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Inferences Used in Comprehension and Recall
at Ages 4 and 7

A Thesis Presented

by

James G. Thompson

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of the requirements for the degree of

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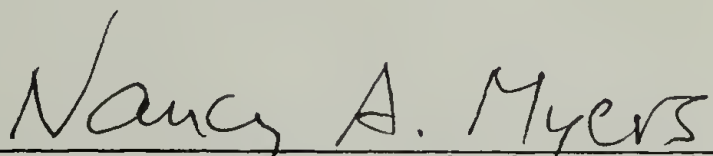
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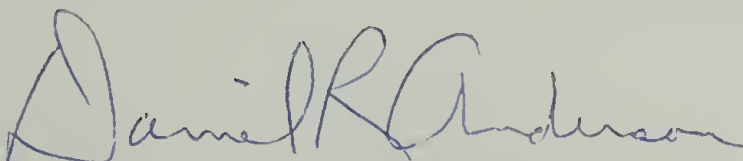
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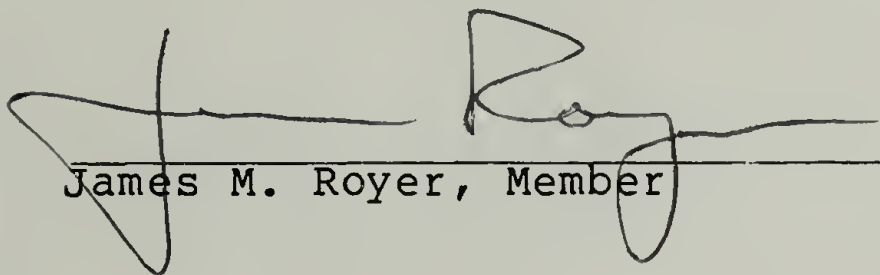
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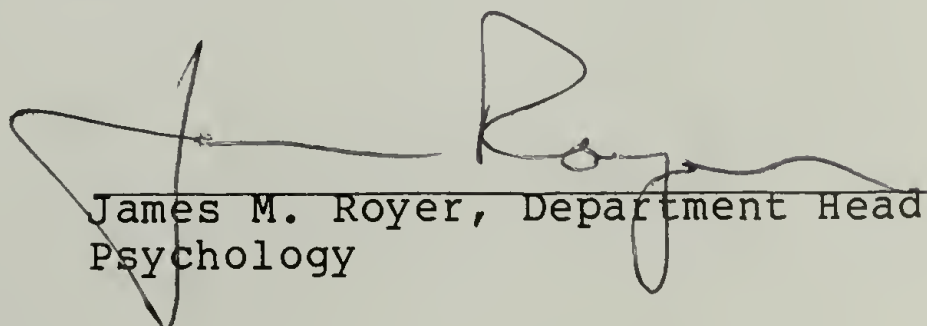
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ABSTRACT

Children at ages 4 and 7 were presented three stories, one in each of three causality versions, in order to determine whether inference ability and recall are influenced by the strength of the causal chain in the story. For each story, children were asked two inference questions about logical causality, two questions constrained by story information, and two unconstrained inference questions. Three question-timing conditions were used to address issues concerning when inferences are drawn in story comprehension and how they are influenced by the total amount of information provided. Questions were asked either on-line, or at the end of the story, or not at all. Following completion of each story, children were asked to retell it, and were then asked premise information questions.

Four-year olds' story comprehension ability and recall were enhanced when provided physical causality information, while 7-year olds' comprehension and recall were unaffected by causality version. Younger children also benefitted from additional story material, while older children did not. Finally, developmental changes in patterns of usage of logical, constrained, and unconstrained inferences were evident.

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C H A P T E R I

INTRODUCTION

The main goal of this research was to specify some elements in the progress of comprehension and recall of stories during development. Major advances in our understanding of text comprehension have been made in recent years, with theoretical accounts of comprehension only very recently converging toward a unified model. This research attempted to delineate the process of inference-making abilities, and thus, to contribute to this developing model. Before explication of the experimental paradigm utilized here, some of the major approaches to understanding text which influenced it will be reviewed.

Background

Story grammars. Several accounts have attempted to characterize the critical importance of the structure of stories (e.g., Johnson & Mandler, 1980; Kintsch, 1977; Mandler & Johnson, 1977; Rumelhart, 1975; Stein & Glenn, 1979; Thorndyke, 1977). The major assumption in all of these attempts is that stories have a canonical structure, and that people use their implicit knowledge of this structure to guide comprehension and recall. The

knowledge of story structure is generally considered to exist as a schema, consisting of expectations concerning elements to be found and relations that will hold between elements (Johnson & Mandler, 1980). It may also serve as a code at the time of retrieval, with individuals having a set of ordered categories, independent of story content, at their disposal (Mandler, 1978). Mandler (1978) points to three primary functions of a schema. First, it directs attention to a general area of memory, which indicates to the reader the type of information which is to be retrieved; second, it provides a temporal sequence to find specific content; third, the schema allows the individual to generate an approximation, if the exact content cannot be retrieved.

Detailed analyses of story structure follow from the analysis by Rumelhart (1975) of the story structure as grammar, with the representation of the story comprised of syntactic and semantic components involving the categorization of events and the causal relations between categories. Many investigators (e.g., Johnson & Mandler, 1980; Mandler & Johnson, 1977; Stein & Glenn, 1979; Thorndyke, 1977) have argued that "rewrite rules" contain knowledge about the generic structure of stories; and the schema which is implicit in these rules (or grammars) is used in a top-down fashion to encode a story in chunks

corresponding to the rules and to generate expectancies about the nature of the story structure. In Johnson & Mandler's (1980) grammar, the important components of this argument may be seen. In general, a hierarchical network of story categories and the logical relationships connecting the categories is used. The episode is the basic unit of analysis, containing two elaborative branches. Each of these branches perform different functions--either allowing the development of the story, or setting the stage for multi-episode stories. In both cases however, the episode forms the initiating elements of the story. The hierarchical network continues with the beginning followed by development, where goals of the protagonist may be seen, or some action may take place. Depending on the sequence in the development stage, either a goal path (following the former sequence), or a reaction (following the latter sequence), may be instantiated. One of these paths will then result in an outcome, signifying whether or not the protagonist attained the goal. The final category, the ending, represents long-range consequences of the development stage, or responses by story characters to that stage.

In recent years, a good deal of support for this type of analysis has been established. One avenue of research

has focused on stories whose structure violates the canonical structure described in the grammar; while a second has looked at patterns of category emergence in both recall tasks and importance (to story) ratings (e.g., Mandler, 1978; Mandler & DeForest, 1979; Mandler & Johnson, 1977; Stein & Glenn, 1979; Stein & Nezworski, 1978). Mandler & Johnson (1977), for example, presented first-graders, fourth-graders, and adults with tape-recorded stories and found recall varied significantly with age, but pointed to the finding that there was a similar ordering among categories in recall (setting, beginning, outcome, etc.) in the three age groups. Mandler & Johnson conclude from this that while complexity and elaborations may become richer with development, even the youngest subjects are sensitive to the underlying structure of stories and use this schema to organize their retrieval. Mandler & DeForest (1978) presented third-graders, sixth-graders, and adults with stories in either a canonical or an interleaved format. The finding that younger children recalled the story in canonical form, regardless of the condition they were in, led Mandler & DeForest to claim that not only can young children use the story schema to guide their retrieval--it appears as though it is the preferred mode of organization. In general, much of the work on story

grammar representation indicates that it may serve as a guide to understanding the processing which must take place in the comprehension of a story, and how expectancies within stories are developed.

While the schema concept is widely employed, there does exist some disagreement concerning the level at which expectancies are generated. Kintsch (1977), for example, provides only a global description of structural elements within a story, without emphasizing the incorporation of prior expectancies that a reader might have about the organization of a particular story. Instead, his model has emphasized the analysis of the structure of text propositions, and relations between propositions. Kintsch argues that while story structure does seem to be an important characteristic in an analysis of story comprehension, the segmentation of text into categories is done through a strategy based on cues in the text, rather than through a rule-based analysis of the story structure.

The global interpretation of the role of story grammar representation as made by Mandler and her co-workers has not gone without empirical challenge as well. McClure, Mason, & Barnitz (1978) used a scrambled story technique in order to examine the role of surface text features as well as the underlying story schema. Using

third-graders, sixth-graders, and ninth-graders, three versions of each of six stories were used to monitor the effects of beginning a story with the setting (which most closely approximated a story grammar structure), with a question, or with a conclusion. While the findings of this study are similar in some respects to those of Mandler & DeForest (1977), in that young children seem more dependent on "normal" structure than older children, they also found evidence that in some cases, surface cues also have an effect on story sequencing. While McClure, et al., confined their discussion of surface cues to a brief mention of "salient lexical ties" and "specific lexical items", other studies have attempted a more specific delineation of factors which may operate in the comprehension of stories. Frederikson (1977), in a summary of research which has been conducted with "degraded" stories (scrambled order, deletions), points to this problem. He suggests the necessity of being aware of alternative explanations for many of the results obtained, including the use of text-based cues and text-based inferences which may generate coherence in a narrative as well as in recall protocols. In other words, a set of important concerns remain centered on whether text-based components of these story grammar categories need to be identified in order to understand how the grammar

operates, and how the developing process of comprehension skills proceeds.

