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Inferences at encoding vs. retrieval: Clarifying the issues based on a developmental perspective

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INFERENCES AT ENCODING VS. RETRIEVAL: CLARIFYING THE ISSUES BASED ON A DEVELOPMENTAL PERSPECTIVE

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Abstract

This study addressed the controversy surrounding the locus of the inferential process (encoding vs. retrieval) in story comprehension by adopting a developmental perspective. Second, fifth, and eighth grade children, and college undergraduates, read eight stories from which two types of inferences could be drawn. Bridging inferences are inferences critical to the comprehension of a story while forward inferences are not. Eight questions (four inference and four filler) were answered to each story, and the dependent variables of reaction time and error rate were measured. The hypothesis that bridging inferences would be drawn at encoding was clearly supported as was the corollary that forward inferences would not be drawn until retrieval. Additionally, the hypothesis that second grade children would successfully draw the bridging inferences was supported, contradicting much previous research. Errors reached asymptotic level at the fifth grade while reaction time decreased until the eighth grade, after which there were no significant differences. Bridging inference questions were answered faster and more accurately than forward inference questions, at all grade levels.

Inferences at Encoding vs. Retrieval: Clarifying the Issues Based on a Developmental Perspective

A recent area of inquiry in the reading literature concerns children's ability to draw inferences from either single stimulus sentences or short prose passages. Some of the empirical issues that have stimulated the research are questions of: (a) age of onset of inferring ability in children; (b) children's ability to draw different types of inferences; and (c) the distinction between inferring ability (can do) and inferring occurrence (does do).

Children's Inference-drawing Abilities

In one of the earliest studies on the ability of children to make inferences from prose, Paris and Carter (1973) tested children's ability to demonstrate constructive memory abilities (can they make inferences?) Their subjects consisted of second and fifth grade children. Simple three sentence stories consisting of two premises and one filler were presented to the children. For example:

The bird is inside the cage. (Premise)
The cage is under the table. (Premise)
The bird is yellow. (Filler)

A recognition test was then given to each child ("Was this sentence heard before?"), and it consisted of both a true and false premise and a true and false inference. Most errors committed by the children were on the true inference questions. This is not surprising, for if children's memory does have a constructive component, the implied information could very easily be expected to become a part of the memory representation for that information. Additionally, it was found that the older subjects made significantly fewer errors than the younger subjects.

While the previous finding would seem to indicate that children can at least make inferences, as seen by their false recognition of them, this actually tells us very little about the inference-drawing process itself. These earlier findings were expanded upon by Paris and Lindauer (1976), who looked at children's ability to use either explicit or implicit cues to recall a previously rehearsed sentence. The explicit cues were actually included in the original sentence while the implicit cues had only been implied by the content of the sentence (an instrument inference task). The argument made by Paris and Lindauer was that if children ordinarily supply missing but implied information into their memory representation for a sentence, then they should be able to utilize the implied instrument of the action as a retrieval cue for the sentence. For example, if the sentence presented was "Our neighbor unlocked the door" and the inference of "key" is made by the child in order to understand the sentence, then presentation of the word "key" ought to facilitate recall. In the explicit condition the words "with a key" would be added to the end of the sentence to make "key" an explicit recall cue. The results showed that their fifth grade subjects were able to make equally good use of the explicit and implicit recall cues while their first and third grade subjects recalled more sentences when given the explicit recall cue. However, the children who could not effectively use the implicit recall cues could generate the appropriate instrument implied by the sentence when asked to do so. Furthermore, Paris and Lindauer manipulated the situation so that the children could be made to make the appropriate inference by simply acting out the described actions in the experimental sentences. In this condition, there was no significant difference in recall between the explicit and implicit recall cues. The conclusion drawn by Paris and Lindauer was that the younger children did not spontaneously encode the inferred relation of the instrument but could be induced to do so. Paris and Lindauer speculated that their younger subjects did not spontaneously generate inferences simply because they did not approach their tasks with specific plans.

A similar study by Paris and Upton (1976), based upon the previous research of Paris and Lindauer (1976), drew essentially the same conclusions, although different inference-drawinq tasks were used. Paris and Upton found that between six and ten years of age, the ability to comprehend and remember semantic inferences such as presuppositions and consequences steadily improved. Presuppositions were loosely defined as inferences about prior actions in a story that were highly probable while consequences were defined as inferences about outcomes in a story that were also highly probable. The major difference between this study and the previously discussed study by Paris and Lindauer is that Paris and Lindauer examined inferences about instruments while this study examined inferences about presuppositions and consequences. An important point further revealed in the Paris and Upton article was that the developmental changes noted were not the result of a change in memory capacity alone, although both improved with age. This latter result was arrived at using an analysis of covariance design.

Another related study (Paris, Lindauer, & Cox, 1977) extended the earlier findings to children's ability to infer the implied consequences of actions. As before, it was found that the seven and eight year old children (first and second graders) did not construct inferential relationships from sentences very often but that older children (sixth graders) and college students did. It was once again shown that the children could be induced to infer the implied consequences by having them make up a story that would go along with the experimenter's sentence. As Paris et al. (1977) conclude, "It is clear that young children are capable of inferring consequences and relationships from sentences as functional goals of some actions. They simply fail to manifest similar constructive actions when they are instructed to remember the sentences" (p. 1732).

A further study by Kail, Chi, Ingram, and Danner (1977) provides more evidence that children can make inferences. In their task, they had second and fifth graders read two types of sentences from which different inferences could be drawn; transitive inferences and contextual inferences. A transitive inference that Kail et al. used as an example was taken from Paris and Carter (1973) and was the one listed earlier in this paper about the bird in the cage. This type of logically ordered relationship with three elements has also been referred to as a three-term series problem (Paris & Lindauer, 1977; Trabasso, 1977). The appropriate inference in this transitive-inference condition would then be "The bird is under the table."

An example of a contextual inference:

Mary was playing a game (Premise)

She was hit by a bat (Premise)

Mary cried out in pain (Filler)

The appropriate inference would be "Mary was playing baseball."

Following each set of three sentences, the children read and answered two questions, one concerning given information and the other concerning inferred information. Both reaction time and accuracy of response were recorded. The distinction between this study and the earlier one of Paris and Carter (1973) is that Paris and Carter tested for false recognition errors (false recognition of sentences that differed in syntax but were consistent semantically) while Kail et al. tested for the semantic consistency of what had been presented rather than the verbatim match. The important finding for our purposes was that the children's accuracy on both the premises and inferences was above chance, indicating that the children could make inferences. A surprising finding from this study, however, was that while the children were more accurate on true premises than on false premises, and on false inferences than on true inferences, this performance did not change with age. It would appear that this research contradicts most of the research of Paris and his associates. Recall that Paris and Lindauer (1976) concluded that their first and third grade subjects did not spontaneously encode the inferred relation of the instrument while their fifth grade subjects apparently did so. Likewise, both Paris and Upton (1976) and Paris et al. (1977) showed that the ability to make inferences increased with age. Kail et al., however, apparently found no developmental change in inference-drawing ability among their second and fifth graders. Which one is correct?

In their paper, Kail et al. stated that Paris and Lindauer (1977) offered a plausible explanation for why developmental differences may not be seen in false-recognition studies. Kail et al. interpreted Paris and Lindauers' explanation to read as follows: On the one hand, improvement in memory skills with age would lead to a decline in the false-recognition of novel inferences. On the other hand, the improvement in inference making with age would lead to an increase in the false-recognition of inferences. Kail et al. concluded that, "A combination of both developmental changes might well produce an overall pattern of no developmental change" (p. 687). Kail et al. argue, however, that such a pattern of compensatory developmental changes could not have operated in their study. They stated that both increased retention and increased inference-making with age would lead to increased accuracy. While Kail et al. were correct in stating that such a compensatory process could not have operated in their study, they were incorrect in stating that Paris and Lindauer (1977) were positing the existence of such an compensatory process. In their article, Paris and Lindauer (1977) proposed an explanation about why the false-recognition paradigm as used by Paris and Carter (1973) is an inappropriate method to use in an analysis of developmental change. Response biases as well as memory capacity will change with age. Nowhere was it stated that these effects would offset each other in such a way as to produce no developmental change. Kail et al., however, stated that no developmental changes were observed in the Paris and Carter (1973) study, therefore lending support to Kail et al.'s findings. However, Kail et al.'s interpretation of Paris and Carter's results is questionable. While it was shown in the Paris and Carter study that second and fifth graders responded similarly in recognizing falsely implied information as what had actually been presented, it was explicitly stated that the error rates <u>decreased</u> with age (as pointed out earlier), therefore showing a developmental difference. In other words, the older subjects were less likely to falsely recognize a semantically congruent sentence. This is an example of developmental change where Kail et al. argued none was shown.

While the difficulties between Paris and Carter's

(1973) study and Kail et al.'s (1977) study have been resolved, a problem still exists with regards to Kail et al.'s findings of no developmental changes while Paris and his associates found developmental changes. Possibly, the differences could be due to something as simple as the different stimulus materials used by each study. For example, Paris and Lindauer (1976) and Paris et al. (1977) used explicit or implicit cues with single sentence stories; Paris and Upton (1976) studied the ability to detect the truth or falsity of 13-16 sentence paragraphs; and Kail et al. (1977) studied the ability to detect the truth or falsity of three sentence paragraphs. Likewise, the difference could stem from the different types of inferences the tasks were asking the children to make. A point should be made at this time about the Kail et al. (1977) study, however. While the tone of Kail et al.'s study has been that the children in their study could make inferences and that this ability did not show improvement with age, this interpretation needs to be tempered. Although performance was near perfect on false inferences, performance on true inferences was only around 70 percent (at least as evidenced by their crude graph). While this was significantly above chance, it is not perfect, indicating room for improvement with continued development. It may be that the observed lack of developmental change was due to the lack of an older group of children.

Dreher (1981) looked at inferences of a different sort - instantiations. Instantiations are particular exemplars or examples that are supposedly generated during reading from the more general terms that were actually used in the passage. The instantiations are then stored in memory and used to represent the meaning of the general terms. For example, in the sentence "The fish chased the man in the water," the word "shark" may be what is represented in memory rather than "fish." While instantiations have been found to be more effective recall cues than the actual word itself for adults (Anderson, Pichert, Goetz, Schallert, Stevens, and Trollip, 1976), the question still remained as to whether children can and do instantiate. Dreher's results, however, convincingly showed that the children in her study (fifth, sixth, and eighth graders) did <u>not</u> instantiate. After reading one of three sentences (exemplar, target, and control), the children were either given a particular cue or the general cue that was given in the sentence itself. For instance:

The scout earned a merit badge (exemplar)

The boy earned a merit badge (target)

The boy saw the policeman's badge (control)

The particular cue in this case would be "scout" while the general cue would be "boy." Whereas the instantiation hypothesis would predict equal performance for the particular cues in both the exemplar and target sentences, this was not found. The particular cues elicited better performance on exemplar than on target sentences. Dreher, however, did show that children can instantiate, and therefore, draw inferences. When Dreher asked her subjects to write down what particular instance of the subject noun occurred to them when reading both target and control sentences, only four percent were left unanswered.

