or pregnant (adapted from Owens, Bower, & Black, 1979) and whether the man had just returned from a house he hoped to buy or rob (adapted from Pichert & Anderson, 1977). Each story was between 2 to 5 paragraphs long and 12 to 21 sentences long. (The story in Table 1 is the shortest). Early in each story was a proper name (of the character, location, or reading material) that provided a superficial reminding cue to one of the earlier source stories. For example, in Table 1, Johnny's reading material was either some Shakespeare or the Delaware Daily.

Each target story could be associated with two source stories, each of which dealt with one of the target story interpretations. For example, the two source stories associated with the Johnny story were (1) a retirement party for a reporter of the Delaware Daily Newspaper who had gotten famous covering a jailbreak and (2) an unusual character whose passions in life were reading Shakespeare and watching wrestling on TV.

A filler story was written as a primacy buffer. Its content was unrelated to the other stories.

Design. The experiment consisted of three parts. First, the subjects read the filler and source stories, rating each on three simple scales (pleasantness, comprehension, interestingness). All subjects read one version of each source story. Second, a distractor task was given which required rating the similarity of polygons. Third, the three target stories were given. For each target story, half of the subjects received each of the superficial cues back to one of the source stories (e.g., either Shakespeare or Delaware Daily). Subjects read each story and provided a brief description of what they thought the story was about.

Procedure. Subjects were told they would be participating in three experiments. First, they received a booklet containing the filler and source stories with a rating sheet after each story. They read through the 7 stories and rated them at their own pace (13-20 min). Second, they received a distractor task

consisting of a booklet of polygon pairs and a rating sheet. They went through the booklet rating each pair on how similar they were (6-11 min). Third, they received a booklet of the 3 target stories (in a random order). After each story, they turned the page and wrote a brief description of what they thought the story was about (9-16 min). Following this phase, they were asked some questions about their interpretations and were debriefed about the purpose of the experiment.

Subjects. The subjects were 37 University of Illinois students who participated for pay or as part of a course requirement. They were tested in small groups of 1 to 5.

Results

The descriptions were prepared for scoring by copying them into a computer and deleting all references to the superficial cues. Three scorers then went through the descriptions and scored each one using a strict procedure as one of the two interpretations or "other." The three scorers agreed on 97.3% of the scores and the other scores were decided by the majority.

The main question of interest is whether the superficial cue manipulation affected the interpretation. In particular, were subjects more likely to interpret the ambiguous target in a way consistent with the source story containing the same superficial cue? The answer is yes. Comparing the number of consistent versus inconsistent interpretations for the strict scoring, the wrestling-jailbreak target had 15 consistent interpretations versus 6 inconsistent, the pregnant-ill target had 19 versus 6, and the burglar-buyer target had 15 versus 8. For each subject, we computed the number of consistent minus inconsistent interpretations (with a 0 given if "other"), so the measure ranged from -3 to 3. Of the subjects showing a nonzero difference, 21 had more consistent interpretations versus 5 with more inconsistent interpretations ($p < .05$). The mean difference was .78, $t(36) = 3.365$, $p < .05$.

EXPERIMENT 2

Experiment 1 shows that the interpretation of the story depends upon the reminding cue. Subject reports suggested that this interpretation occurred during the encoding of the story. However, because the dependent measure was collected after the encoding, it is possible that the interpretation was made at the time of test. To provide evidence for the hypothesis that the interpretation was made during encoding, Experiment 2 used an on-line reading measure. Reading time is a useful measure because it indicates how easy it is to integrate new text: a

sentence that is not consistent with a person's current interpretation will produce a longer reading time than if the sentence was consistent with the existing interpretation. If interpretation is done during encoding, then those sentences consistent with the interpretation should be read faster than those sentences inconsistent with the interpretation.

Method

Materials. The materials were a modification of the stories from Experiment 1. The wrestling-jailbreak story and the pregnant-ill story were rewritten to have two sentences consistent with each interpretation that were inconsistent with the other interpretation (see Table 2). These four critical sentences were separated by three to eight sentences and appeared in different paragraphs.

The nine stories had 19 to 32 sentences (or new paragraph markings). In addition to the two target stories, there were two source stories for each, and three filler stories.

Design. Again, the primary manipulation was the relation between the superficial reminding cue in the target story and the source stories. For half of the subjects, each superficial cue was used. The question of interest is how reading time on the consistent

versus inconsistent sentences in the target story will vary as a function of the superficial cue manipulation.

Procedure. Subjects were told that they would be participating in an experiment on understanding. The stories were shown one sentence at a time in the middle of a computer screen. As soon as the subject understood the sentence, he or she pressed the + (plus) key for the next sentence. They were told that there would be questions at the end, so they should try to understand the story well enough to answer these questions. In addition, after each story they were asked to rate its comprehensibility.

Subjects. The participants were 37 subjects who participated for course credit. The complete experiment took about 25 mins. The data from one subject was not included, because she had participated in some pilot work using the same materials.