Conceptual schemas. Most of the research in this direction may be traced to the influence of the work of Schank & Abelson (1977). Their examination of research from a wide diversity of disciplines (including linguistics and artificial intelligence) suggested two major points which can be seen developing in current thinking about story comprehension. First, they assert that widespread agreement has been developing that semantic features are considerably more important than had previously been believed; and second, the role of context has come to be seen as overwhelmingly important in the interpretation of text. The implications of these two factors for text comprehension is that while text content guides the process of understanding, important components to understanding are located outside the text itself--primarily in the knowledge of actions and causality which the reader or listener brings to the task. This type of mental representation is defined by Schank & Abelson (1977) as a script, which they argue functions in the interpretation of stories and aids in the prediction of likely sequences of events. Nelson, Fivush, Hudson, & Lucariello (1982) have also argued that the scriptal

organization points to temporal and causal relations between components of narratives, with a particular sequential structure of events called for in a given context. Relations between details in the narrative are considered optional in this scheme with the only constraint being that they are described in a manner logically consistent with the broad structure. Major support for these claims comes from work with adult subjects (e.g., Bower, Black, & Turner, 1979) in which it has been found that there is often confusion of actions which are implied by the scriptal organization of stories with stated actions. Scriptal knowledge and use of scripts in story recall with children has been examined by Nelson and her co-workers (e.g., McCartney & Nelson, 1981; Nelson, 1979; Nelson, Fivush, Hudson, & Lucariello, 1982; Nelson & Gruendal, 1981). In general, it has been found that young children's knowledge about routine events fits the script model, with a great deal of commonality among reports, and reliable sequencing of actions between children (Nelson, 1979; Nelson & Gruendel, 1981). The use of scripts in story recall has also been promising. McCartney & Nelson (1981) found that young children's recall of stories was influenced by event knowledge sequences as opposed to state knowledge. They also found that changes in the story during recall reflected the fact

that detail information is not as tightly constrained as event sequencing, and that logically consistent changes were the predominant type of changes made.

According to Schank (1977) the representation of text in memory, which exists as a sequence of causally connected actions and states, is described by conceptual dependency theory. This theory describes conceptually primitive elements representing specific classes of actions and states in such a way as to ensure that sentences which differ in language but are identical in meaning have only one representation, and that information which is implicit in the text will be explicit in the representation of the text in memory. This view, that the text will be decomposed into underlying states or actions, and that representation of text is influenced by the unfolding of a chain of events over time has recently been the focus of many researchers. More specifically, the causal connections between states and actions has been the primary point of emphasis, with the study of the inferential process assuming an increasingly important role (e.g., Graesser, Robertson, & Anderson, 1981; Omanson, in press; Omanson, Warren, & Trabasso, 1978; Trabasso, Secco, & van der Broek, 1983; Trabasso & Nicholas, 1981; Warren, Nicholas, & Trabasso, 1979).

Event chains and inferences. Most developmental studies which address the question of the role of inferences in text comprehension have looked at children in the 5- to 11-year-old range (Paris & Upton, 1976; Omanson, et al., 1978), and while a few studies have employed younger children and noted significant improvements in performance, they leave unanswered many questions about potential underlying processing differences. For example, Poulsen, Kintsch, Kintsch, and Premack (1979) using picture stories, tested 4-year olds and 6-year olds and found 6-year olds better able to make stories out of scrambled pictures, but found 4-year olds performed quite well in recall of "ordered" stories. They suggest that while 4-year olds can provide inferences within a clearly regularized story format to link different components of the story, only the older children use some sort of inference-making procedure to link randomly ordered pictures. Similarly, Wimmer (1980) studied children in the 4-year-old range in a task involving comprehension of "well-structured" and "destructured" text. In this study, it was found that although 4-year olds showed better recall of the well structured than the destructured version, they did not show "full comprehension" of text material. Importantly, Wimmer questions, "what prevents full comprehension?" and suggests that the answer may lie

in a lack of relevant world knowledge, specifically the knowledge required to figure out the specific causal connections between the states, actions, and events of the story. This interpretation of performance differences is interesting, and clearly suggests the necessity for more work with children of these ages if we are to delineate just what is involved in the inferential process in story comprehension.

According to Nicholas & Trabasso (1981), there are a number of problems which need to be addressed in any attempt to carefully examine the role of inference in the comprehension process. Basically, the problems center on the question of how the term "inference" is defined--with almost as many definitions as there have been researchers interested in the question. The fact that slightly different meanings have been employed in the development of theoretical arguments may reflect the many types of inferences which may exist rather than a serious communication problem. Recently, Hildyard & Olson (1978) have reviewed general categories of usage of the term inference in their attempt to differentiate inferences into three main classes. In their system of classification, propositional inferences refer to the implications of explicit propositions. A defining

characteristic of propositional inferences is that it is the form of the proposition, rather than the content which determines inference making. Included in this classification are many types of inferences which have been described by other researchers. Transitive relations (e.g., Inhelder & Piaget, 1958; Trabasso, 1975), comparative terms (e.g., Olson & Nickerson, 1977), and class inclusion relations (e.g., Griggs, 1976) are all subsumed under this general heading. The second class described are referred to as enabling inferences which are determined by both content and form, and are seen by Hildyard & Olson as the links between concepts in a story which otherwise would not form coherent units. Their final classification is comprised of pragmatic inferences which are considered useful in elaborating text material, but not seen as necessary for comprehension. They result, primarily, from implicit world knowledge which the individual brings to the task.

Although the classification model proposed by Hildyard & Olson is useful as a beginning step, their interpretation of developmental differences reveal its limitations. A major conclusion centers on the finding among children in the 10- to 12-year-old age range that there is an increasing ability to differentiate propositional from pragmatic inferences. According to

Hildyard & Olson, this change was the result of older children's ability to reject pragmatic inferences as necessarily true; an ability grounded in increased "schooled competence", rather than the development of any inferencing ability. In a related study using 6-, 8-, and 10-year olds, Hildyard (1979) attempted to substantiate the claim that different types of inferences exist, and that there are developmental differences in usage. She found that the youngest children were as capable as the older children in providing integration and implicit inferences (which are subclasses of the pragmatic and enabling inferences discussed above), but were unable to draw formal, or propositional, inferences. In considering both of these studies, it seems as though the nature of underlying process changes are left unexplored. While the distinctions serve as an aid in thinking about past work involving inferences with children, they demonstrate more decisively the breadth of related issues which need to be addressed.

A taxonomy of inferences. A series of papers, including Nicholas & Trabasso (1981), Omanson, et al., (1978), Trabasso & Nicholas (1981), and Warren, et al., (1979), have been focused on the underlying processing changes which accompany the development of inferential reasoning.

In particular, these researchers have been developing a taxonomy of inferences, based upon their functional relationship between events in a story. According to their arguments, some model of language understanding must encompass any formal definition of inferences, and as was suggested above, a great deal of this theoretical foundation is evident in Schank & Abelson's (1977) work on representation. The event chain model presupposes the individual to be a flexible processor of information--able to develop (using information in the narrative as a starting point) a structure using knowledge about available connections between events rather than applying a preconceived higher order structure.

Warren, et al., (1979) provide a description of an event chain representation which both indicates important components of the model and relates it to categories found in story grammar representations. Text structure is represented in a non-hierarchical fashion, with this representation being the result of an analysis of seven main proposition types and their logical connectives. Proposition types include a state which describes the conditions of the physical world, or the conditions of a character in a story. Events are changes of state, and consist of two main types--those initiated by the protagonist and those occurring independently of the

protagonist. Changes of state which occur as a result of the protagonist's voluntary behavior are referred to as actions (internal counterpart--cognition), and since the event chain model description is considered from the point of view of the protagonist all other state changes are simply events. Involuntary reactions are classed into displays and impulses--corresponding to external movements and internal states, including affect, intuitions, and beliefs. The final proposition type, the goal, may be either a voluntary or involuntary internal mental event representing desires or plans which are held by the protagonist. The logical connectives which describe relations between propositions include inferential relations, which have become the focus of much work in this area.

Warren, et al., (1979) claim that inferences may be based on three types of information. The first of these involves the basic causal connections which occur between different events and are the result of logical relations. Inferences based on logical relations are basic structures which allow a narrative to exist. Within the system developed here, these logical inferences may be of one of four classes including motivational inferences, which involve inferring causes for characters' voluntary

thoughts or actions; physical cause inferences which require inferring "mechanical causes" for events or states which follow in the story; psychological causation inferences involving the characters' involuntary actions; and enablement inferences, where story conditions which are stated are necessary but not sufficient for a particular event to have occurred. A second type of inference centers on informational relations involving people, objects, times, places, etc.--the general context of a particular narrative. Informational inferences do not deal with causes or consequences and are not tied to intra-propositional relationships. Five types of informational inferences are specified, including pronominal inferences which specify the antecedents of pronouns; referential inferences which specify the antecedents of actions or events and clarify the roles of people and objects in related propositions; spatio-temporal inferences which are used to establish times and places within the story; world-frame inferences which primarily serve the function of setting constraints on possible interpretations; and elaborative inferences which serve to add detail to a story--generally irrelevant circumstances to the progression of the story. A third type of inference involves judgements about aspects of the narrative such as characters' action, authors' intentions,

etc. These inferences which are primarily evaluative in nature, draw upon the individual's values surrounding the situation described.

Related to the taxonomy of inferences described above, are questions concerning how and when inferences are made. One line of argument is that inferencing is an automatic process and all possible inferences will be generated; a second argument holds that limits need to be established to describe the comprehension process. Trabasso and his co-workers hold the belief that an individual makes only those inferences which are "relevant to the progress of the narrative", a belief they refer to as the relevancy hypothesis (Warren, et al., 1979). In the context of this hypothesis, four degrees of inferential constraint are proposed, including those consistent with, but undetermined by the text (usually considered elaborative or unconstrained inferences); determined but irrelevant inferences, which are constrained by material in the narrative; determined and relevant inferences, which are more tightly constrained because they are important to the development of the story; and lastly, those which are overconstrained or redundant inferences which duplicate given information. Warren, et al., (1979) suggest that those inferences which

are both determined and relevant are most likely to be made since they are necessary for event-chain comprehension. Undetermined and irrelevant inferences are considered to be unnecessary to understanding, their only contribution being one of embellishment of the narrative. It is important to note, however, that the effect of these inferences may not be trivial in recall, and significant developmental changes may occur in their usage.

Measurement of inferences. Most theories of narrative representation and comprehension have been supported using free recall as the primary dependent measure. As discussed earlier, the use of recall has been related to, and used to support the notion of underlying structural dimensions in stories with some success (Mandler & Johnson, 1977; Rumelhart, 1977; Thorndyke, 1977). Graesser (1981) points to similar success in recall-based analyses of scriptal theories as well (e.g., Black & Bower, 1980; Bower, Black, & Turner, 1979).