Some summary remarks can be given, based upon the evidence presented thus far. Regardless of the methodology, regardless of the type of inference studied, and regardless of age - at least as young as kindergarteners - it would appear that children can make inferences. It does not appear, however, as if young children spontaneously and reliably draw their own inferences and encode them with their reading of a passage. Likewise, children's inference-drawing ability is not perfect. This ability would appear to be a developmental phenomenon which increases through at least the sixth grade. The only study cited which might question this latter point would be the Kail et al. (1977) study, and these differences have already been discussed. It is hoped that with the introduction of still another controversy in the reading literature, a unique methodology will present itself which might help resolve the ambiguity surrounding the children's reading literature. It is to this second controversy that we now turn.

Encoding vs. Retrieval Debate

Questions still remain as to where the inferential process occurs. Is an inference truly encoded as text is comprehended and, therefore, stored as a part of the memory representation for that text, or do subjects simply draw the inference at retrieval, when they encounter it for the first time? Miller (1980), has argued that the determination of the locus of inferential elaboration is necessary because the alternative explanations have different implications for cognitive theories of memory, language comprehension, and reading. This is so because the effective stimulus (text base) will be significantly influenced by the elaboration process. If inferential information is contained in the text base constructed by a reader, then processes operating at comprehension must account for their generation. Alternatively, if the text base does not contain the inferential elaborations of interest, then the presence of such inferences can only be explained by processes occurring at retrieval.

Miller (1980), in a recent comprehensive review of the inference literature, attempted to resolve much of the ambiguity surrounding the encoding versus retrieval debate.

He identified three experimental paradigms within which much of the inferential research is conducted: cued recall, recognition, and reaction time.

Cued Recall Literature

Taking the cued recall studies first, Miller (1980) stated that their validity rests upon the encoding specificity principle first developed by Tulving (Tulving & Thompson, 1973). The encoding specificity principle makes the assumption that retrieval cues which are part of the information originally encoded during an episode will act as the most successful cues. Therefore, if individuals make inferences during the process of comprehension (the inference-at-encoding view), then the inferred information should act as a successful retrieval cue because it is part of the memory representation resulting from that particular episode. The earlier mentioned study by Paris and Lindauer (1976) is a prime example of a cued recall study. Evidence supporting the inference-at-encoding viewpoint utilizing the cued recall paradigm is provided by Miller (1980) and Paris and Lindauer (1976). However, the issue is far from resolved.

Corbett and Dosher (1978) provide evidence that questions the conclusion drawn above. They utilized a methodology similar to that of Paris and Lindauer, but argued against Paris and Lindauer's interpretation that the implicit recall cues were effective due to the appropriate inference being encoded. Essentially, Corbett and Dosher showed that a highly probable instrument was an effective recall cue even when a low probability instrument had been encoded. Furthermore, this finding was not due to the similarity of the high and low probability instruments, as evidenced by the finding that the subjects recalled the high probability instrument significantly more often in the high probability than in their other two conditions. They concluded that retrieval cue effectiveness cannot be relied upon as an indicator that implicit instruments are inferred and encoded in reading.

Further cued recall data contradicting the inference-at-encoding explanation are provided by the instantiation literature (Gumenik, 1979; Sanford, Garrod, & Bell, 1978; Whitney & Kellas, 1984). Gumenik argued that if only predicates of the sentences were used ("attacked the swimmer" rather than "The fish attacked the swimmer"), there would be no opportunity to instantiate the sentence subjects. Therefore, if the inference-at-encoding view is taken, "shark" should not function as an effective retrieval cue. In addition, a less accessible cue ("barracuda," for example) would not be expected to be an effective cue. An inference-at-retrieval view would predict, however, that both "shark" and "barracuda" would still be better recall cues than "fish" because they share more features with the phrase "attacked the swimmer" than does "fish." "Shark" would produce better performance than "barracuda," though, because it shares more features in common with the to-be-remembered material. Gumenik's results convincingly supported the inference-at-retrieval viewpoint. Since there were no nouns presented in the phrase condition, there was no opportunity for them to be instantiated. And yet, they functioned as efficient retrieval cues. In another experiment, Gumenik even showed that a word which could not possibly be an instantiation but which shared meaning with the sentence as a whole functioned as a more effective retrieval cue than did the general nouns themselves.

The research of Whitney and Kellas (1984) provides further corroborating evidence against the instantiation hypothesis and the inference-at-encoding view. In a series of three experiments, they found no evidence for the inference-at-encoding view. Indeed, using a modified Stroop design, they found that even with sentences that were biased toward an atypical exemplar, the presentation of the typical exemplar produced significant semantic interference. Furthermore, these differences were not due to different encoding strategies. Whitney and Kellas were led to conclude, as was Gumenik (1979), that recall studies do not provide convincing evidence for the inference-at-encoding position.

Finally, Sanford et al. (1978), utilizing a self-paced reading paradigm, found that a final sentence of a three or five sentence passage that mentioned an instantiated object actually took longer to read than did a sentence that mentioned the more general term that had been used earlier. This was true even for passages which were heavily biased toward the drawing of the typical exemplar.

False Recognition Literature

Returning to Miller's (1980) review of the inference literature, he next summarized the studies using the recognition paradigm for studying inferences. Assuming the inference-at-encoding point of view, if subjects encode inferential elaborations during comprehension, then it would be expected that they would falsely recognize test sentences which explicitly state those inferences. Three studies have reported just such a finding (Johnson, Bransford, and Solomon, 1973; Paris and Carter, 1973; Thorndyke, 1976), providing evidence for an inference-at-encoding view. Miller (1980) argued, however, that firm conclusions could not yet be drawn regarding the recognition literature for two reasons. The first deals with the fact that isolated sentence recognition tests often result in the use of inappropriate strategies by the subjects (i.e., they tend to judge the truth of the test sentence rather than determining if it is a verbatim match to one held in memory; Anderson & Bower, 1973). The second criticism has to do with the subjects' own perception of their performance. If the subjects attributed the incompleteness of their memory representations to forgetting rather than to the implicit nature of the study sentences, the explicit test sentences may have been recognized as true because they were logically consistent with what was remembered.

In order to control for the extraneous variables listed above, Miller (1980) utilized a forced-choice recognition test. All of the subjects were presented with implicit study sentences. At test, the subjects were then presented with both the actual implicit study sentence and an explicit version of the same sentence. Miller argued that if subjects make the inference at encoding, then their false recognition of explicit sentences should occur at a chance level (.50) if not higher because it would be the closest match to their memory representation. A chance level of false recognitions might occur rather than a higher level simply because a particular inference might not be made by the subjects or some surface information about the study sentence in short-term memory may be retained. If subjects make the inference at retrieval, however, we would expect them to select the correct (implicit) sentence significantly more often than chance because it would be the closest match of the memory representation. The results showed that the subjects did not differ from chance in their ability to discriminate the actual implicit study sentence from its explicit distractor. These findings would then seem to be in agreement with the inference-at-encoding position and lend further credibility to the two aforementioned studies.

A final pair of studies also utilizing the recognition paradigm provides further evidence for the inference-at-encoding viewpoint. McKoon and Ratcliff (1980, 1981) investigated recognition using a priming technique. Their method consists of giving subjects a series of four preparatory sentences followed by one of two final sentences which would either act to prime the target word or not. For example:

> Bobby got a saw, hammer, screwdriver, and square from his toolbox.
>
> He had already selected an oak tree as the site for the birdhouse.
>
> He had drawn a detailed blueprint and measured carefully.
>
> He marked the boards and cut them out.
>
> Final sentence, version 1: Then Bobby pounded the

boards together with nails.

Final sentence, version 2: Then Bobby stuck the boards together with glue.

(McKoon & Ratcliff, 1981, p. 674).

In this case, version 1 primed the target word "hammer" and version 2 did not. The subjects' task was to respond "yes" or "no" according to whether or not the target word appeared in the paragraph. The results showed that the appropriate action did prime the target word and resulted in shorter response latencies. In a related study, it was also found that a less related target word (such as "mallet" for the above example) did not result in shorter response latencies. In still another pair of experiments in the same study, it was found that the appropriate inference ("hammer") was drawn at encoding while the less appropriate inference ("mallet") was not. It would appear that the recognition literature provides universal agreement that inferences are drawn at encoding.

Reaction Time Literature

Finally, Miller (1980) reviewed the reaction time literature with regard to the inference at encoding versus retrieval debate. The underlying assumption of these studies is that, if inferences occur at encoding, then we would expect no differences in subject response latencies to a true-false verification test in which the tested information was either explicitly stated or only implied. In other words, subjects should be able to verify as true the implicit information just as quickly as the explicitly stated information.

Experiments by Keenan and Kintsch (1974) and Singer (1979) reported findings in which the implicit versions had longer response latencies than did the explicit versions. For example, in the Singer study, subjects took longer to respond that they comprehended the sentence "The shovel was heavy" if first given the sentence "The boy cleared the snow from the stairs" than if given the sentence "The boy cleared the snow with a shovel." These results would tend to argue against the inference-at-encoding view and support the alternative inference-at-retrieval view.

In order to provide a clearer picture of the reaction time data, Miller (1980) constructed a study with three treatments; the typical explicit and implicit treatments and an additional implicit-prompted treatment which required the subject to covertly infer the implied instrument or consequence. The implicit-prompted treatment was actually a question whose answer forced the subject to make the appropriate inference. If subjects infer the implied instruments during retrieval, as suggested above, then their latencies for the implicit paragraphs should be longer than those for the explicit and prompted paragraphs because in the implicit treatment, the inferences would have to be made at the time of testing. If, on the other hand, subjects infer the implied instruments at the time of reading (encoding), then their response latencies should not differ from the implicit and implicit-prompted paragraphs. Miller's (1980) findings were consistent with the inference-at-encoding viewpoint. There were no significant differences between the implicit and implicit-prompted paragraphs. In addition, an unexpected finding (but one consistent with the inference-at-encoding view) is that the implicit and explicit conditions did not differ.

Miller (1980) resolved his findings in relation to those reported by Keenan and Kintsch (1974) by citing his counterbalanced block design and use of a within-subjects design as his main advantage over the study by Keenan and Kintsch. It is true that Keenan and Kintsch's first experiment did not utilize a within-subjects design. Each subject received only the explicit version or the implicit version of each paragraph. It should be pointed out, however, that Keenan and Kintsch ran a second experiment in the same study in which a within-subjects design was used. Surprisingly, the results from this second experiment confirm nicely Miller's results. The subjects responded equally quickly on both the implicit and explicit paragraph forms. While Miller's arguments about counterbalancing and within-subjects designs may well discount Keenan and Kintsch's first set of findings, what of those of Singer (1979)? As it turns out (whether by design or accident), Miller failed to mention the article by Singer. Curiously enough, Singer did counterbalance his test sentences and he did utilize a within-subjects design. Miller, however, simply concluded "Thus, the significant difference between implicit and explicit response latencies in these earlier experiments may have been due to extraneous variance" (p. 294).