Results

The only data to be reported are the reading times on the four critical sentences from each of the two target stories. The question of interest is how reading time for these stories varied as a function of the superficial cue. In particular, were the sentences read faster when they were consistent with the source story having the same superficial cue than when they were

Table 2: Revised version Wrestling/Jailbreak Story

It was a big day for Johnny, but he tried to keep to his usual routine.
 He read part of <reading material> and completed his morning stretches.
 The routine helped calm him down.
 {NEW PARAGRAPH}
 Time seemed to crawl by.
 Johnny repeatedly checked his watch.
He skipped breakfast to be sure he made the cut. (Wrestling-consistent sentence)
 He would soon find out if he had prepared enough.
 {NEW PARAGRAPH}
 The critical moment was at hand.
 Johnny slowly pushed up, planning his move.
 Things were not going well.
 The lock that held him was strong, but he thought he could break it.
 He knew that his timing would have to be perfect.
 He concentrated carefully on what had to be done.
He looked to make sure no one was around. (Jailbreak-consistent sentence)
 {NEW PARAGRAPH}
 Johnny knew his early roughness had led to his being penalized.
 The reward system here seemed to work against people like him.
 However, there was not much he could do about it.
He had to get more points than the other guy. (Wrestling-consistent sentence)
 The situation was becoming frustrating.
 He was ready to make his move.
 {NEW PARAGRAPH}
 Johnny tested the lock again.
 His success or failure would be decided in the next few seconds.
He knew how badly failure would be punished. (Jailbreak-consistent sentence)
 He breathed deeply and began his move.

inconsistent? For example, was the sentence "He skipped breakfast to be sure he made the cut." read faster when the reminding cue biased subjects to think of wrestling than when the cue biased them to think of a jailbreak? The answer is yes, 2395 msec for consistent sentences to 2711 msec for inconsistent sentences. Remember that these differences are not due to differences in sentences, because which sentence was consistent or inconsistent switched with the manipulation of the superficial cue.

To analyze the data, we first subtracted out the subject and overall sentence effects (i.e., equating the overall time for each subject and the overall time for each sentence). Of the eight critical sentences, six were faster when they were consistent with the superficial cue source story interpretation and two were faster when they were inconsistent (though one of these only showed a 10 msec difference). For each story, we computed a consistency effect for each subject (inconsistent minus consistent). If consistent sentences are read faster, this difference should be positive. The wrestling-jailbreak story showed a 212 msec effect, while the pregnant-ill story showed a 419 ms effect. Averaging the two measures for each subject, there was a significant difference of 316 ms, $t(35)=2.38$, $p<.05$, with 24 of the 36 subjects responding faster in the consistent condition.

General Discussion

These two experiments provide converging evidence that strongly supports our hypothesis that interpretative processes can exploit reminders to operate in a dynamic, interactive fashion to embellish a text as it is read. In the first experiment, we introduced an experimental paradigm to explore interpretation, and showed that subjects' final interpretation of an ambiguous text most often followed the theme suggested by the superficial reminding cue. The second experiment used an online measure of encoding, sentence-by-sentence reading time, to show a difference in processing times: subjects take longer to read sentences that are not consistent with the theme suggested by the reminding than sentences that are consistent with the theme suggested by the superficial reminding cue.

The interpretation effect is triggered by a reminding. In all cases, subjects have read both potentially-relevant source stories, and could use either recent experience to suggest helpful themes. Yet subjects strongly favor the theme suggested by the superficial reminding cue.

These results provide support for the idea that specific past memories can affect the encoding of the target information. They suggest that theories of reminding and transfer cannot assume that the target is fully encoded prior to the onset of inferential

processes. Rather, the theories need to allow for the possibility of interactions among the component processes. In addition, we believe that this work provides a way of beginning to bridge the interesting work on text processing (e.g., Kintsch, 1988) with the work on reminding-based transfer.

Acknowledgements

This work was a collaborative effort: the order of authors is arbitrary. We thank Miriam Bassok, Stephanie Doane, Barbara Malt, and Gregory Murphy for their advice and comments on this research.

References

- Anderson, R.C., Reynolds, R.C., Schallert, D.L., & Goetz, E.T. (1977). Frameworks for comprehending discourse. *American Education Research Journal*, 14, 367-381.
- Bransford, J.D. & Johnson, M.K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior*, 11, 717-726.
- Gentner, D. (1989). The mechanisms of analogical learning. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning*. New York: Cambridge University Press.
- Gick, M.L., Holyoak, K.J. (1980). Analogical problem solving. *Cognitive Psychology*, 12, 306-355.
- Holyoak, K.J. (1985). The pragmatics of analogical transfer. In G.H. Bower (ed.) *The Psychology of Learning and Motivation, Volume 19*. New York: Academic Press, Inc.
- Kintsch, W. (1988) The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review*, 95, 163-182.
- Owens, J., Bower, G.H., and Black, J.B. (1979). The "soap opera" effect in story recall. *Memory and Cognition*, 7, 185-191.
- Pichert, J.W., & Anderson, R.C. (1977) Taking different perspectives on a story. *Journal of Educational Psychology*, 69, 309-315.
- Ross, B.H. (1984). Reminders and their effects in learning a cognitive skill. *Cognitive Psychology*, 16, 371-416.
- Schank, R. (1982). *Dynamic Memory*. Cambridge: Cambridge University Press.