Whenever free recall is used as a dependent measure, there is a representation being tapped which relies on connections made between events in the narrative through logical inferences. It is becoming apparent that the role of inference-making as a component of the understanding process has been implicit in much of the work done in the area of story comprehension. Using the event-chain

representation as a basic assumption, it may be argued (Omanson, in press; Warren & Trabasso, 1979) that inferences are acts of comprehension, and their measurement an alternative (or addition) to the use of free recall in specifying degree of understanding.

In a number of papers (Graesser, Robertson, & Anderson, 1981; Graesser, Robertson, Lovelace, & Swinehart, 1980), Graesser and his co-workers have attempted to examine the usefulness of employing inferential components to delineate the comprehension process. The primary technique used here has been to expose inferences made during comprehension. Questions which may be asked include "why-" and "how-" questions which expose causal information (and fall into the logical inference category specified by Warren, et al., 1979); and "where-", "what-", and "who-" questions which are similar to the broad category of informational inferences discussed earlier. Graesser, Robertson, & Clark (1980), (reported in Graesser, 1981) used a question-answering procedure to explore the role of context in the interpretation of an inference question. Graesser, et al., (1980) examined the effect of three context conditions. In the no-context condition subjects were presented with a target statement in isolation, with that

statement probed by questions requiring inferences. The prior-context condition included, along with the target statement, the narrative events immediately preceding it; while in the full-context condition, the subject received the entire passage before the target statement was probed. Using these different levels of context condition, it was possible to develop a model which predicted from where the final inference representation would be generated. While conclusions drawn from their analysis are varied, a few seem most central to their arguments. To begin with, it is the set of prior sentences, rather than the immediately preceding sentence, that is most responsible for inferences to be made--a finding which implies that a given sentence is linked to a representation in memory of some integrated information. A second finding was that inferences associated to a given statement are rarely generated by subsequent information. Virtually all of the inferences associated with a given statement will be established upon its occurrence, a result of the statement alone, or by the statement together with prior context. Finally, and related to the previous finding, the later in a narrative the target statement is, the higher the likelihood of its producing inferences which remain in the final representation.

The findings of Graesser and his co-workers lend

themselves well to the causal chain model discussed earlier, and the question-answering procedure for probing this representation appears to be a useful technique for establishing how actions and events in a narrative are conceptually related (Graesser, 1981; Warren, et al., 1979). Lehnert (1977) argues that the ability to answer questions is the strongest demonstration of text comprehension, preferable even to recall measures because often, reasonable recall of a narrative can be made without including any inferences, which are necessary for real understanding. Warren, et al., (1979) take what may be seen as an even stronger position on this issue, beginning with the assumption that the event chain model presupposes the making of inferences as an integral component of comprehension, leading to more complete recall. A questioning procedure may be used, it is claimed, to promote the making of text-connecting inferences during the listening to, or reading of, text.

Statement of the Problem

The present study was formulated to address some of the issues raised in the preceding discussion. Four- and 7-year-old children were asked a specific set of questions

either "on-line" at the earliest opportunity during the story presentation, or at the end of the story, or not at all. Each child listened to three stories, each representing a different level of causal relation in a critical story event; physical, psychological, or enablement. Within each story, three types of inference constraint levels were specified--logical, constrained informational, and unconstrained informational. At the completion of each story, children were asked to recall the story and determine whether each of a series of six pictures "went with the story". After hearing all three stories, children were again shown all the pictures and probed as to their reasons for accepting or rejecting each.

The three question-timing conditions were employed in order to ascertain whether there is a developmental change in ability to generate inferences as a function of amount of information provided in a story. The findings reported by Graesser and his co-workers (Graesser, 1981; Graesser, et al., 1980) suggest that information which follows a target statement does not aid in inference-making ability, and while this apparently is a reasonable description of adult comprehension, it is less apparent with young children. It has been suggested by a number of researchers that world knowledge may be the limiting

factor in young children's lack of ability to make causal connections necessary for comprehension of narratives. Although the end-of-story condition does not increase world knowledge, it does provide--in subsequent story events--information which will clarify and/or constrain the inferences required of a given target sentence. It was therefore hypothesized that while older children should reveal no differences in ability to infer or recall as a function of question-timing, younger children should perform better on inference questions and recall measures when provided with more complete story information before questioning, i.e., in the end-of-story condition. Following the claim made by Warren, et al., (1979) that comprehension is influenced by the making of text connecting inferences, it is further hypothesized that children in the two questioning conditions will perform better in recall than children in the no-question condition.

Three levels of inference constraint (logical, constrained informational, and unconstrained informational) are also included in this study. This manipulation, as well as the following one, is included in an effort to address more directly the kind of question raised by Wimmer (1980) and alluded to earlier, and more

specifically to explore the usefulness of the inference taxonomy developed by Warren, et al., (1979). Logical inferences represent the basic causal connections between events which allow narratives to exist, and reflect conversational convention and basic linguistic skills. The central role of logical inference-making in comprehension and communication leads to the hypothesis that at both ages, logical inferences will be most likely to be made and to occur in recall protocols. Informational inferences determine the general context of a narrative, and represent completeness of interpretation. Constrained informational inferences which are determined by, and relevant to the text are necessary for full comprehension. Indirectly, this type of inference reflects the general description which was provided by Hildyard & Olson (1978) with regard to 12-year olds' increased facility in accepting or rejecting inferences as necessarily true. Since older children are likely to have established representations of story events which include many more connections with events and actions external to the story, it is hypothesized that they will perform better on inference demands reflecting this type of constraint than younger children will. Younger children may be less constrained by representation demands, however, and thus produce informational inferences of the

unconstained, undetermined, and irrelevant types faster than the older children will. These unconstrained informational inferences may also be more likely to turn up in recall protocols of younger children following questioning than with young children in the no-question condition, since the representation of the story is more likely to include this type of inference after being made through a questioning procedure. Further, differences between younger and older children should be noted in response reaction times, with older children displaying faster responding to constrained than unconstrained inference probes, and young children showing no difference in their response times to these two types of queries.

Warren, et al., (1979) identify four classes of logical causality inferences: motivation, physical cause, psychological cause, and enablement. The last three of these are included in this study. As mentioned previously, three versions of each of three stories were constructed. These varied in only one respect, the type of logical inference required in one of the two logical inferences in the complete story.

Understanding the nature of physical causality is one of the earliest concepts acquired. Nelson (1973), in a classification of earliest words used, found that very

young children use words which represent the production of movements or changes in their world. Whiteman (1967) using groups of 5- and 6-year olds and 8- and 9-year olds, conducted a study concerned with the understanding of psychological causality. The comprehension of short stories related to psychological defense mechanisms varied significantly with age. Younger children displayed successful levels of understanding only 10% of the time, while older children were successful 71% of the time. In a follow-up study, a series of questions dealing with physical causality were employed and it was found that in this case, age differences in performance were not significant. More recently, Glasberg & Aboud (1982) studied 5- and 7-year-old children in an attempt to discover age-related changes in emotional experience. The results of their study indicated that older children were likely to attribute emotional states to a range of experiences, including both physical and psychological components. Younger children, in contrast, did not display this range of components. They saw physical causes as playing a much more causal role at all levels of emotional experience. Enabling relationships which leave the causal link between events more ambiguous are likely to have a similar effect, since they also require an understanding of a range of potential causal factors. For these

reasons, it is hypothesized that children of both ages will perform similarly and do their best when they experience the physical causality version of stories. With the psychological causality and enablement versions, however, the older children will be more likely to produce inferences in both comprehension and recall than the younger children will.

C H A P T E R II

METHOD

Subjects. Fifty-four children in each of two age groups participated in the study. The range of ages in each of the groups was 4-years, 6-months to 5-years, and 7-years, 6-months to 8-years, with an equal number of boys and girls at each age level. Seven four-year olds did not complete the warm-up task, and were replaced. All of the children were from middle-class families in the greater Springfield, Mass. area.

Design. The study employed a 2 (age) x 3 (question-timing condition) x 3 (inference constraint) x 3 (causality version) mixed design, with the last two factors within subjects. In order to ensure counterbalanced orders of causality versions, and equal representation of each story context, 18 different sequences balancing story context, causality version, and order were generated, and one child at each age in each question-timing condition was assigned to each of these sequences.

Materials. Three stories were created or adapted such that all included the same type of target inferences. They ranged from 80 to 84 words in length, and contained nine or ten propositions. Three versions were generated for each story according to the manipulation specified

above. All versions of the stories are to be found in Appendix A. Each version of the three stories was recorded on a separate cassette in a single female voice. Intonation, temporal, and intensity characteristics of the tapes were carefully balanced. The entire session was recorded using a second cassette recorder.

Two "warm-up" stories were also constructed and given in fixed order to all children. The first of these was 25 words long with four propositions, and the second was 52 words in length with 7 propositions. These, too, are available in Appendix A. The gradual increase in length and complexity was arranged to enable that each child to understand the type of response required.

Eighteen pictures (black and white line drawings) were created, with six pictures used in conjunction with each of the three stories. For each of the stories, three pictures reflect either stated or inferred text material, while the remaining pictures depict non-story events. Two pictures were developed for use with the second warm-up story. All pictures are included in Appendix B.

Five plates from the Peabody Picture Vocabulary Test (PPVT) were used to assess the younger children's familiarity with concepts employed in the stories. These may also be seen in Appendix B.

Procedure. After children became acclimated to the

laboratory setting, they and their parent(s) were invited to play the "story game" in a nearby room. The child was then told that he or she would hear a story and would be asked questions about it. For all children, the experimenter then played the first warm-up story on the tape recorder, asking two premise questions and two inference questions at the end of the story. After this brief period of questioning, the experimenter then asked the child to re-tell the story, and provided general approval and encouragement. The second warm-up story was then introduced, with the experimenter employing on-line questioning with children in this experimental group; end-of-story questioning with children in the second experimental group; and no questioning with children in the third group. Following completion of the story, all children were asked to re-tell it. Following recall of this story, all children were shown two pictures and asked to tell whether or not they "show something that goes with the story". In this warm-up task all children were also probed for their reason for answering this question, in order to ascertain whether they understood the task requirements.