Clarification of the Issues

Taking into consideration all of the evidence thus far, can any definitive statements be made concerning the encoding versus retrieval debate? At the end of his article, Miller (1980) seems content with his conclusion that, at least as regards inferred instruments and consequences of action, inferences appear to be drawn at encoding. The issue is simply not that clear cut, however. Many of the articles arguing for an inference-at-encoding position were not even addressed in Miller's article (Gumenik, 1979; Sanford et al., 1978; Singer, 1979; Whitney & Kellas, 1984). Consider the evidence as presented here. With regards to recall, the instantiation literature supports an inference-at-retrieval position

(Gumenik, 1979; Sanford et al., 1978; Whitney & Kellas, 1984). The implicit instrument literature (still within the recall paradigm) is divided. Support for retrieval comes from Corbett and Dosher (1978) while support for encoding is provided by Paris and Lindauer (1976) and Miller (1980). Examination of the recognition literature provides unilateral support for the inference-at-encoding view. But once again, the reaction time literature is inconclusive. Miller's results, as well as those of Keenan and Kintsch's (1974) second experiment, argue for encoding while the results of Keenan and Kintsch's first experiment, as well as Singer's (1979), argue for retrieval. If nothing else, it should by now be apparent that the inference literature is characterized by inconsistency. Perhaps, however, this should not be viewed as a fault, but rather as a consequence of the complexity of the issue at hand. Obviously, there is no such thing as one type of inference. Even within a single research paradigm, different types of inferences have been studied. For example, within the cued recall paradigm, what are termed "instantiations" and the implied instruments in a sentence are two entirely different things. In addition, as McKoon and Ratcliff (1981) pointed out, one reason that instrumental inference designs are so hard to interpret is that the drawing of the instrumental inference is not usually necessary for comprehension. But even more to the point, it is possible that inference-drawing differs as a function of the stimulus materials. For instance, some authors have postulated that the locus of inference-drawing might change, depending upon the text base; single sentences versus passages or paragraphs (Dosher & Corbett, 1978; Singer & Ferreira, 1983; Paris & Lindauer, 1977; Whitney & Kellas, 1984). Even when a paradigm apparently offers unilateral evidence, as with the recognition literature, there is not agreement on the interpretation. Singer and Ferreira (1983) point out:

> In particular, it has been pointed out that neither the false recognition of an implicational test sentence, nor the effectiveness of an implicit recall prompt, nor the reader's ability to answer questions that require inferences from text, prove that the inferences in question were drawn when the text was originally examined" (p. 438).

Probably the most fruitful line of research would adopt a more global view of the inference-drawing process in an attempt to integrate some of the discrepant findings. If a more unified approach were stressed, the possibility is greater that originally discrepant findings could be resolved. But how does this argument help extend the present discussion? Recall the inconsistencies in the reaction time literature between the results of Miller and those of Singer (1979) and Keenan and Kintsch's (1974) first experiment. Miller argued that his results supported an inference-at-encoding viewpoint while Keenan and Kintsch's as well as Singer's supported an inference-at-retrieval view. While Keenan and Kintsch's results were dismissed on methodological grounds by Miller, Singer's results cannot be. Can an explanation be found?

Singer and Ferreira (1983), apparently not content with the contrasting results, undertook to correct the problem. They distinguished between two types of inferences: forward and backward inferences. Forward inferences, they argued, are ones which might almost certainly be true (highly probable), but do nothing to contribute to the coherence of the message. For example, upon reading "The egg fell to the floor," do we encode that the egg broke? Backward inferences (Just & Carpenter, 1978; Singer, 1979; Thorndyke, 1976), also referred to as bridging inferences (Clark, 1975; Garrod & Sanford, 1981) are inferences that enhance the coherence of a message because, without them, a message would become disjoint. They specify a connection between the current phrase and the earlier discourse and appear to function so that context can be established (Thorndyke, 1976). For example, the inference that "The pitcher threw the ball" establishes a connection between "The pitcher threw to first base" and "The ball sailed into the field." Singer and Ferreira went on to argue that since backward inferences contribute to coherence, it is likely that they are drawn during reading, unlike forward inferences, which are probably not drawn until retrieval. In this sense, backward inferences are actually quite similar to Haviland and Clark's (1974) discussion of the Given-New Strategy. The first sentence provides both "Given" and "New" information. Upon encountering the second sentence, the subject attempts to locate antecedent information in memory (the first sentence) that matches the second sentence's "Given" information. If antecedent information is found, the "New" information from the second sentence is added to the "Given" information already present, thus forming a revised memory trace. The presence of the second sentence for backward inferences actually contributes more "New" information than do the single sentence forward inferences. For this reason, if the "New" information is not resolved with the "Given" information, comprehension of the sentences will suffer.

Given what appears to be a difference in terminology, how does this play on words help resolve the separate findings of Miller (1980) and Keenan and Kintsch's (1974) second experiment versus Singer (1979)? First, recall the previous example of one of Singer's test sentences: "The boy cleared the snow from the stairs." The subjects' task was then to respond as soon as they comprehended the following sentence: "The shovel was heavy." According to Singer and Ferreira's (1983) terminology, this would be an example of a forward inference, which, they would argue, should not be drawn until retrieval (as was found). Although the word "shovel" is a high probability instrument for the sentence "The boy cleared the snow from the stairs," it does not contribute to the coherence of the sentence. Also, as previously pointed out by McKoon and Ratcliff (1981), this type of inference is not necessary for comprehension.

Next, examine one of the implicit test paragraphs utilized by Miller (1980) and adapted from Keenan and Kintsch (1974): "A burning cigarette was carelessly discarded. The fire destroyed many acres of virgin forest." The subjects' task was then to respond true or false to the question "The cigarette started a fire." Is this not a case of a backward inference? Most certainly "The cigarette started a fire" forms a connection between the two sentences. It would, therefore, be a backward inference and would be predicted by Singer and Ferreira (1983) to be made at encoding (as was found).

In a series of three experiments, Singer and Ferreira

(1983) revealed that their adult subjects (college students) drew backward consequence inferences more reliably than forward consequence inferences. As materials, they constructed four sets of 11-sentence short stories. Within each of the four stories, two forward inferences and two backward inferences could be drawn. The backward inferences were prompted using a companion sentence (backward inference-inducing) that stated an outcome of the previous sentence, analogous to Miller's (1980) implicit sentences. The subjects' task was to respond true or false as quickly as they could to questions regarding the two types of inferences (see Table 1). It was found that that the backward inferences had a significantly lower overall response latency compared to the forward inferences. This would imply that the backward inferences were made at encoding while the forward inferences were only drawn at retrieval.

If we assume that this methodology has merit (and I believe it does), then another argument can be made that it also helps account for the discrepant findings in the children's reading literature. Recall that the results of Kail et al. (1977) were at variance with those of Paris and his associates (Paris & Lindauer, 1976; Paris et al., 1977; Paris & Upton, 1976) in that Kail et al. found that the ability to respond to inference questions did not

TABLE 1

Singer and Ferreira's "Spy Story"

Sentence	Sentence Function
Bob the spy read a report by the fire.	Filler
A rock flew through the windowpane.	Forward inference
Bob read a not attached to the rock	Filler
He quickly threw his report in the fire.	Backward inference
The ashes floated up the chimney.	Backward inference-inducing
Next he called the airline.	Filler
He placed the coded sugar cube in water.	Backward inference
He poured the clear liquid into the drain.	Backward inference-inducing
Bob left and flew to a tropical resort.	Filler
He sat all the next day in the sun.	Forward inference
But Bob knew he was not safe here.	Filler

(Singer & Ferreira, 1983, p. 445)

improve with age in terms of either accuracy or response latency. While it might justifiably be argued that the discrepant results were due to Paris and associates' use of either cued recall or question accuracy and Kail et al.'s use of response latency, this cannot be the sole cause. Kail et al. also studied accuracy of responses, and the accuracy results agreed with the response latency results in that the inference-drawing ability did not improve monotonically with age. As a result, I will advance the argument that the discrepant results are due simply to the type of inference that was studied in the opposing experiments.

As noted earlier, Kail et al. studied two types of inferences - transitive and contextual. Examining contextual inferences first, I argue that they are analogous to backward inferences; that they form a connection between the first and second sentences. Kail et al.'s example was that "Mary was playing a game" and "She was hit by a bat." The appropriate inference was then "Mary was playing baseball." By using Singer and Ferreira's (1983) definition of a backward inference, "Mary was playing baseball" does form a connection between the two test sentences, and without it, comprehension would not be possible. The premise "She was hit by a bat" is even analogous to Singer and Ferreira's backward inference-inducing sentences, because without it, the appropriate inference could not even be made.

While the argument would appear to be the strongest for contextual inferences, I believe a case can also be made for the transitive inferences. Again, Kail et al.'s two example inferences were "The bird is inside the cage" and "The cage is under the table." The appropriate inference was, therefore, "The bird is under the table." As with contextual inferences, the second premise could not be understood unless the appropriate inference was drawn; in other words, a connection was drawn between the two premises by the appropriate inference, and that connection, as defined by Singer and Ferreira, would be termed a backward inference. As Thorndyke (1976) noted, without the appropriate inference in this case, context could not be established.

If this argument is accepted, it could be that Kail et al.'s results simply reflect the drawing of backward inferences, which are hypothesized to be drawn at encoding. It may be that since backward inferences enhance the coherence of a message and ensure comprehension, that they should appear developmentally earlier in the young child than should forward inferences. It should by now be apparent that the stimulus materials of Paris and associates allowed the drawing of only forward inferences.

This was assured by the single-sentence stimulus materials used. In the one study of the three that did utilize stories (Paris & Upton, 1976), at least in the one example listed, nothing analogous to a backward inference-inducing sentence was present. Without such an inference-inducing sentence, the inferences drawn would have had to be forward inferences.

Although I believe that Singer and Ferreira's distinction of inferences can be fruitfully applied to Kail et al.'s stimulus materials, there is still a basic difference between their two specific types of inferences that needs to be made. While the two studies' stimulus materials can be somewhat equated in terms of forward and backward inferences, this is not to say that the forward and backward inferences were the same. Singer and Ferreira studied inferences about consequences which simply may not be the same as contextual or transitive inferences. Indeed, Singer and Ferreira made this point in the first paragraph of their article. While the methodology of forward versus backward inferences provides a useful distinction, it should not be implied that it replaces the concept of different types of inferences (e.g., consequences, presuppositions, implied instruments, etc.). It should be noted that from this point on, backward inferences will be referred to as bridging inferences. The term "bridging inference" appears to describe more accurately the type of inference that is being made. It is an inference that establishes a connection (a "bridge") between a preceding and a subsequent sentence, thereby contributing to coherence. In addition, in place of the term "backward inference-inducing sentence," the term "bridge-mate" will be used. "Bridge-mate" has the advantage of being shorter than "backward inference-inducing sentence" while still retaining its descriptive value.

Although the distinction of forward and bridging inferences does seem to have merit, a recent article (Garrod & Sanford, 1981) cautions that bridging inferences are not always necessary. In many cases, Garrod and Sanford argue, certain words in a sentence are decomposed into their implied entities as soon as they are encountered. Garrod and Sanford used verbs that strongly implied certain entities (for example, the verb "dressed" implies the presence of "clothes"). The time it took a subject to read a final sentence from a three sentence phrase was measured in one of two conditions: The entity had either been explicitly stated previously or it had only been implied. Reaction time to questions concerning the passages was also measured. The results showed that there were no differences in either the reading times for the final sentences or the reaction times to the questions. Garrod and Sanford interpreted these results as meaning that the verbs were decomposed as they were encountered, and thus, bridging was unnecessary. Supposedly, this accounted for the lack of a significant difference in the reaction times. Garrod and Sanford proposed the term "focus" to identify the currently active portion of memory represented by the decomposition of the various verbs. Explicit focus refers to those items stated explicitly while implicit focus denotes those entities implied by the verbs. Garrod and Sanford argued that the results of their experiment supported a notion of "primary processing," where no inferential bridge was needed and referents were mapped directly onto their decomposed memory representation. Garrod and Sanford further argued, however, that there are instances in which primary processing sometimes fails (as evidenced by their second experiment) and the search for an inferential bridge then becomes necessary (secondary processing). In other words, it is not that bridging does not ever occur, but simply that there are instances in which it is unnecessary. A look at Singer and Ferreira's (1983) materials, however, reveals that their inferences would not be influenced by primary processing; the search for a bridge would still be necessary. Singer and Ferreira did not utilize verbs where an entity was implied, and as a result, decomposition could not have occurred.