The test materials were then introduced, with the procedure for each child following that prescribed by the

questioning condition and sequence to which the child was assigned. After free recall of each story, two premise information questions were asked of all children. To equalize the time elapsing before recall, a delay, equivalent to the period needed to ask the inference questions in the end-of-story condition was imposed for all children in the on-line and no-inference-question conditions.

Immediately following the premise information questioning, all children were asked to determine whether each of a series of six pictures showed something which went with the story; and immediately after the third story questioning was completed--all children were shown all 18 pictures a second time, this time with probes concerning their reasons for selecting or rejecting each picture. Following presentation of all 18 pictures, the 4-year olds were given an abbreviated vocabulary test with the PPVT plates described above, to make sure that the term "excitement" was not an unfamiliar one at this age.

C H A P T E R III

RESULTS

The presentation of results is organized in five major sections. These include an analysis of responses to inference questions; examination of free recall data; correlations between different free recall measures and responses to inference questions; analysis of responses to pictures; and consideration of responses to premise information questions and vocabulary items.

Inference questions.

Correct responding. The mean number of correct responses to inference questions may be seen in Figure 1, as a function of age and causality version. After preliminary analyses showed no order, story version, or sex effects, an analysis of variance was carried out on these data as a function of age, causality version, question-timing condition, and inference type. Overall, the mean number of correct responses increased with age. Four-year olds correctly answered an average of 4.11 of the six questions asked for each story, while 7-year olds correctly answered an average of 5.19 questions, $F(1,68)=46.38$, $p<.001$. The greatest number of correct answers were given with the physical causality version (4.89), followed by the enablement version (4.62), and the

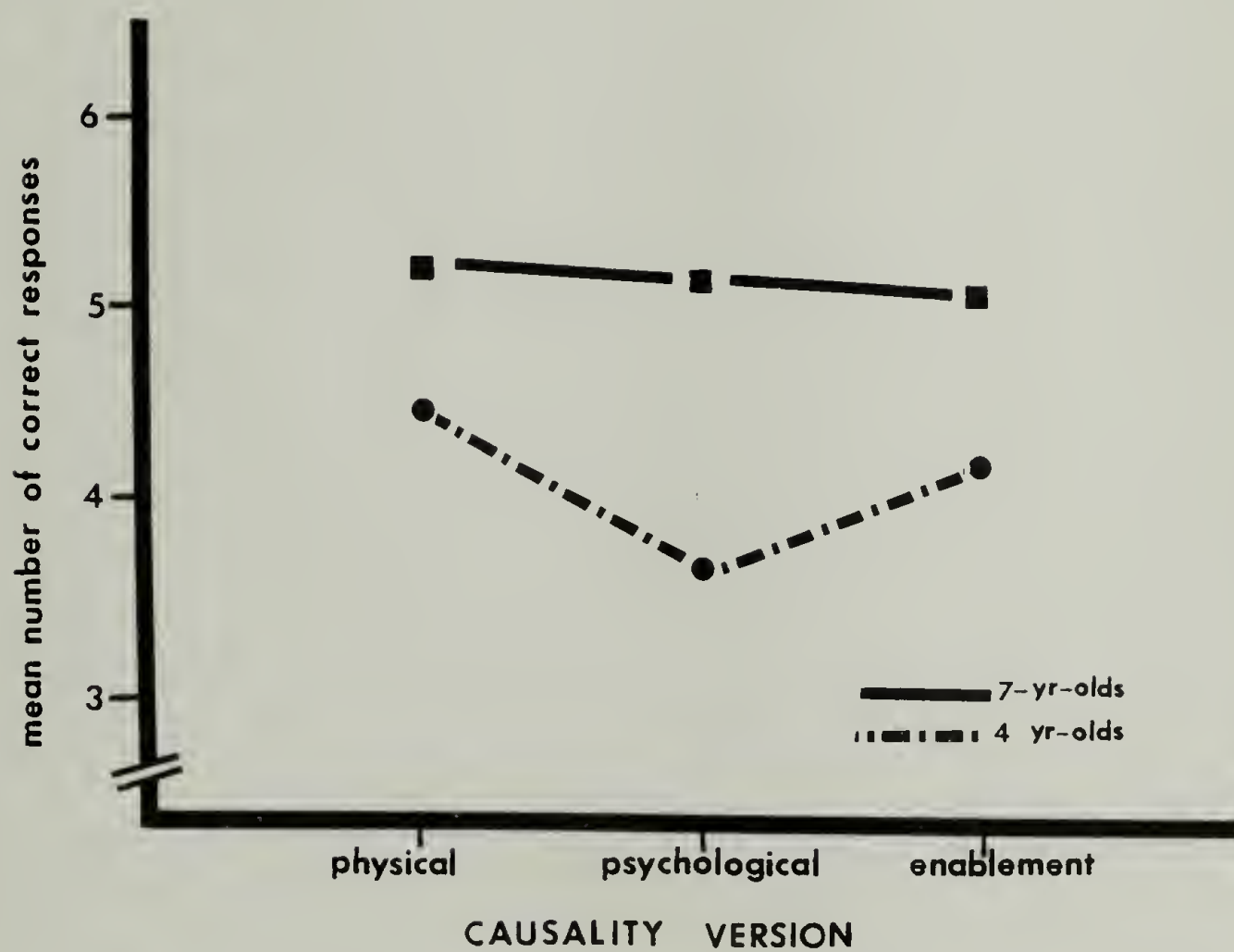


Figure 1. Mean number of correct responses as a function of causality version and age.

psychological causality version (4.44). This causality effect was significant, $F(2,136)=3.25$, $p<.05$, and Bonferroni t -tests indicated that only performance in the physical and psychological causality versions differed significantly ($t(71)=2.54$, $p<.05$). Furthermore, as may be clearly seen in Figure 1, the age difference in correct answers to inference questions differed with causality version ($F(2,136)=3.40$, $p<.05$). Performance on inference questions in the physical causality version did not vary significantly between 4- and 7-year olds, while the mean number of correct responses in the psychological causality and enablement versions increased significantly as a function of age (Bonferroni t 's(136)= 5.50, 3.06, p 's<.05).

Age differences also occurred in the pattern of responding in the on-line, and end-of-story question-timing conditions in the three different causality versions (age x causality version x question-timing condition, $F(2,136)=3.02$, $p=.05$). As can be seen in Figure 2, performance on inference questions was about the same in both question-timing conditions in all causality versions among 7-year olds, and while 4-year olds showed no difference in ability to answer questions as a function of question timing in either the physical or psychological causality versions, the mean number of

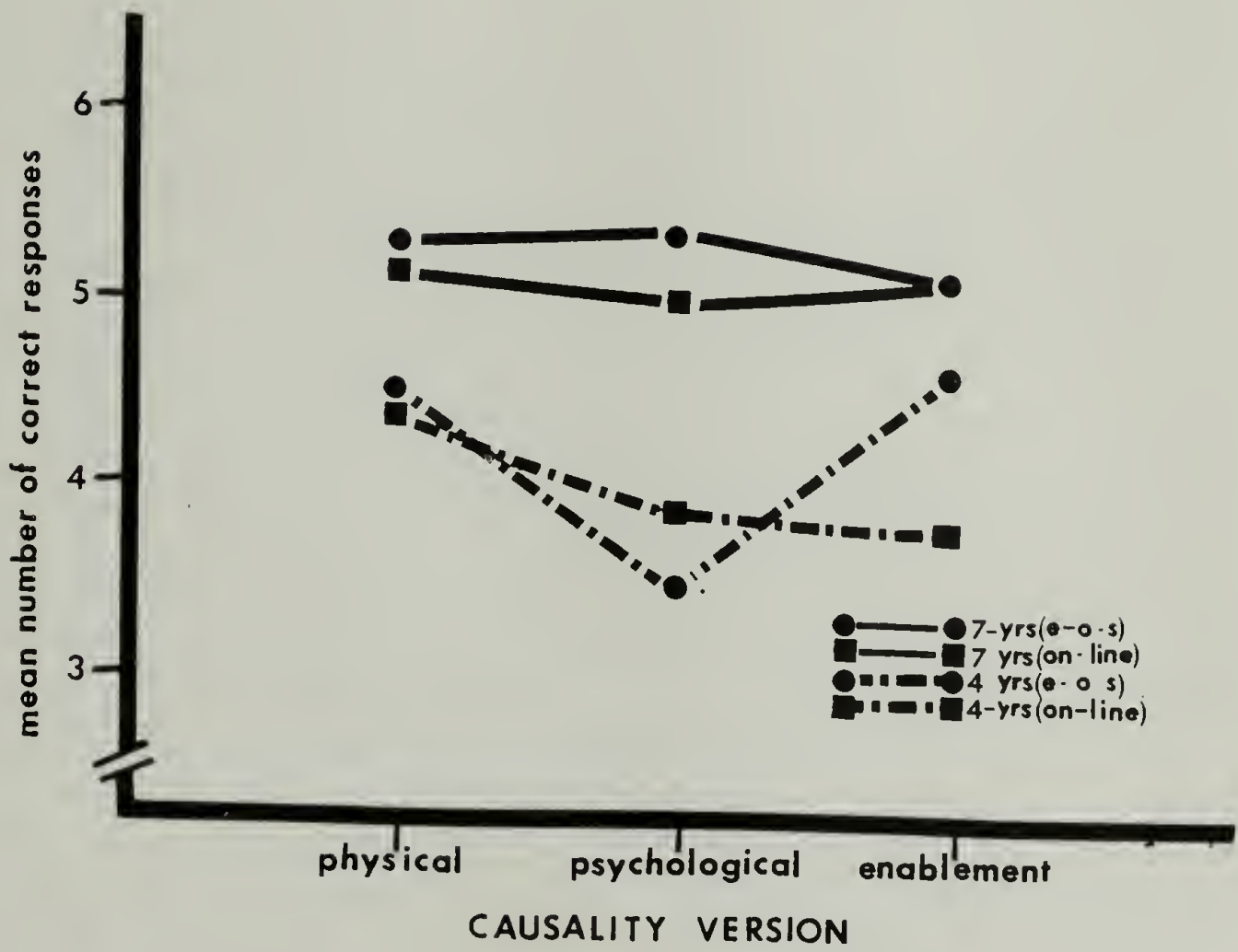


Figure 2. Mean number of correct responses as a function of causality version, question-timing condition, and age.

correct responses in the enablement version was significantly greater in the end-of-story question condition than in the on-line condition (Bonferroni $t(136)=2.75, p<.05$).

The mean number of correct answers to inference questions may be seen in Figure 3 as a function of age and inference type. Overall, children responded with more correct answers to questions about unconstrained inferences than to questions about logical or constrained inferences; the means were 5.46, 4.89, and 3.60, respectively, $F(2,136)=68.45, p<.001$. Bonferroni t -tests indicated significant differences in performance between unconstrained, and logical and constrained, and between logical and constrained inference questions (Bonferroni t 's(136)= 3.05, 8.34, 7.82, p 's<.05). Important age differences, which help to clarify these results, also were present, however. Seven-year olds answered logical inference questions best, while 4-year olds were most facile with the unconstrained inference questions (age x inference type, $F(2,136)=31.32, p<.001$). Moreover, younger children were significantly poorer at answering either the logical or constrained inference questions than they were at answering the unconstrained type question (Bonferroni $t(35)=5.53, p$'s<.05). On the other hand, 7-year olds, although most adept with the logical inference

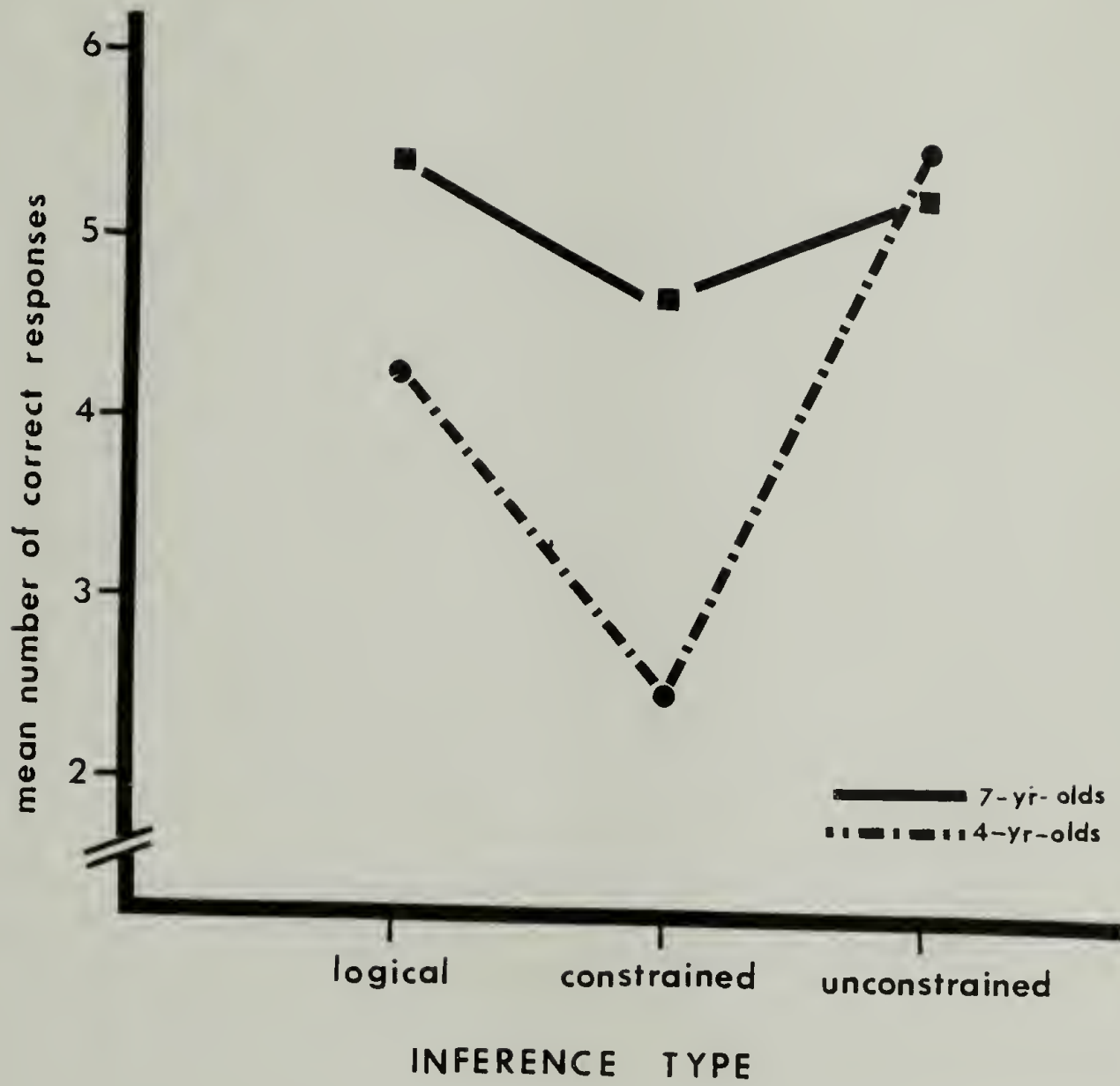


Figure 3. Mean number of correct responses as a function of inference type and age.

questions, did almost as well with unconstrained questions, while showing significantly less ability to answer the constrained inference questions (Bonferroni $t(35)=4.59$, $p<.05$). Even so, it is also apparent from Figure 3, that the performance of 7-year olds did not drop as dramatically as that of 4-year olds when asked to make constrained inferences.

Logical inference questions were more likely to be answered correctly in the physical causality version ($M=1.86$ for the two questions of this type), than in either the psychological causality or enablement versions (M 's=1.52 and 1.51, respectively), $F(4,272)=4.66$, $p<.001$. This facilitating effect of the physical causality version for answering inference questions was further supported by examination of the causality version x inference type x question-timing condition interaction, as seen in Figure 4, $F(4,272)=2.49$, $p<.05$. With the physical causality version, children were able to answer all types of inference questions, logical, constrained, or unconstrained, equally well whenever the questions were asked, i.e., on-line, or at the end of the story. That was not the case with the other causality versions, however. Logical inference questions in the psychological causality version were more easily answered in the on-line question condition, and constrained inference questions in

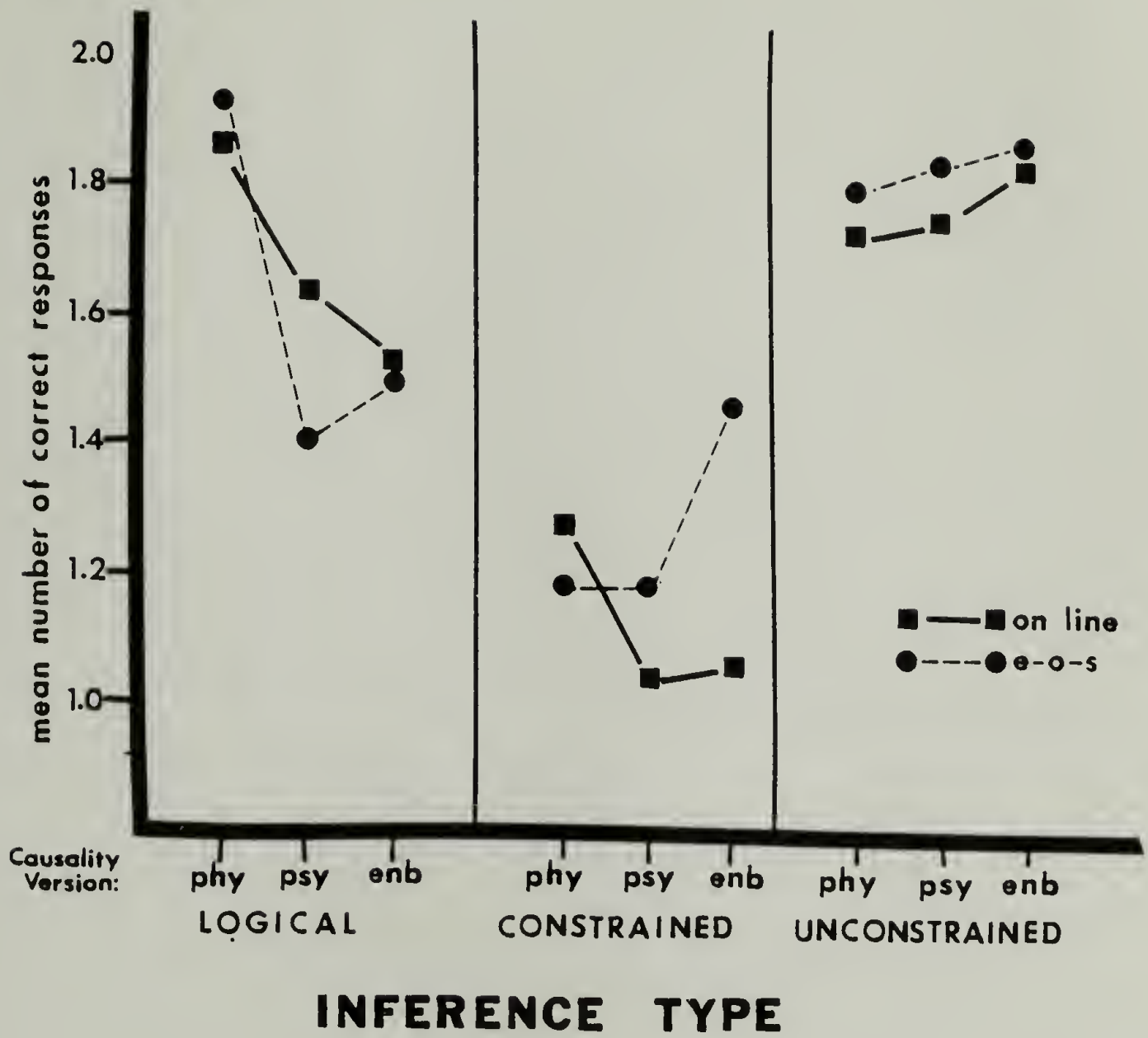


Figure 4. Mean number of correct responses as a function of inference type, causality version, and question-timing condition.

the enablement version were more readily answered in the end-of-story question condition (Bonferroni t 's(71)=2.8, 4.5, p 's<.05).