The question as to why bridging inferences would be drawn at encoding could justifiably be asked at this point. Wherein does the difference lie between the two types of inferences that one is reliably drawn during encoding while the other is not? Singer and Ferreira (1983) argued that the difference most probably stems from human information processing limitations. But they did not elaborate upon this statement, so the reader is unsure of their implication. It might be reasonable to argue that, at least as regards inferences about consequences, while forward inferences are highly probable, they are not necessarily true. Take, for example, the forward inference cited earlier. While "shovel" is a reasonable instrument for the action "cleared the snow from the stairs," it certainly is not the only possible one. "Broom," for example, could be an equally reasonable instrument for that particular action. Given this assumption, it would not be surprising that forward inferences are <u>not</u> drawn at encoding. If this were true, it might produce errors later if "shovel" had been encoded and "broom" was the actual intended inference. This explanation could not, however, account for all of the findings.

In another of Singer and Ferreira's stories, the forward inference was "The rock flew through the windowpane." The question asked of subjects was then "Did the windowpane break?" In this instance, the fact that the windowpane broke would have to be true. Another possibility stems from a methodological issue. It could be that inferences, whether forward or bridging, are not drawn until needed for comprehension. In Singer and Ferreira's methodology, their backward inference-inducing sentences (our bridge-mates) "forced" the inference to made so that comprehension was ensured. On the other hand, their forward inferences did not need to be made to ensure comprehension. In other words, it may be that bridging inferences are drawn at encoding because they are needed for text comprehension, unlike forward inferences, which are basically optional. If this argument is accepted, however, it gives rise to questions of the validity of the forward/bridging inference distinction as it pertains to the encoding versus retrieval debate. If inferences are not drawn until needed for comprehension, and the bridge-mate sentences "force" the inference to be made, is this truly evidence for the inference having been made at encoding?

The issue revolves around the definition and use of the term "encoding." Does the inference-at-encoding position argue that an inference has to be drawn the exact moment it is implied in the text, or is possible that it can be drawn at a later time, although still while reading the text? In other words, does the encoding position demand that the inference "The cigarette started a fire" was drawn when the sentence "A burning cigarette was carelessly discarded" was encountered, or is it ambiguous enough to allow that the inference was drawn at a later moment in the text base, as when the second sentence "The fire destroyed many acres of virgin forest" was then encountered? In order to answer the question, the definition of the encoding position needs to be made more explicit, and to date, this issue has not been addressed. It is a crucial methodological issue. Even if it can be argued that the use of bridge-mate sentences does not *necessarily* imply that the inference was made at encoding, the methodological point *does* help explain the discrepancies noted in some of the previous work.

There were two main goals of this study. The first was to attempt to determine at what age the ability to draw bridging inferences at encoding develops (if, indeed, bridging inferences are found to be made at encoding). Therefore, additional light could be shed on many of the discrepancies noted in some of the earlier children's inference literature. The second goal was to replicate the findings of Singer and Ferreira (1983), but with an extended range of test materials. Singer and Ferreira used only four stories from which two inferences of each type could be drawn (bridging or forward) for a total comparison of eight bridging inferences against eight possible forward inferences. In this study, second, fifth, and eighth grade children, in addition to college undergraduates, were used. A total of eight experimental stories for a test of 16 bridging inferences against 16 forward inferences were also used. My hypothesis was that there would be an overall main effect for inference type, with the bridging inferences showing shorter response latencies and fewer errors compared to the forward inferences. In addition, I suspected an age effect to be present, which I would then be able to tease apart to see if and when the ability to draw bridging inferences develops.

Briefly, this study presented four different groups of subjects with a total of eight experimental paragraphs. Within each paragraph, two forward and two bridging inferences were able to be made. At the end of each story, eight questions were asked related to the drawing of the forward and bridging inferences. Reaction time and error rates to the truth or falsity of each question were then measured as an indication of whether a particular inference type was more reliably drawn during encoding or retrieval. If bridging inferences are made at encoding while forward inferences are not, as was hypothesized, then the response latency to the bridging inference questions should have been significantly shorter than the response latency to the forward inference questions.

Method

Norms

A preliminary norming study was conducted to identify a pool of events which have consequences agreed upon by most people. One hundred naive introductory psychology students were asked to write a brief description of the most likely outcome or consequence of events described in 200 single sentences.

Each of the 200 stimulus sentences had a consequence that the experimenter believed many people would agree with. An example (taken from Singer and Ferreira, 1983) would be the sentence "An egg falls on the floor," for which the expected consequence concerns the breaking of the egg. Following Singer and Ferreira's suggestion, subjects were given credit for agreeing with the consequence if their answer (1) stated it directly, (2) replaced it with a synonym, or (3) expressed the expected consequence plus some additional ideas (e.g., the egg breaks and makes a mess).

Thirteen test narratives were originally constructed. As a cursory check, the 52 inference sentences used in these narratives were read singly, both out of context and in a random order, to ten second grade children who did not participate in the actual experiment. Each child was asked to tell the experimenter what he/she thought was the most likely outcome of each sentence. This was done to ensure that the inferences being drawn by the adult subjects in the norming study were also valid for the youngest subjects. This check resulted in some stories receiving good overall agreement while other stories turned out to be quite poor. The "poor" stories generally had lower agreement on all of their inference sentences, in contrast to the "good" stories which contained a majority of well-agreed upon inference sentences. Therefore, the eight stories receiving the most overall agreement were used. Actually, two of the stories had to be modified somewhat to ensure that their inference sentences reached the 80 percent criterion level. Well-agreed upon sentences from stories that did not receive much agreement were substituted for those sentences in "good" stories that were rather poor. Some of the wording was also changed to make the stories more comprehensible. As a result, the inference sentences embedded in the eight experimental narratives all reached the 80 percent criterion level, at least with the ten second grade children tested.

Materials

The materials consisted of eight test stories, each story being 11 sentences long. Each story consisted of two forward inference sentences, two bridging inference sentences, two bridge-mate sentences, and five filler sentences, two of which began and ended each story, with the remaining three inserted between the inference sentences. The forward and bridging inference sentences were constructed from the ones chosen in the norming procedure, and in the case of a bridging inference, a bridge-mate sentence was added in order to ensure that the inference would be made.

For each story, eight questions were written. Four of the questions interrogated the experimental sentences and were intended to be answered "yes." The other four questions interrogated the filler sentences and were intended to be answered "no." It was hoped that this manipulation would eliminate any response bias. The eight questions for each story were assigned to a single random order.

Two experimental lists were used. In List 1, the four experimental sentences in each story were randomly assigned to the forward and bridging inference conditions. List 2 consisted of the same four experimental sentences, but the assignment of forward versus bridging inference conditions was simply reversed. Thus, across the two lists, each experimental sentence occurred once in each condition (forward or bridging inference).

In addition to the story materials, 15 sentences were written to be used as an indication of each subject's reading speed. In this way, reading speed could be covaried out of the analysis in order to control for the possibility that the younger subjects take longer to answer questions simply because they are slower readers. Three of the sentences constituted practice with the remaining 12 being experimental. A question followed each sentence, each question testing either knowledge of the subject, object, or verb of the preceding sentence. Five questions of each type were therefore used, comprising a total of 15 questions.

Subjects

A total of 120 subjects were tested, 30 from each grade level. The subjects consisted of equal numbers of males and females from second, fifth, and eighth grade in addition to college undergraduates. The mean age of the groups were: grade 2, mean = 8 yr. 0 month, range 7-5 to 8-10; grade 5, mean = 11 yr. 1 month, range 10-7 to 12-1; grade 8, mean = 13 yr. 11 month, range 13-5 to 14-9; and college undergraduates, mean = 22 yr. 7 month, range 18-6 to 33-5. The school-age children were drawn from the District 66 Public School system while the undergraduates were drawn from introductory psychology students at the University of Nebraska at Omaha. The only requirements for participation were that the subjects speech English as their native language and not be eligible for any special educational needs. None of the subjects participated in the norming procedure.

<u>Procedure</u>

Each session was conducted individually with each subject. The sentences were displayed on a 22 cm. video monitor screen with the subjects seated at a comfortable distance of their choice in front of the screen. The experimental events were controlled by a Commodore PET 2001 Series Professional Computer.

Informed consent forms were sent home for parental approval with each school-age child by their respective teachers. Each child that chose to participate was also requested to sign a simpler version of the form, which was read aloud by the experimenter. In addition, the college undergraduates who participated in either the norming study or the actual experiment also signed informed consent forms.

Before presentation of the stories, each subject's reading speed was measured. The subjects read silently 15 sentences, each individually, from the computer screen. Three of the sentences constituted practice with the remaining 12 being experimental. Before each session, the subjects were instructed to read each sentence as rapidly as possible while still retaining comprehension and were told that they would have to answer a question about each sentence as soon as they had finished reading it. In this manner, comprehension was doubly stressed. Preceding each sentence, a dot appeared, centered in the screen, which acted as a prompt for attention. The dot remained on the screen for five seconds. A sentence then followed the prompt, also centered in the screen. The onset of the sentence on the screen started a millisecond timer in the computer. The subjects then read the sentence and pressed a button on the response box with the index finger on their dominant hand. The button press stopped the timer after each sentence. The experimenter then read a question following each sentence, testing memory for either the subject, object, or verb of the preceding sentence. The subjects responded verbally to the experimenter. Incorrect or incomplete responses by the subject prompted the experimenter to tell the subject to slow down. In addition, he or she was then told that understanding the story was as important as speed. After each response, the experimenter pressed the space on the computer and the prompting dot reappeared followed by the next sentence. Elapsed reading time was then recorded by the computer for each sentence.

Each subject then saw nine stories, the first of which constituted practice and was the "Spy Story" drawn from Singer and Ferreira's (1983) article and given in Table 1. For each story, the subjects were asked to read each sentence carefully and then answer the questions appropriately. The sentences in the stories and the questions were displayed one by one. Before each story, a fixation point appeared in the middle of the screen for 5 seconds. The fixation point was then replaced by a prompt, also centered in the screen, which read "Story" (or "Practice Story," in the case of the practice session). After a 1 second delay, the 11 sentences constituting the story then appeared in succession. The subject had control over the presentation rate by pressing either of the two response keys. Although it would have been advantageous to have a constant presentation rate, the rate of reading speed for the second grade children varied so much that it was impossible to arrive at a speed that would have been fair for all subjects. It would have either been too fast for the second graders or too slow for the college undergraduates, thereby allowing them to read each sentence more than once. Therefore, each subject had control over the presentation rate, with the stipulation that he or she read each sentence only once.

The questions were then presented next. They were preceded by a prompt, centered in the middle of the screen, which read "Questions" (or "Practice Questions during the practice session). The prompt remained on the screen for 5 seconds. The questions then followed the prompt and the timer started immediately after the presentation of each question on the screen (the timer was actually an internal component of the program). The subjects were asked to respond as quickly as possible without error. Each question remained on the screen until the subject answered it, after which it disappeared and was replaced, one second later, by the next question.