Time to respond. An analysis of variance was carried out on the time to respond to inference questions answered correctly as a function of age, causality version, question-timing condition, and inference type. Although there was no overall age difference in response times, the average time to respond was affected by inference type. Logical inferences were made more rapidly than constrained or unconstrained inferences (M 's=1.7, 1.9, and 2.2 sec., respectively), $F(2,136)=11.46$, $p<.001$. As may be seen in Figure 5, the response time analysis also revealed an age pattern which was consistent with the question-answering data described above. Four-year olds were equally fast in responding to all types of questions, while 7-year olds showed a clear progression from very fast responding with logical inference questions to significantly slower response times to constrained and unconstrained inference questions (Bonferroni t 's(35)=2.79, 4.73, p 's<.05).

Free recall.

Several dependent measures of free recall were analyzed. These included several indices of idea units (proportion of total idea units provided, proportion of

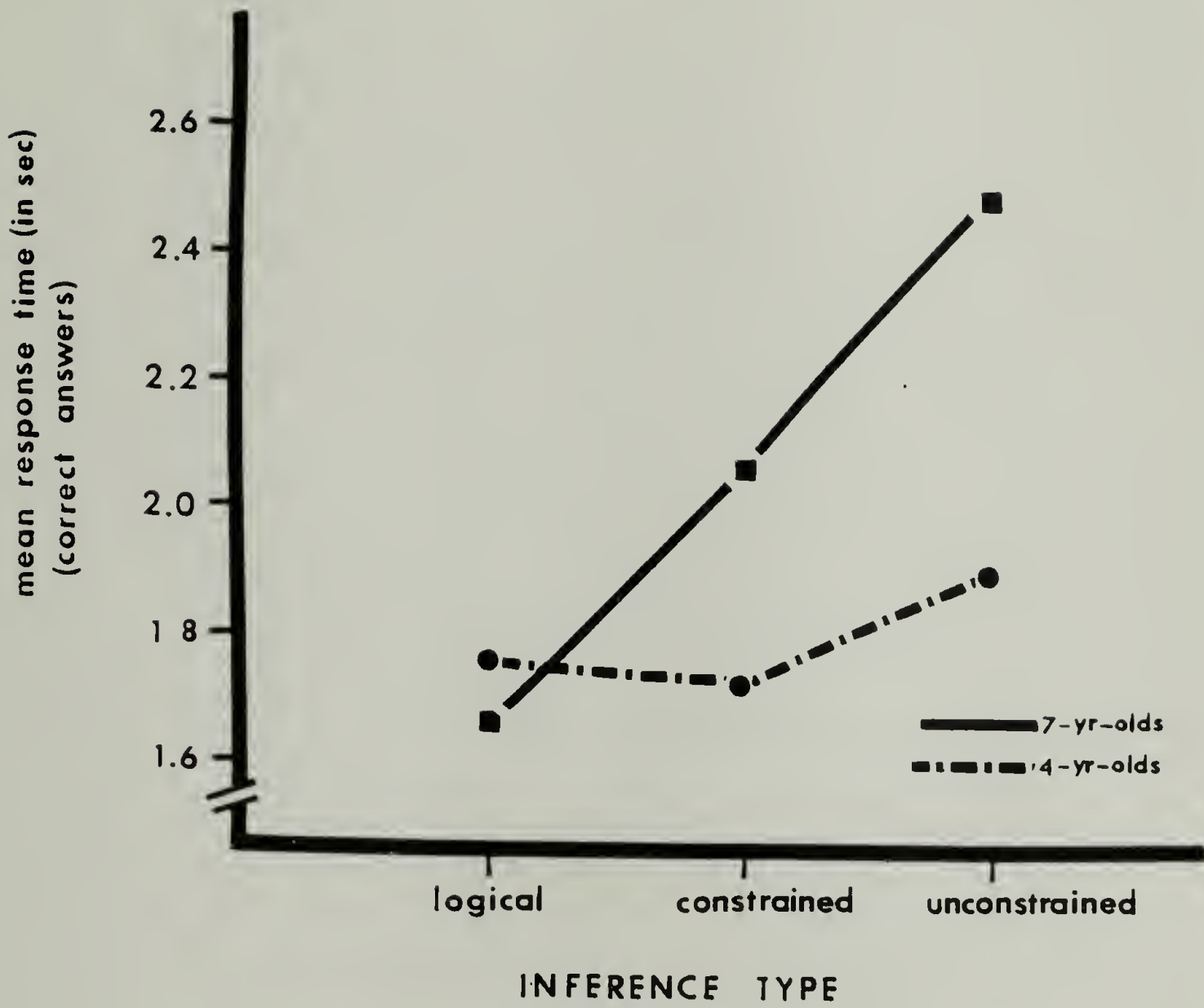


Figure 5. Mean response time (in seconds) as a function of inference type and age.

central idea units provided, ratio of central idea units to total idea units in the protocols), expansions or elaborations, number of words, and comprehension ratings. Preliminary analyses revealed no order, story version, or sex effects of significance. The main analysis for each of these measures was a mixed, 2 (age) x 3 (question-timing condition) x 3 (causality version) analysis of variance, with the last variable a repeated measure.

Idea Units. Analysis of the proportion of total idea units indicated that older children recalled more of the story than did younger children, 59.25% and 28.60%, respectively, and this was the only significant effect ($F(1,102)=165.95, p<.001$). Analysis of central idea units revealed similar results, with 7-year olds recalling 77.52% of the central idea units provided, and 4-year olds recalling 45.23%. This was, again, the only significant effect ($F(1,102)=139.75, p<.001$). Analysis of the ratio of central idea units to total idea units in each child's recall protocols revealed that although younger children do not recall as much as older children do, more of their recall is comprised of ideas central to the story. Thus, the proportion of 4-year olds' recall which was central was 58.68%, while for 7-year olds, this proportion was 46.27% ($F(1,102)=29.65, p<.001$).

Expansions. The number of ideas not expressed in

the original story which were included in recall protocols also varied as a function of age, with 7-year olds including in their recall an average of 2.14 expansions per story, while 4-year olds included an average of 1.49 expansions per story ($F(1,102) = 14.29, p < .001$). Question-timing condition also affected the number of expansions, $F(2,102) = 23.40, p < .001$. The average number of expansions in the two question conditions did not differ, but they averaged ($M = 2.23$) significantly higher than the average number of expansions in the no-question condition ($M = .98$) (Bonferroni $t(107) = 5.95, p < .05$). As may be seen in Figure 6, this timing-of-question effect on expansions was different with different causality versions, however ($F(4,204) = 3.42, p < .01$). Those children questioned at the end of each story averaged 2.02, 2.27, and 2.52 expansions for the physical, psychological, and enablement versions, respectively. Bonferroni t -tests indicated that the number of expansions in recall of the physical causality version was significantly less than for the enablement version ($t(204) = 3.33, p < .05$), while expansions in recall of physical causality and psychological causality versions, or psychological and enablement versions, did not differ significantly. Children in the on-line question condition, i.e., those who were asked inference questions during the story presentation, showed a

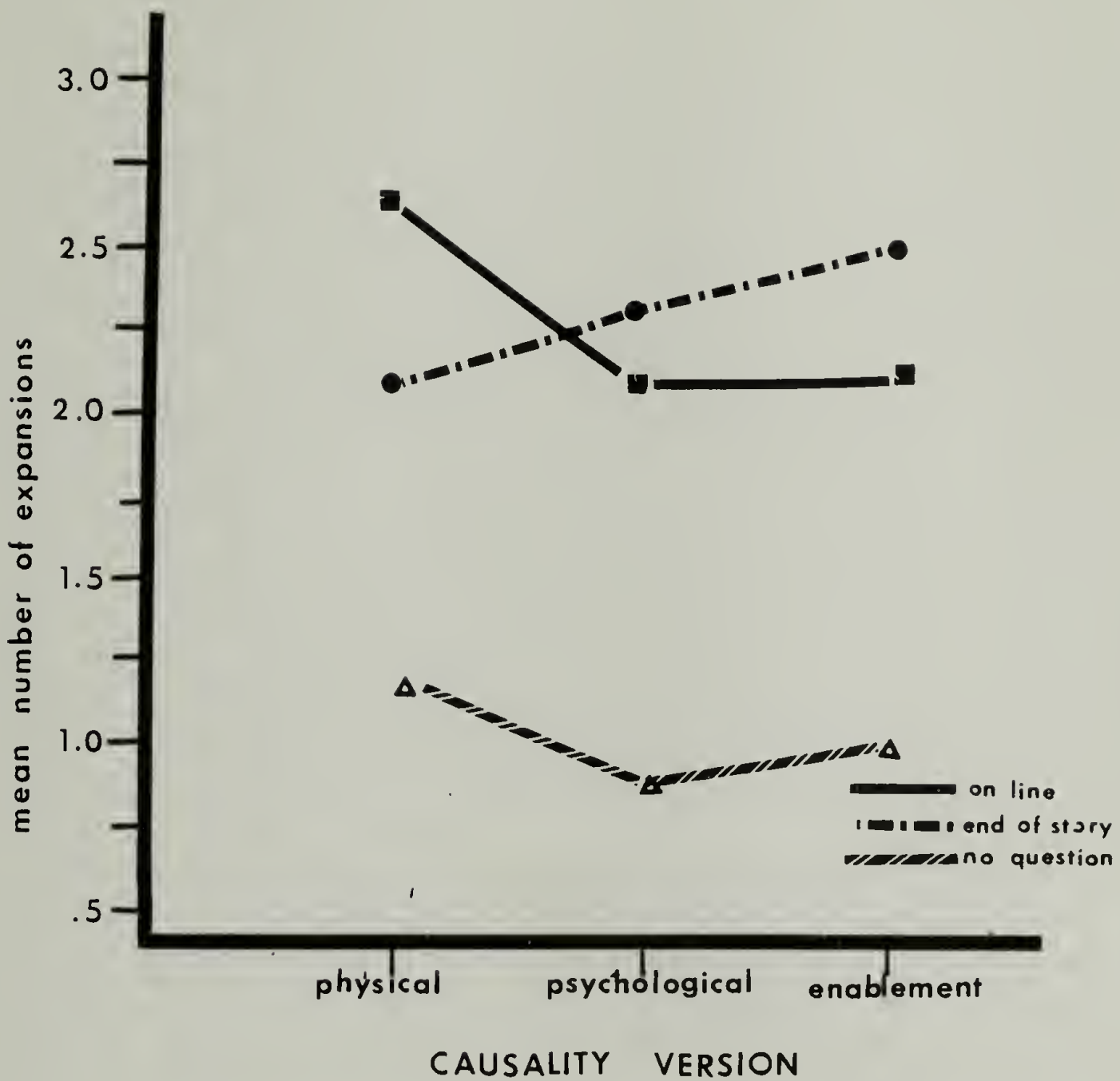


Figure 6. Mean number of expansions as a function of causality version and question-timing condition.

different pattern of expansions. More expansions in recall occurred following the physical causality version ($M=2.66$) than following either the psychological ($M=2.19$), or enablement ($M=2.20$) versions (Bonferroni t 's (204)= 3.13 , $p<.05$).

Number of words. Similar results were obtained in an analysis of the number of words in the recall protocols. Older children's protocols were comprised of more words ($M=60.60$) than younger children's ($M=33.91$), $F(1,102)=119.63$, $p<.001$. Causality version also affected the average number of words in children's recall. The number of words recalled following the physical causality version averaged 49.88, while the number of words following the psychological version was 45.58, and the number of words following the enablement version was 46.33 ($F(2,204)=4.03$, $p<.05$).

Comprehension ratings. It is interesting that a comprehension rating based on a rather global evaluation of recall, proved to be sensitive to a number of manipulations which were not detected by the more constrained analyses on number of words and idea units. These ratings were carried out by three naive raters who were instructed to assign 1 to 5 points to each recall protocol, reflecting degree of story understanding. Interrater reliability was very high (97% agreement with

7-year olds', and 92% with 4-year olds', protocols); and consistent with previous analyses, 7-year olds' protocols received a higher rating ($M=3.49$), than those of 4-year olds ($M=2.08$), $F(1,102)=150.21$, $p<.001$. At both ages, causality version clearly affected comprehension ($F(2,204)=3.03$, $p=.05$). Comprehension of the physical causality version was rated as greater ($M=2.90$) than for either the psychological causality version ($M=2.75$), or the enablement version ($M=2.71$) (Bonferroni t 's(107)=2.24, 2.29, p 's<.05). As may be seen in Figure 7, different effects of question-timing condition were noted for each age level, however ($F(2,102)=5.41$, $p<.05$). Although it was expected that the comprehension of 4-year olds in either of the two question conditions would be enhanced by the questions, and the results were in the predicted direction (average comprehension rating for question conditions, 2.13; average rating for the no-question condition, 1.98), these differences were not significant. Older children, for whom it was believed the question condition was not critical, revealed an interesting pattern of results. Their comprehension was rated highest in the no-question condition ($M=3.74$), and while average comprehension ratings in the end-of-story question condition did not differ significantly from this ($M=3.59$), average ratings for the on-line question condition were significantly

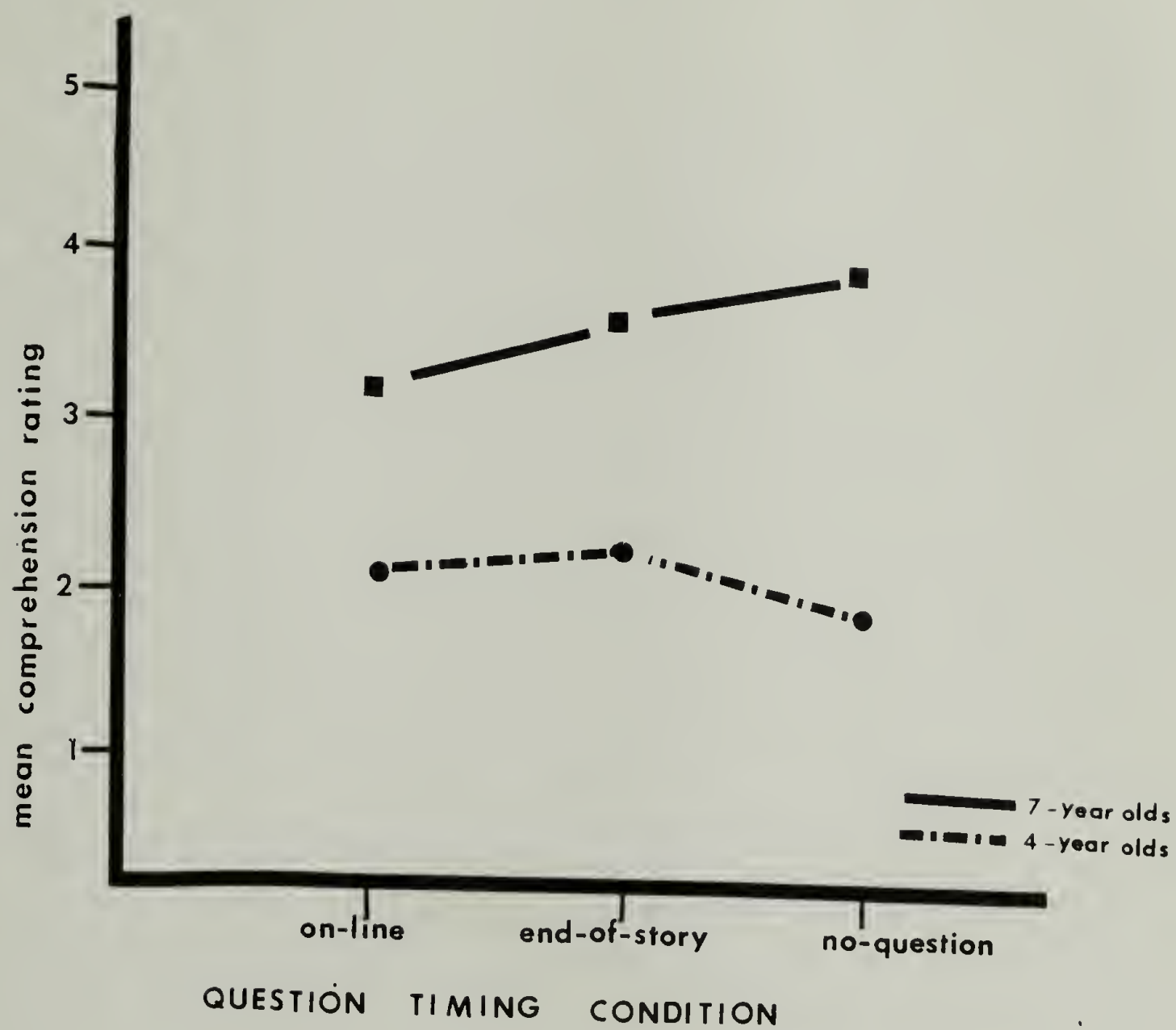


Figure 7. Mean comprehension rating as a function of question-timing condition and age.

lower ($M=3.16$) (Bonferroni t 's(108) = 4.14, 3.07, p 's < .05). It appears that for older children, answering inference questions during the processing of story material is disruptive and leads to impaired recall.

Relations among dependent measures. For a number of theoretical and practical reasons, the relations between a number of the dependent measures described above were examined. The argument put forth by Graesser (1981), and Trabasso and his colleagues (Warren, et al., 1979) that question-answering is a reasonable alternative, or a good addition, to recall measures as a means of studying comprehension processes has not been adequately studied; the correlations between responses to inference questions and various recall measures were seen as addressing that issue. A second concern resulted from the large variety of approaches to assessing recall that have surfaced recently. Examination of correlations between various recall measures themselves, was seen as potentially useful in identifying strengths or weaknesses of measures.

Table 1 shows that the correlations between correct answers to inference questions and recall measures were very high, and quite similar, ranging from $r=+.69$ to $r=+.73$ for the four recall measures. Within this narrow range, it is still of some interest that the greatest degree of relationship was between inference question

Table 1

Correlations between Inference Questions
and Recall Measures

<u>Recall measures</u>	<u>Responses to inference questions</u>		
	<u>full sample</u>	<u>4-year olds</u>	<u>7-year olds</u>
<u>Comprehension rating</u>	+.72*	+.53*	+.26
<u>Total idea units</u>	+.71*	+.51*	+.10
<u>Central idea units</u>	+.73*	+.51*	+.13
<u>Number of words</u>	+.69*	+.38*	+.28

*p<.001

responses and the proportion of recall protocols which represented central idea units. A core of comprehension apparently can be tapped either through questions or derived recall measures of this sort. Inference question responses related only minutely less well with the comprehension ratings, again support for the notion that these indices, although applied at different times, and representing very different levels of measurement, were assessing a common understanding. In general terms, at least, questions about inferences made during text processing are getting at similar comprehension processes to those called upon in recall. Of course, the correlations drop off considerably when age groups are examined separately. This was especially true with the older children, reflecting the very little variability in inferencing ability at this older age, with the particular questions employed.