The subjects were told to respond "yes" with the index finger of one hand, and "no" with the index finger of the other. The subjects were reminded to keep their fingers resting on the response keys to facilitate responding. The subjects were assigned, on the basis of their dominant hand, to use either their left hand or right hand for the "yes" key. The responses and response times were then recorded automatically to the nearest millisecond by the computer and stored for future access. After each set of eight questions, the screen went blank for 1 second and the story prompt then reappeared, followed 5 seconds later by the next story. In this fashion, all eight stories were responded to. At the completion of each experimental session, each subject was debriefed. The computer then printed out all responses and reaction times which were written down by the experimenter.

Results

Reaction Time

The adjusted mean reaction times (adjusted by the reading speed covariate) for each type of inference, list, and grade are shown in Tables 2 and 3. The reaction time data were subjected to a grade (4) X sex (2) X list (2) X type (2) unweighted means repeated measures analysis of covariance (harmonic mean per cell = 7.18). A quasi-F procedure (min *F*') was utilized, based on Clark's (1973) suggestion that a quasi-F statistic should be computed when lanaguage-based materials are used. The min *F*' quasi-F statistic is a conservative estimate utilizing both the F_1 (subjects-random) and F_2 (stories-random) statistics in its computation. The logic of its use hinges on the generalizability of a particular set of findings. With its use, results can be generalized to both a new sample of subjects *and* a new sample of language-materials. In the first analysis, subjects were treated as a random effect with reading speed (words per minute) as the covariate. Inference type (forward or bridging) was within-subjects. Between-subjects factors were grade (second, fifth, eighth, and college undergraduate), sex, and list. For the

TABLE 2

Adjusted Mean Reaction Times in Msec to the Inference Questions - Both Lists

	List 1			List 2		
	Fwd	Brdg	Diff	Fwd	Brdg	Diff
Grade 2	4311	3564	747*	4051	4127	-76
Grade 5	3030	2468	562*	2650	2740	-90
Grade 8	2603	2099	504*	2217	2262	-45
College	2571	2204	367*	2314	2300	14

* Denotes significance at p < .001

(Fwd - Forward Inferences)

(Brdg - Bridging Inferences)

(Diff - Forward RT minus Bridging RT)

Table 3

Mean Reaction Times in Msec to the
Inference Questions Collapsed Across Lists

	Combined Lists	
	Forward	Bridging
Grade 2	4181	3845
Grade 5	2840	2604
Grade 8	2410	2180
College	2442	2252

analysis treating stories as a random effect, all factors were within-stories. In addition, omega squared values were computed for all significant effects, using the sum of squares and mean squares values from the appropriate analysis treating subjects as a random effect. The main effects of grade and inference type were significant: grade, min $\underline{F}'(3,115) = 18.23$, $\underline{p} < .001$, $\omega^2 = .297$; type, min $\underline{F}'(1,11) = 9.78$, $\underline{p} < .01$, $\omega^2 = .019$. With regard to the grade effect, there were no significant interactions. The data revealed that each succeeding grade level responded faster than the preceding younger group with the exception of the college undergraduates. The undergraduates were actually slower than the eighth graders, although this differences was not significant. Newman-Keuls multiple comparisons indicated that all of the differences among the school-age children were significant ($\underline{p}$s $< .01$). The main effect for type is tempered somewhat by a significant interaction between list and type, min $\underline{F}'(1,12) = 17.28$, $\underline{p} < .01$, $\omega^2 = .029$. Simple comparisons performed on the data revealed that the bridging inferences were only significantly faster than the forward inferences for list 1 $\underline{F}(1,59) = 107.10$, $\underline{p} < .001$. In fact, the bridging inferences were slightly slower than the forward inferences for list 2. When all the experimental manipulations were combined, including the nonsignificant *F*s, they accounted for 34.6 percent of the total variance.

Error Percentages

The mean error percentage rates for inference type, list, and grade are listed in Table 4. A grade (4) X sex (2) X list (2) X type (2) analysis of variance was performed. For the subjects analysis, inference type was again within-subjects while the three factors of grade, sex, and list were all between-subjects. All factors were within-stories for the analysis treating stories as a random effect. Omega squared values were again computed for all significant treatment effects, utilizing the procedure outlined previously. The main effects of grade and type were again significant: grade, min $F'(3,75) = 6.18$, $p < .001$, $\omega^2 = .117$; type, min $F'(1,17) = 30.13$, $p < .001$, $\omega^2 = .122$. Newman-Keuls multiple comparisons performed on the grade data indicated that second graders made significantly more errors than all other grade levels, with no other significant differences ($p < .01$). The type effects reflect the finding that more errors were made to forward inference questions than to bridging inference questions. In addition, there was a significant three-way interaction: grade by sex by list, min $F'(3,112) = 3.26$, $p < .025$, $\omega^2 = .039$. This interaction was further analyzed by collapsing across

TABLE 4

Mean Proportion of Errors
for Each Type of Inference Question

	List 1		List 2	
	Forward	Bridging	Forward	Bridging
Grade 2	.31	.24	.44	.32
Grade 5	.20	.16	.28	.11
Grade 8	.23	.15	.30	.15
College	.23	.18	.30	.09

inference type and comparing the sex effect against the list effect at each of the four grade levels. At the second grade level, only list was found to be a significant factor, $F(1,26) = 6.63$, $p < .025$, and the data revealed that all second grade children made significantly more errors to list 2 than to list 1. At the fifth grade level, both list and the sex by list interaction were significant: list, $F(1,26) = 5.07$, $p < .05$; and sex by list, $F(1,26) = 4.32$, $p < .05$. Taken together, the data from the analysis indicated that while list 1 questions had significantly fewer errors than list 2 questions, this effect was attributable completely to the males. At the eighth grade level, only the sex by list interaction reached significance, $F(1,26) = 4.27$, $p < .05$. In this case, however, only the females made fewer errors to list 1 questions rather than to list 2 questions (a finding directly opposite that of the fifth grade children). Finally, at the college level, none of the effects reached significant levels. Once again, the variance accounted for by all of the experimental manipulations was calculated. The value obtained, 33.8 percent, is quite consistent with the reaction time value.

In order to assess whether the second grade children in the study were drawing the two types of inferences significantly more often than chance (.50), t tests were conducted. The error rates for both forward and bridging inferences were found to be significantly less than chance: forward, $t(29) = -4.63$, $\bar{x} = .375$, $p < .001$; bridging, $t(29) = -6.51$, $\bar{x} = .279$, $p < .001$. In order to rule out the possibility that the subjects had simply developed a response bias to answering "yes," the error rates to the filler questions (which required a "no" response) were also analyzed. The filler question errors were also found to be significantly below chance, $t(29) = -24.52$, $\bar{x} = .105$, $p < .001$, implying that the above chance performance on correctly answering inference questions was not a function of a response bias.

Discussion

Based on the results of the analyses, it would appear that the subjects at all of the grade levels successfully drew the inferences. Even the second grade children drew both types of inferences, as exhibited by their greater than chance performance. Inference-drawing ability did increase with age, however, as the two main effects for grade indicate. In addition, the bridging inferences were responded to significantly faster than the forward inferences, although this effect was completely due to list 1. Again, this was true for the second grade children as well. Both the reaction time and error rates indicated that bridging inferences are drawn more easily than forward inferences.

Although the type effect did reach significance in the min *F'* analysis, its omega squared value for the reaction time data was in the low range of effect strength, according to Cohen's (1977) interpretation. While this manipulation did not account for as much variance as was hypothesized, perhaps this is simply due to the fact that at all grade levels, both types of inferences were being drawn relatively easily. Although it will be argued that the bridging inferences in this study were drawn at encoding while the forward inferences were not, this does not imply that forward inferences are extremely slow to be drawn, and are only arrived at after much deliberation. In other words, while bridging inferences were significantly faster than forward inferences at all grade levels, forward inferences apparently were still being made quite easily, possibly accounting for the relatively small strength of the effect, as measured by omega squared. The type effect is actually outlined more clearly, however, in the error rate analyses. For both the subjects-random and stories-random analyses, the omega squared values revealed that approximately 12 percent of the total systematic variance was accounted for by the inference type manipulation. Due to the consistency of the error rate data, as compared to the reaction time data, perhaps the small omega squared value for inference type in the reaction time data should be interpreted cautiously.

An uninterpretable finding from this study was the presence of the significant list by type interaction when reaction time was the dependent variable. For some reason, the list 2 bridging inferences were drawn no faster than the forward inferences. Upon examining the bridging inferences for the two lists, no glaring inconsistency is readily apparent. Table 2 shows that for list 2, the forward inferences were drawn more quickly and the bridging inferences were drawn more slowly than for list 1. The interaction is not readily interpretable, and it could simply be that a Type I error has occurred. Indeed, this assumption is plausible given that the interaction was only significant for the reaction time analysis, but not for the error rate analysis. Additionally, the omega squared value for the effect was quite small, indicating that it is of little practical significance. In light of these facts, the interaction will not be discussed further.

Another uninterpretable finding from this study was the significant three-way interaction of grade, sex, and list for the error rates. The practical importance of the effect, however, is even harder to determine than the list by type effect. At the fifth grade level, males made more errors on list 2 questions than on list 1 questions. This pattern was completely reversed at the eighth grade level, with only the females making more errors to list 2 questions than to list 1 questions. Due to the uninterpretable nature of this finding, the most plausible explanation is that a Type I error was again obtained.

Probably the most compelling reason to argue for a Type I error in both of the significant interaction effects is that each was significant for only one of the analyses (either reaction time or error rate), never both. Coupled with the facts that the omega squared values were relatively small and that the pattern of obtained results does not make any intuitive sense, one is left with the argument that two Type I errors have occurred.

The findings of this study would seem to contradict Paris and his associates' claim (Paris & Lindauer, 1976, 1977; Paris et al., 1977; Paris & Upton, 1976), as well as Dreher's (1981) that second grade children can draw inferences, but do not spontaneously generate them while reading a prose passage. If inferences of neither type had been drawn, it would have been expected that no significant differences between the two types of questions would have been seen, for either reaction time or error rate. In fact, this pattern of results did not occur. Both the reaction time data and the error rate data supported the hypothesis that bridging inferences were drawn at the second grade level. In addition, if inferences had not been drawn by the second grade children, the percentage of inference questions answered correctly should have been no greater than chance. In fact, however, the error rates for both forward and bridging inferences were considerably below chance, with the bridging inferences having significantly fewer errors than the forward.

While these results would appear to refute Paris and his associates' (Paris & Lindauer, 1976, 1977; Paris et al., 1977; Paris & Upton, 1976) contention that second grade children do not spontaneously generate inferences, they also contradict Kail et al.'s (1977) conclusion that there is no developmental progression between the second and fifth grades in the ability to draw inferences. In the earlier discussion of the discrepancy between Kail et al.'s findings and those of Paris and his associates, it was argued that the differences were probably largely due to the types of inferences that the children were asked to make (e. g., transitive inferences, presuppositions, contextual inferences, instrumental inferences). The materials used in the present study resemble those of the Kail et al. study much more closely than they do any of the Paris studies. Based on this fact, the finding that the fifth grade children made significantly fewer errors and answered <u>all</u> questions significantly faster is of considerable interest. Both findings directly contradict Kail et al.'s conclusions and suggest the existence of a developmental trend in the ease of drawing inferences between the second and fifth grade.

The difference in results between the Kail et al. study and the present one may be due to the use of longer passages in this study compared to Kail et al.'s use of three sentence passages. This argument is also supported by the only other study discussed which used passages of comparable length - namely, the study of Paris and Upton (1976), who found an increase in inference-drawing ability between the ages of six and ten with passages ranging from 13 to 16 sentences. Whatever the reason, the grade effect, as exhibited by both reaction time and error rates, must not be overlooked. Grade accounted for large percentages of the total systematic variance in both the reaction time and error rate analyses. The omega squared values for both error rate values (subjects-random and stories-random) were in the medium range of effect strength (Cohen, 1977) while the omega squared values for both reaction time analyses were in the large range of effect strength (Cohen, 1977).

With regard to the error rates, the Newman-Keuls multiple comparisons revealed that the largest and only significant decrease in errors was between the second and fifth grade. Reaction time, however, reached its asymptotic level around the eighth grade, as evidenced by the lack of a significant difference between the eighth grade children and the college undergraduates. While the second grade/fifth grade difference has been emphasized, this is not to imply that the second grade/fifth grade difference is any more important than the fifth grade/eighth grade difference. The second grade/fifth grade difference has been emphasized due solely to its importance in contesting the conclusions of the Kail et al. study.

The argument concerning the existence of a developmental increase in the ability to draw inferences between the second and fifth grade is not as important theoretically as the finding (previously unsuspected) that second graders can make spontaneous inferences. Although the inferential process was not perfect in the present study - both reaction time and the error rates for the inference questions changed with age - second graders were still successful at drawing the inferences themselves. Performance for both forward and bridging inferences was significantly better than chance.

The issue of when each type of inference is drawn (encoding vs. retrieval) has also been clarified somewhat by the present results. While virtually none of the developmental literature has concerned itself with this issue, much of the adult literature has. Indeed, Miller (1980), on the basis of his review and his own research, concluded that much of the inference literature provided support for the inference-at-encoding view. The work of Singer and Ferreira (1983) pointed to a conclusion that such a general statement is unwarranted, however. Their work posited that backward inferences (our bridging inferences) were drawn at encoding while forward inferences were not drawn until test time (the inference-at-retrieval view). The results of the present study lend support to Singer and Ferreira's conclusion, while extending it further to include school age children as well. If both types of inferences were being drawn at the same time (either during encoding or retrieval) then there should have been no difference between reaction times. Such was not the case, however. Due to the finding that the bridging inference questions were responded to faster, the implication is that they were drawn as the text was being comprehended, and thus, were stored as part of the memory trace for that text.

This study has helped resolve much of the ambiguity surrounding both the adult and developmental inference literature. First, it would appear that children as young as seven years of age can spontaneously generate inferences as they read a prose passage. While this ability continues to develop with age in terms of speed of inference generation and increasing accuracy, it does at least reflect that second grade-aged children can generate their own inferences, a finding clearly at odds with the earlier research. Secondly, the determination of the locus of inference generation (encoding vs. retrieval) does not necessarily represent an either/or decision, as many previous authors have implied. Inferences might best be thought of as consisting of two types: (1) Those that are almost demanded by the text, without which the text would appear disjoint (bridging inferences); and (2) Those that are certainly implied by the text but not necessary for comprehension (forward inferences). Based on the results of the present study, bridging inferences are argued to be drawn at encoding while forward inferences are not drawn until needed, at retrieval.

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Appendix A

Norming Study Informed Consent Form

CONSENT FORM

You are invited to participate in a norming study designed to reveal which of a given set of sentences receives the highest agreement in terms of their most likely consequences. As a participant in this study, you will simply be asked to indicate what you feel is the most likely consequence of the action described in each sentence, for a total of 200 sentences. At the conclusion of the experimental session, the investigator will describe the purpose of the norming study and its possible importance. At this time, you will have an opportunity to discuss the reasoning behind the study and its possible benefits to psychological knowledge.

Your responses will be kept confidential. Your name will not be associated in any way with the information you provide.

No significant risks are involved in this study beyond those of everyday life. The benefits for participation in this study are simply those of having an opportunity to see how a research project of this type is conducted, and to possibly learn something about an area of current research interest in cognitive psychology. We cannot promise you that you will receive any benefits other than those discussed here. Should you decide to participate in this study, your participation may satisfy one of several options available to you for obtaining extra course credit in your psychology course, as described to you by your instructor. However, you do have the option of performing alternate activities for such credit should you choose not to participate.

Participation in this study is voluntary. Your decision whether or not to participate in this survey will not affect your relationship with the University of Nebraska, nor your participation in any of your classes in psychology. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time. Furthermore, you have the right to withdraw your

Appendix A - Continued

data from this study following completion of the questionnaire should you decide to do so. If you have any questions, please ask the investigator now. If you have any additional questions later, Mark Casteel, who many be reached at the phone number listed below, will be happy to answer them.

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE HAVING READ THE INFORMATION PROVIDED ABOVE. YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP.

_______________ Date

_______________ Participant's Signature

Mark A. Casteel (554-2398)
Greg Simpson, Ph.D.

_______________ Investigator's Signature

Appendix B

Norming Study Questionnaire

Please read each sentence below carefully. After reading each sentence, please write underneath it what you feel the consequence of the action in the sentence would be. There are no right or wrong answers to any of these sentences and there is no time limit. This study is simply a norming study in which we wish to determine which of the below sentences have the most agreement in terms of their consequences. The results of this study will be used to prepare the materials needed in a later study. Please take this questionnaire seriously. While the sentences might seem simple-minded, the results to be obtained from them will be invaluable. This questionnaire will be kept completely anonymous, and you are under no obligation to complete it if you so choose.

If you choose not to participate in the study, your choice will in no way affect your relationship with the University of Nebraska, nor your participation in any of your classes in psychology.

EXAMPLE - The dog jumped into the lake.

For the most likely consequence, you might write "The dog got wet."

1. The pin was pushed into the balloon.

2. The rock flew through the window.

3. The paper was thrown into the fire.

4. The sugar cube was placed in the glass of water.

5. The egg was dropped on the floor.

Appendix B - Continued

6. The tire ran over a nail.

7. The burning match was placed in a glass of water.

8. The sharp knife cut the finger.

9. The light switch was flipped up.

10. The boy turned on the flashlight.

11. The boy stepped on the banana peel.

12. the key was turned in the ignition of the car.

13. The man in the car put on its brakes.

14. The orange juice carton tipped over.

15. The lady stepped on the ant.

16. The lady forgot to wind her watch.

17. The mouse ran in front of the cat.

18. The boy pulled the fire alarm.

19. The girl's glasses fell to the cement.

20. The icecube was placed in the sun.

Appendix B - Continued

21. The car ran over a cliff.

22. The ink pen was broken in two.

23. The boy put his hand into the fire.

24. The bag of sugar ripped while being carried.

25. The boy caught his pants on a nail.

26. The dog rolled in the mud.

27. The cake was put into the oven.

28. The woman was in the rain without an umbrella.

29. The man fell down the stairs.

30. The boy went to the barber.

31. The bread was put into the toaster.

32. The man dropped the radio.

33. The bowl of soup fell off the table.

34. The firecracker fell into the fire.

35. The mirror fell to the ground.

Appendix B - Continued

36. The boy leaned far back in his chair.

37. The boy turned on the water faucet.

38. The dog saw the mailman.

39. The woman dropped her ring down the drain.

40. The child sat all day in the hot sun.

41. The grass seeds were planted in the ground.

42. The child ate as often as possible.

43. The curtain was pulled back from the window.

44. The child rubbed the magic lamp.

45. The knight stabbed the dragon with his sword.

46. The child hit the bell with a hammer.

47. The clown told the boy a joke.

48. The girl blew into the trumpet.

49. The princess kissed the frog.

50. The chicken sat on her egg.

Appendix B - Continued

51. The duck was thrown into the water.

52. The boy sneezed into the candle.

53. The child put a penny into the gumball machine.

54. The child shook the bottle of soda pop.

55. The man told the child a ghost story.

56. The running man stepped on his shoestring.

57. The wind blew into the windmill.

58. The hamburger fell off the table by the hungry dog.

59. The baseball hit the lightbulb.

60. The dog saw the cat through the window.

61. The man pulled the trigger on the gun.

62. The man forgot to put gas in the car.

63. The boy tore the scab off of his knee.

64. The boy stepped on a piece of bubblegum.

65. The cookies were left in the oven too long.

Appendix B - Continued

66. The cap was left off of the magic marker.

67. The woman ran over the paper clip with the vacuum cleaner.

68. The pillow ripped apart as it was picked up.

69. The batteries ran down in the toy car.

70. The man unplugged the television set.

71. The girl cut her hair into the bathroom sink.

72. The burglar cut the telephone wire.

73. The boy lost his balance looking into the deep well.

74. The gardener sprayed poison all over the weeds.

75. The rubber band was stretched too far.

76. The bear ate the poisonous berries.

77. The burglar lit the dynamite stick.

78. The girl got pepper up her nose.

79. The key was turned in the locked door.

80. The ladder tipped over as the boy was on the top step.

Appendix B - Continued

81. The father spanked the little boy very hard.

82. The mother patted the baby on the back after dinner.

83. The dragon opened his mouth wide and breathed hard.

84. The boy threw some popcorn into the fire.

85. The boy fell and hit his tooth on the cement.

86. The clown rang the doorbell and said "Trick or Treat."

87. The woman put too much soap into the washing machine.

88. The ghost sneaked up behind the girl and yelled "boo."

89. The horse bucked the cowboy.

90. The man shut the safe and spun the dial.

91. The mother hung her wash out on the sunny day.

92. The car's radiator ran out of water on the long trip.

93. Reaching for the ball, the boy slid in the grass.

94. The speedy arrow pierced the indian's heart.

95. The raw meat was left out under the hot sun.

Appendix B - Continued

96. The man stood up in the canoe and waved

97. The cap was left off of the glue bottle.

98. The lid was left off of the soda pop bottle.

99. The doughnuts were left sitting out in the sun.

100. The karate expert hit the thick board.

101. The boy stuck his finger into the fan.

102. The boy got too close to the bumblebee.

103. The man ate the hot soup too fast.

104. The little boy ran toward the rabbit.

105. The girl landed on the trampoline.

106. The mosquito landed on the boy's arm.

107. The batteries were left in the flashlight for two years.

108. The boy did not study for his hard test.

109. The woman left her keys in her car.

110. It rained all over the campfire.

Appendix B - Continued

111. The boy threw his fishing line into the tree.

112. The fish saw the bug on the top of the lake.

113. The boy put too many groceries into the sack.

114. The shiny gun was left out in the rain.

115. The little boy told his father a lie.

116. The boy left his toy truck out in the rain.

117. The boy let the dog out without a leash.

118. The boy didn't wear enough heavy clothes on the cold day.

119. The girl stepped out of the shower into the cold breeze.

120. The man listened to the boring speech.

121. The man bought his girlfriend a diamond ring.

122. The inner tube had a leak in it.

123. The girl got a terrible headache.

124. The boy got hit in the stomach with the football.

Appendix B - Continued

125. The boy yelled at the sleeping baby.

126. The door of the dog's cage was left open.

127. The airplane's engine conked out.

128. The submarine fired a torpedo at the boat.

129. The water in the teakettle started boiling.

130. The watch fell off of the man's arm into the lake.

131. The woman left the iron on her pants as she answered the telephone.

132. The rabbit sneaked into the carrot patch through a fence hole.

133. The two boys each tugged at the map.

134. The fat boy jumped on the small bed.

135. The boy put the glass of water out into the snow.

136. The fat boy tried to slide down the chimney.

137. The mother put the butter into the hot skillet.

138. The boy dropped the brick on his toe.

Appendix B - Continued

139. The boy kept his tadpoles for a year in the garage.

140. The girl spelled every word in her spelling bee correct.

141. A spike was driven into the vampire's heart.

142. The man slept under the hole in the tent during the rainy night.

143. The girl turned the handle on the jack-in-the-box.

144. The man was late getting to his bus stop.

145. The mother put her hand on the fidgeting boy's knee.

146. The wind took the kite into the trees.

147. The girl pressed down too hard on her pencil.

148. The dog got a flea behind his ear.

149. The boy knocked down the wasp's nest.

150. The soldier pulled the pin on the grenade.

151. The boat had a hole in it.

152. The man struck the match on the side of the box.

Appendix B - Continued

153. The mother sung a lullabye to her baby.

154. The cannonball was shot into the lake.

155. The little boy was clumsy with the sharp knife.

156. The woman poured dishsoap into the running water.

157. The secretary put the two pages into the stapler.

158. The swimming suit was untied as the girl jumped into the pool.

159. The girl tried to rollerskate for the first time.

160. The leaf blew off of the tree into the the river.

161. The steamroller ran over the boy's toy truck.

162. The boy flew his kite in the rainstorm.

163. The girl watched the sad movie.

164. The player hit the baseball over the fence.

165. The boy poured water onto the dirt.

166. The little boy touched the hot stove.

167. The lumberjack hit the tree with an axe.

Appendix B - Continued

168. The man's billfold fell out of his pocket.

169. The bread was left out while the family went away.

170. The man dropped the magnet into the sack of nails.

171. The coyote sat out under the full moon.

172. The cowboy dug his spurs into the horse and said, "Giddyup."

173. The boy stroked the cat as it sat on his lap.

174. The man threw the boomerang high into the air.

175. The boy pulled strongly on the worn out shoestring.

176. The hungry man stared at the delicious meat cooking.

177. The boy yelled out into the deep canyon.

178. The boy pulled open the rusty door of the haunted house.

179. The girl played out in the cold without a coat or hat.

180. The magician stuck his hand into his magic hat.

181. The boy put his money into the candy machine.

Appendix B - Continued

182. Pinnochio told another lie.

183. The riverside house had a leaky basement.

184. The mouse ran to the cheese in the mousetrap.

185. The man and woman drank too much wine.

186. The burglar alarm rang as the robber opened the safe.

187. The storm blew down the town's powerlines.

188. The mother poured too much milk into her son's glass.

189. The cigarette was dropped into the dry and brittle forest.

190. The man put a dollar bill into the quarter change machine.

191. The boy picked up the melted chocolate bar.

192. The man tried to call the telephone that was off of the hook.

193. The boy hit the baseball with the cracked bat.

194. The girl patted the friendly dog's head.

195. The man worked hard in the hot sun.

Appendix B - Continued

196. The child accidentally let go of the balloon.

197. The driver of the car saw a cow in the road.

198. The boy lost his pet dog.

199. A puff of air hit the boy in the eyes.

200. The fish ate the worm on the hook.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Appendix C

Parental Informed Consent Form

Dear Parents:

Your child has been invited to participate in a research project on children's ability to infer outcomes or consequences from a story. The project will be conducted by Mark Casteel, a graduate student in developmental psychology, and Dr. Gregory Simpson, an Associate Professor in the UNO Psychology Department. Your child has been selected for possible participation only because he or she is a member of the school grades that we are studying: second, fifth, or eighth.

The study examines the developmental phenomenon of the ability to make inferences from information that is only implied in a story. We are especially interested in the earliest age at which this ability develops.

Your child, if he or she participates, will see sentences on a computer screen that form a short story. After the child reads this stimulus, a series of questions will be asked, and the child is asked to respond to each question as quickly as possible, simply by pressing one of two buttons corresponding to "yes" or "no". We learn about the inference-drawing process by measuring the speed of response to these different questions. The study will take place in a room on the school grounds and should take no more than 20 minutes.

We hope that the children will benefit from the exposure to new reading materials, and we believe that we will be able to advance our knowledge about the development of the inference-drawing process. There are no risks involved. We present the task as a game, and have always found that children enjoy participating. Your child's name will not be associated in any way with the research results. Families of those children who participate will be sent a report of the results of the research.

Your cooperation in permitting your child to participate will be greatly appreciated. Please complete the bottom portion of this form and return it to the school as soon as possible. If you have any questions, please don't hesitate

Appendix C - Continued

to call either Mark at 554-2398 (office) and 558-2925 (home), or Dr. Simpson at 554-2592 (office).

Sincerely,

Mark A. Casteel
Psychology Graduate Student

Gregory B. Simpson, Ph.D.
Associate Professor of Psychology

I have read the description of the inference-drawing project, and I understand the procedures to be followed, the absence of risk and discomfort, and the benefits to be received. I understand that any questions I have about the project will be answered. I also understand that I may withdraw my consent and discontinue my child's participation at any time.

YOU ARE MAKING A DECISION WHETHER TO ALLOW YOUR CHILD TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT, HAVING READ THE INFORMATION PROVIDED ABOVE, YOU HAVE DECIDED TO PERMIT YOUR CHILD TO PARTICIPATE. YOU WILL BE GIVEN A COPY OF THIS CONSENT FORM TO KEEP.

______________________________ has my permission to participate in Mark Casteel's inference-drawing project.
Name of Child

________________________________ ______________
Signature of Parent of Guardian Date

Appendix D

School-Age Children's Informed Consent Form

You are being asked to participate in a study that will tell us how people answer questions about things they have read in stories. You will be shown some sentences on a computer screen that will tell a story. There will be nine stories to read. After each story, you will be asked to answer 11 questions as fast as you can.

There is no right or wrong way to perform in this study, we just want you to do the best that you can.

You do not have to be in the study, and even if you decide to participate, you may change your mind and quit at any time. Before you decide to be in the study, you should talk to your parents about it.

I agree to participate in this research project.

______________________________ ____________________

Signature of Child Date

Appendix E

Undergraduate's Informed Consent Form

CONSENT FORM

You are invited to participate in a research project examining people's ability to infer outcomes or consequences from a story. As a participant in this study, you will see sentences on a computer screen that form a short story. After you have read this stimulus, a series of questions will be asked, and your task is to respond as quickly as possible, simply by pressing one of two buttons corresponding to "yes" or "no." We will learn about the inference- drawing process by measuring the speed of response to these different questions. A total of nine stories will be presented, one practice and the rest timed. Eight questions will be asked about each story. In addition to the stories, you will asked to read fifteen individual sentences and press a button as soon as you have completed reading each one. This will give us an indication of your reading speed. At the conclusion of the experimental session, the investigator will describe the purpose of the study and its possible importance. At this time, you will have an opportunity to discuss the reasoning behind the study and its possible benefits to psychological knowledge.

Your responses will be kept confidential. Your name will not be associated in any way with the information you provide.

No significant risks are involved in this study beyond those of everyday life. The benefits for participation in this study are simply those of having an opportunity to see how a research project of this type is conducted, and to possibly learn something about an area of current research interest in cognitive psychology. We cannot promise you that you will receive any benefits other than those discussed here. Should you decide to participate in this study, your participation may satisfy one of several options available to your for obtaining extra course credit in your psychology course, as described to you by your instructor. However, you do have the option of performing alternate activities for such credit should you choose not to participate.

Appendix E - Continued

Participation in this study is voluntary. Your decision whether or not to participate in this survey will not affect your relationship with the University of Nebraska, nor your participation in any of your classes in psychology. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time. Furthermore, you have the right to withdraw your data from this study following completion of the questionnaire should you decide to do so. If you have any questions, please ask the investigator now. If you have any additional questions later, Mark Casteel, who may be reached at the phone number listed below, will be happy to answer them.

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE HAVING READ THE INFORMATION PROVIDED ABOVE. YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP.

______________ Date

______________ Participant's Signature

Mark A. Casteel (554-2398)
Greg B. Simpson, Ph.D.

______________ Investigator's Signature

Appendix F

Reading Speed Sentences and Questions

Sentences	Questions
Practice	
Mike threw the ball to home plate.	What did Mike throw? (O)
The train did not stop at the small town.	What did not stop? (S)
Because she was excited, Kim ran home from school.	What did Kim do because she was excited? (V)
Timed	
The old man slipped on the ice.	What did the old man do? (V)
Jack found some money and put it in his pocket.	What did Jack find. (O)
Betsy went to the store and bought some candy.	Who went to the store? (S)
The dog named spot found the blue ball.	What did Spot find? (O)
When the lady got home from work, she ate her supper.	What did the lady do when she got home from work? (V)
The big white cat sat on the fence.	What did the cat do? (V)
The mean old man did not have any friends.	Who did not have any friends? (S)
The teacher took her class to go see the zoo.	Where did the teacher take her class? (O)

Appendix F - Continued

When her mother turned out the light, the child got scared.	What did the child do when her mother turned out the light? (V)
The big bully was mean to all of the children.	Who was mean to the children? (S)
The little boy thought that his teacher was pretty.	Who thought that the teacher was pretty? (S)
The fireman went to the house to put out the fire.	What did the fireman put out? (O)

(S) indicates that the subject of the sentence was tested.
(O) indicates that the object of the sentence was tested.
(V) indicates that the verb of the sentence was tested.

Appendix G

Example Story - Both Lists

Sentence	Sentence Function
Bob the spy read a report by the fire.	Filler
A rock flew through the window.	Forward inference
Bob read a note that was on the rock.	Filler
He quickly threw his letter in the fire.	Bridging inference
The ashes floated up the chimney.	Bridge-mate
Bob left and ran to the bus stop.	Filler
He watched as the bus went around the corner.	Forward inference
He went back home and put the rock in his safe.	Bridging inference
He shut the safe and spun the dial.	Bridge-mate
But Bob knew that someone was after him.	Filler

Appendix H

Questions Asked to the Example Story

Questions	Correct Response
Did Bob miss the bus?	Yes
Did the window break?	Yes
Did Bob go to the airport?	No
Did the note arrive in an envelope?	No
Did Bob burn the letter?	Yes
Did Bob put the rock under his bed?	No
Did the safe lock?	Yes
Was Bob reading a newspaper?	No

Appendix I

Experimental Stories - List 1

Sentence	Sentence Function
Story 1	
One day a big rainstorm hit the farm.	Filler
The strong wind blew into the windmill.	Forward inference
The farmer's wife had gone to feed the chickens.	Filler
She was caught in the rain without an umbrella.	Forward inference
The farmer made soup for his cold wife.	Filler
His wife ate the hot soup too fast.	Bridging inference
His wife spit the soup out and yelled.	Bridge-mate
When he heard barking, the farmer looked out the window.	Filler
The farmer's dog was rolling in the mud.	Bridging inference
The farmer would not let the dog into the house.	Bridge-mate
The farmer and his wife then took a hot bath.	Filler
Story 2	
Mike and his family took a trip to the beach.	Filler
He stepped on some bubblegum he did not see.	Bridging inference

Appendix I - Continued

Mike wiped his shoes on the grass.	Bridge-mate
Mike then went floating on his inner tube.	Filler
The inner tube had a leak in it.	Forward inference
Mike then went to get a glass of soda pop.	Filler
After he was done, Mike placed an icecube in the sun.	Forward inference
He then saw a ball and ran to get it.	Filler
As he ran, Mike stepped on his shoestring.	Bridging inference
He skinned his knee but kept on running.	Bridge-mate
Mike and his family then left to go home.	Filler

Story 3

One morning Lisa helped her mother water the garden.	Filler
She turned on the water faucet to fill a bucket.	Forward inference
While she was outside, Lisa saw a rabbit.	Filler
Lisa quickly ran toward the rabbit.	Bridging inference
She just was not fast enough.	Bridge-mate
That afternoon the gardener came to spray the garden.	Filler
The gardener sprayed poison all over the weeds.	Bridging inference

Appendix I - Continued

Soon, all that was left were the pretty red flowers.	Bridge-mate
When it got dark Lisa went back inside.	Filler
The rabbit sneaked back into the carrot patch through a fence hole.	Forward inference
The next morning the fence hole was fixed.	Filler

Story 4

One day Tom went to the grocery store.	Filler
As he left his house he caught his pants on a nail.	Bridging inference
Tom's pants would have to be fixed.	Bridge-mate
Tom ran to get to the store before it closed.	Filler
As he ran he stepped on a banana peel.	Forward inference
At the store he bought many groceries.	Filler
Tom put too many groceries into the sack.	Bridging inference
Tom picked up all of the cans off of the floor.	Bridge-mate
Tom then decided to carry the sugar sack by itself.	Filler
The sack of sugar ripped while being carried.	Forward inference
That night Tom went to bed early.	Filler

Story 5

Because she was bored, Tina drew a picture.	Filler

Appendix I - Continued

She pressed down too hard on her pencil.	Bridging inference
She had to get a new pencil.	Bridge-mate
Tina then got some magic markers and colored her picture.	Filler
The cap was left off of the green magic marker.	Forward inference
She then rolled up her picture and put a rubber band around it.	Filler
The rubber band was stretched too far.	Bridging inference
She tied the rubber band together.	Bridge-mate
Tina felt hungry so she went to get a snack.	Filler
Her mother poured too much milk into her glass.	Forward inference
That night, Tina's father thought the picture was pretty.	Filler

Story 6

One morning Jane helped her mother with breakfast.	Filler
First of all, Jane put butter into the hot pan.	Forward inference
Jane's baby sister started to cry.	Filler
Jane picked her up and sang a lullabye to the baby.	Bridging inference
Jane put the baby back into her bed.	Bridge-mate
Jane decided that she wanted eggs, toast, and juice.	Filler

Appendix I - Continued

As she got the eggs, Jane dropped one on the floor.	Bridging inference
There was a mess all over the floor.	Bridge-mate
Jane then got two pieces of bread.	Filler
The bread was put into the toaster and pushed down.	Forward inference
Both Jane and her mother got very full.	Filler

Story 7

One weekend, Pam went rollerskating with her friends.	Filler
She tried to rollerskate for the first time.	Forward inference
After skating, the girls had a slumber party at Pam's	Filler
Pam's father told the girls a ghost story.	Bridging inference
All of her friends screamed.	Bridge-mate
The girls then had a pillow fight.	Filler
As Pam grabbed it, the pillow ripped apart.	Bridging inference
Pam had to go get the broom.	Bridge-mate
Pam and her friends then watched the T.V.	Filler
They all watched the sad movie.	Forward inference
Since they were tired, they fell asleep easily.	Filler

Appendix I - Continued

Story 8

The little girl had a birthday party.	Filler
Her mother put the cake into the oven.	Bridging inference
An hour later candles were put on.	Bridge-mate
For a present, the girl got a trumpet.	Filler
She blew into her trumpet.	Forward inference
She also got a red jack-in-the-box.	Filler
She turned the handle on her jack-in-the-box.	Forward inference
Her mother lit the candles on her cake.	Filler
One of her friends sneezed into the candles.	Bridging inference
Her mother went to get some more matches.	Bridge-mate
The little girl got a lot of nice presents.	Filler

Appendix J

Experimental Stories - List 2

Sentence	Sentence Function
Story 1	
One day a big rainstorm hit the farm.	Filler
The strong wind blew into the windmill.	Bridging inference
You could not even see the blades.	Bridge-mate
The farmer's wife had gone to feed the chickens.	Filler
She was caught in the rain without an umbrella.	Bridging inference
Her husband brought her some dry clothes.	Bridge-mate
The farmer made soup for his cold wife.	Filler
His wife ate the hot soup too fast.	Forward inference
When he heard barking, the farmer looked out the window.	Filler
The farmer's dog was rolling in the mud.	Forward inference
The farmer and his wife then took a hot bath.	Filler
Story 2	
Mike and his family took a trip to the beach.	Filler
He stepped on some bubblegum he did not see.	Forward inference

Appendix J - Continued

Mike then floating on his inner tube.	Filler
The inner tube had a leak in it.	Bridging inference
Mike had to swim to the shore.	Bridge-mate
Mike then went to get a glass of soda pop.	Filler
After he was done, Mike placed an icecube in the sun.	Bridging inference
Soon the icecube was gone.	Bridge-mate
He then saw a ball and ran to get it.	Filler
As he ran, Mike stepped on his shoestring.	Forward inference
Mike and his family then left to go home.	Filler

Story 3

One morning Lisa helped her mother water the garden.	Filler
She turned on the water faucet to fill a bucket.	Bridging inference
The bucket was so heavy that she had trouble carrying it.	Bridge-mate
While she was outside, Lisa saw a rabbit.	Filler
Lisa quickly ran toward the rabbit.	Forward inference
That afternoon the gardener came to spray the garden.	Filler
The gardener sprayed poison all over the weeds.	Forward inference
When it got dark Lisa went back inside.	Filler

Appendix J - Continued

The rabbit sneaked back into the carrot patch through a fence hole.	Bridging inference
There would be no carrots for supper the next night	Bridge-mate
The next morning the fence hole was fixed.	Filler

Story 4

One day Tom went to the grocery store.	Filler
As he left his house he caught his pants on a nail.	Forward inference
Tom ran to get to the store before it closed.	Filler
As he ran he stepped on a banana peel.	Bridging inference
Tom skinned his knee and got back up.	Bridge-mate
At the store he bought many groceries.	Filler
Tom put too many groceries into the sack.	Forward inference
Tom then decided to carry the sugar sack by itself.	Filler
The sack of sugar ripped while being carried.	Bridging inference
The sugar sack was empty when Tom got home.	Bridge-mate
That night Tom went to bed early.	Filler

Story 5

Because she was bored, Tina drew a picture.	Filler

Appendix J - Continued

She pressed down too hard on her pencil.	Forward inference
Tina then got some magic markers and colored her picture.	Filler
The cap was left off of the green magic marker.	Bridging inference
The green marker did not work anymore.	Bridge-mate
She then rolled up her picture and put a rubber band around it.	Filler
The rubber band was stretched too far.	Forward inference
Tina felt hungry so she went to get a snack.	Filler
Her mother poured too much milk into her glass.	Bridging inference
Her mother went to get a sponge.	Bridge-mate
That night, Tina's father thought the picture was pretty.	Filler

Story 6

One morning Jane helped her mother with breakfast.	Filler
First of all, Jane put butter into the hot pan.	Bridging inference
Soon the pan was slippery.	Bridge-mate
Jane's baby sister started to cry.	Filler
Jane picked her up and sang a lullabye to the baby.	Forward inference
Jane decided that she wanted eggs, toast, and juice.	Filler

Appendix J - Continued

As she got the eggs, Jane dropped one on the floor.	Forward inference
Jane then got two pieces of bread.	Filler
The bread was put into the toaster and pushed down.	Bridging inference
In two minutes the bread popped back up.	Bridge-mate
Both Jane and her mother got very full.	Filler

Story 7

One weekend, Pam went rollerskating with her friends.	Filler
She tried to rollerskate for the first time.	Bridging inference
Pam really got a sore bottom	Bridge-mate
After skating, the girls had a slumber party at Pam's	Filler
Pam's father told the girls a ghost story.	Forward inference
The girls then had a pillow fight.	Filler
As Pam grabbed it, the pillow ripped apart.	Forward inference
Pam and her friends then watched the T.V.	Filler
They all watched the sad movie.	Bridging inference
Pam had to get tissues for the girls.	Bridge-mate
Since they were tired, they fell asleep easily.	Filler

Appendix J - Continued

Story 8

The little girl had a birthday party.	Filler
Her mother put the cake into the oven.	Forward inference
For a present, the girl got a trumpet.	Filler
She blew into her trumpet.	Bridging inference
All of her friends covered their ears.	Bridge-mate
She also got a red jack-in-the-box.	Filler
She turned the handle on her jack-in-the-box.	Bridging inference
The puppet surprised the little girl.	Bridge-mate
Her mother lit the candles on her cake.	Filler
One of her friends sneezed into the candles.	Forward inference
The little girl got a lot of nice presents.	Filler

Appendix K

Questions Asked to the Experimental Stories - Both Lists

Questions	Correct Response
Story 1	
Did the farmer's wife burn her mouth?	Yes
Did the dog get dirty?	Yes
Did the farmer make his wife some cake?	No
Did the farmer hear laughing?	No
Was the sun shining?	No
Did the farmer's wife get wet?	Yes
Did the farmer's wife feed the cows?	No
Did the blades on the windmill turn around?	Yes
Story 2	
Did the bubblegum stick to Mike's shoe?	Yes
Did the icecube melt?	Yes
Did the inner tube go flat?	Yes
Did Mike go to the movies?	No
Did Mike trip and fall?	Yes
Did Mike ride on a boat?	No
Did Mike buy a candy bar?	No
Did Mike run after a kite?	No

Appendix K - Continued

Story 3

Did the rabbit eat the carrots in the patch?	Yes
Did Lisa see a frog?	No
Did Lisa play outside after it got dark?	No
Did the weeds die?	Yes
Did water come out of the faucet?	Yes
Did a man come to paint the house?	No
Did the rabbit hop away?	Yes
Did Lisa help her mother was the car?	No

Story 4

Did Tom walk slowly to the store?	No
Did the grocery sack break?	Yes
Did Tom go to the paint store?	No
Did Tom put the sugar sack in a car?	No
Did the sugar spill out of the sack?	Yes
Did Tom buy any nails?	No
Did Tom's pants rip?	Yes
Did Tom slip and fall on the banana peel?	Yes

Story 5

Was Tina full from eating dinner?	No
Did the green marker dry up?	Yes
Did the rubber band break?	Yes
Did Tina's pencil tip break?	Yes

Appendix K - Continued

Did Tina paint a horse?	No
Did milk spill out of Tina's glass	Yes
Did Tina put tape around the picture?	No
Did Tina tear up her picture?	No
Story 6	
Did the egg break?	Yes
Did Jane want any pancakes?	No
Did Jane's baby sister start to laugh?	No
Did the bread get toasted?	Yes
Did the butter in the pan melt?	Yes
Did Jane go and get two muffins?	No
Did the baby fall asleep?	Yes
Did Jane help to make supper?	No
Story 7	
Did Pam go fishing?	No
Did the movie make the girls cry?	Yes
Did Pam and her friends listen to the radio?	No
Did the stuffing come out of the pillow?	Yes
Did the girls throw food at each other?	No
Did Pam fall down a lot from rollerskating?	Yes
Did the ghost story scare Pam's friends?	Yes
Did the girls go to Pam's to go swimming?	No

Appendix K - Continued

Story 8

Did the trumpet make a noise?	Yes
Did the girl have a Christmas party?	No
Did the mother light a fire in the fireplace?	No
Did the candles go out?	Yes
Did the cake bake?	Yes
Did the jack-in-the-box pop up?	Yes
Did the girl get a baseball bat?	No
Did the girl get a green doll?	No