The second question centers on comparisons between the various recall measures employed in this study. As can be seen in Table 2, for the full sample, these dependent measures are all highly and similarly correlated, ranging from $r=+.85$ to $r=+.93$. Even when the age groups were considered separately, most of these relations remain strong. The most apparent change was with respect to word count. At age 7, the number of words

Table 2

Correlations among Recall Measures
(all significant at $p < .001$)

	<u>Total idea</u> <u>units</u>	+ .93		
<u>Full sample</u>	<u>Central idea</u> <u>units</u>	+ .90	+ .93	
	<u>Number of</u> <u>words</u>	+ .87	+ .90	+ .85
		<u>Comprehen-</u> <u>sion rating</u>	<u>idea</u> <u>units</u>	<u>Central</u> <u>idea units</u>
	<u>Total idea</u> <u>units</u>	+ .89		
<u>4-year olds</u>	<u>Central idea</u> <u>units</u>	+ .84	+ .89	
	<u>Number of</u> <u>words</u>	+ .80	+ .88	+ .79
		<u>Comprehen-</u> <u>sion ratings</u>	<u>idea</u> <u>units</u>	<u>Central</u> <u>idea units</u>
	<u>Total idea</u> <u>units</u>	+ .84		
<u>7-year olds</u>	<u>Central idea</u> <u>units</u>	+ .72	+ .77	
	<u>Number of</u> <u>words</u>	+ .54	+ .64	+ .50
		<u>Comprehen-</u> <u>sion ratings</u>	<u>idea</u> <u>units</u>	<u>Central</u> <u>idea units</u>

in recall clearly did not relate as highly with the other measures, reflecting no doubt the quite complete, quite invariant, size of recall protocols for these stories at this age. It may well be that simple word counts are useful indices of comprehension only for younger children.

Not surprisingly, since both of these measures are based on idea unit scoring, maximum correlation was obtained between total idea units and the proportion of central idea units in recall. More interestingly, no less of a relationship was shown between total idea units and the comprehension ratings, and in this instance, no common metric could be contributing. Several additional factors point to the merits of the comprehension ratings as well. First, it is a technique which can be readily and reliably employed by naive judges with minimal instruction. More importantly, the ratings were as sensitive as any other measure to most variables of interest in this study, and at the same time provided a more detailed picture of age-related question-timing effects. Apparently, the comprehension rating was able to capture some global quality of the protocol which could not be characterized as well by those other measures involving discrete components.

Responses to pictures.

Responses to pictures were scored by three naive raters on a scale from 0 to 2. If the child's response to a picture was completely in error, that response was scored as zero. If the child not only gave the correct answer, but also provided an appropriate rationale, that response was scored as two. A score of one was given if the response was correct but rationale was wrong, or if the response was wrong but the rationale made sense of a wrong answer. The analysis conducted on these scores was a mixed 2 (age) x 3 (question-timing condition) x 3 (causality version) analysis of variance with the last variable a repeated measure. Older children's responses to pictures received an average score of 10.43, and the average score for younger children was 9.27, out of a potential 12 points ($F(1,102)=29.14, p<.001$). Although the pattern of correct responding appeared quite similar at both ages, and the on-line-questioning condition resulted in the best performance at both ages, it was only at age 7 that the questioning conditions resulted in significantly different scores ($F(2,102)=3.25, p<.05$). Four-year olds scores averaged 9.55, 9.14, and 9.12 for the on-line, end-of-story, and no-question conditions, respectively. For 7-year olds, the scores for children in the on-line-question condition averaged 10.61, while the average score for responses of children in the end-of-

story condition was 9.94, and in the no-question condition was 9.85 (Bonferroni t 's(108)=2.57, 2.92, p 's<.05).

Nine of the presented pictures (3 from each story) depicted non-story events, and as expected, 7-year olds were easily able, and 4-year olds less likely to reject, these pictures (M 's=8.50 and 6.81, respectively), t (106)=8.50, p <.001. Although it was expected that children at both ages would be equally likely to judge as appropriate the six pictures (two from each story) which depict story events, 7-year olds proved to be better at this task as well (M 's=5.31 and 4.90, respectively), t (106)=2.19, p <.05.

Two separate analyses, on "correctness" score, and time to respond to picture, were carried out with respect to the one picture for each story depicting one of the required logical inferences. No overall age differences in either correct responding or in response latency were obtained. At both ages, responses to the logical inference picture for the physical causality version were scored as significantly more correct (1.80), than for either the psychological causality version (1.57) or the enablement version (1.56) (F (2,204)=4.69, p <.01). Response times to these logical inference pictures were also significantly shorter for the physical causality

version (1.6 sec) than for either the psychological causality version (2.2 sec) or the enablement version (2.3 sec) ($F(2,80)=6.31, p<.01$).

These responses to pictures were not totally in accord with the results obtained in the analysis of inference questions or recall. The average score for all pictures was unaffected by causality version; moreover, the response to the one logical inference picture was significantly and equivalently better with the physical causality version at both ages. It was expected that older children's inferences of possible causal factors would lead them to include these pictures with the other causality versions as well. Secondly, the timing of inference questions affected picture responding for both age groups in a similar fashion, i.e., best performance was in the on-line question condition. This stands in contrast to the debilitating effects of on-line questions at age 7 previously reported. The third instance of results which seem somewhat at odds is the rather equivocal pattern of responses to story and non-story pictures. The fact that 7-year olds were able to reject pictures depicting non-story events more readily than 4-year olds is consonant with the inference question performance where 7-year olds made less unconstrained, and more constrained inferences. Seven-year olds were also

better than 4-year olds at judging whether story depicting pictures went with the story, however, and this finding did not fit the previous pattern of 4-year olds' relatively good responding when given strong story support.

It is difficult to worry too seriously about the inconsistencies noted above between picture responses, and recall and inferences, however, as there were several inadequacies of the picture task. It was obvious that there was considerable misinterpretation of the pictures' meaning; the development of ratings considering the rationale of answers about the relevance of the pictures provided a partial correction, but even so, the pictures were clearly more ambiguous than was anticipated. The picture queries themselves were not always communicated unambiguously to the children either; it seemed at times as though they interpreted the questions much more generally, and were reacting not so much to particulars of the content, as to other, more summary features such as temporal sequencing or main character depiction. Finally, the picture probes followed presentation and recall of all three stories, and the delays and intervening material may well have confused the children.

Premise and vocabulary measures. Responses to

questions about premise information as well as vocabulary requirements of the stories were examined. Seven-year olds were able to correctly answer premise information questions 97% of the time and 4-year olds were correct 92% of the time. This high level of correct responding was indicative of the children's active involvement in the listening task, and provided evidence of their abilities to remember the basic story material. The short vocabulary test administered to all 4-year olds was aimed at ascertaining whether the term "excitement" was familiar to them. More than 85% of the children correctly identified the picture chosen rather arbitrarily to represent the term, evidence that the concept was understood at this age level, even with virtually no contextual support.

C H A P T E R IV

DISCUSSION

This study sheds considerable light on several important developmental features of story comprehension and recall. Recently, models of text comprehension have emphasized the concept of schema driven expectancies which guide understanding; and questions have arisen concerning when, and from where, these expectancies are generated. A central idea of this paper is that text can only become meaningful when relations between events become clear, and while this is not a new idea (e.g., Nicholas & Trabasso, 1981; Schank & Abelson, 1977), it remains an important directive in the quest for process factors involved in story-related schema models. The recent work of Trabasso and his co-workers concerning inference taxonomies emphasizes functional relationships between events in text, and clearly views the individual as actively developing a representation of text by using knowledge about available connections between events. The evidence provided in this paper takes this notion one step further and points to the differential development in ability to generate specific types of relations between narrative events.

Differential reliance on the strength of the

causal chain at 4- and 7-years points to one important developmental change. Four-year olds, when provided physical causality information, can utilize their knowledge to aid comprehension of stories; with weaker causality versions, they clearly did not understand as well as older children. A parallel can be seen in younger children's need for additional story material for comprehension, at least when presented with the weakest versions of the causality chain, while older children did not benefit from added story material. A third characterization of story comprehension development concerns the different patterns of use of logical, unconstrained, and constrained inferences. Each of these three points will next be examined in more detail.

Strength of the causality chain. The responses of 4-year olds to inference questions indicates that their comprehension ability is related to the type of causality information which they encounter in stories. They were able to utilize information for question answering most readily after hearing the physical causality version, and since this causality version represents the strongest example of a causal chain included in this study, it is important to note that younger children are able to use this physical causality information at least, to connect up story events. Their performance was less good,

however, after hearing the enablement and psychological causality versions. Of course, it was important to ascertain whether this inability was simply a reflection of younger children's lack of understanding of the concept employed in the psychological causality version, and the vocabulary test effectively ruled out this possibility. Apparently then, it was the rather complex application of causal knowledge required that baffled the children here. Older children, in contrast, were able to utilize the causal chain, and incorporate information relevant to inference-making regardless of which causality version they heard.

Further support for the notion that the strength of the causality chain affects comprehension was evident with respect to children's abilities to answer specific types of inference questions given varying amounts of story information. When children heard the physical causality version, all types of inference questions were answered equally well, regardless of when questions were asked. This indicates that their story representations were very complete; apparently, the children had minimal difficulty incorporating this physical causality information and related interpretations of story events. With the other causality versions, this was not the case. For example,

in the enablement version, which represented the weakest causality version, constrained inference questions were more readily answered in the end-of-story question condition. Constrained inference-making requires a story representation which is well developed to allow for meaningful extractions of specific events and their relations. It is interesting that in this weakest causality version, children needed the added story information provided in the full story, in order to make the appropriate inferences to answer questions. Together, these findings suggest that not only are individual causal events responded to differentially--but they carry with them a set of expectations and specific possibilities for interpretation of story meaning which enhance the story representation.

The facilitating effect of a strong causality chain on text processing was also evident in recall analyses. At both ages, children's recall was lengthier and was rated as showing a higher level of comprehension when they experienced the physical causality version than with either the psychological or the enablement versions. A related finding was that with the enablement version there were more elaborations during recall when children were questioned about story events after hearing the entire story. Since this version represented the weakest

causality version presented, it also suggests that the representation called upon in recall is not as tightly constrained when the event-chain is relatively weak; and children are likely to call upon information from direct questioning to fill out their story accounts. The story representation developed by children when listening to the physical causality version during the on-line questioning of story events led to more elaborations in recall, indicating that with this strong causality version, a more tightly constrained representation could be developed as the story unfolded. Children at both ages were also better able to correctly respond to the pictures which illustrated the logical inferences after listening to the physical causality version, and their response times were also more rapid.

The pattern of results which emerged with respect to this causality version manipulation indicate support for the event-chain formulation; clearly, text-based phenomena and children's ability to utilize information provided are critical here. It is important to note that all causality versions presented in this study shared the same basic structure or grammar and would have been treated as essentially the same story from a more general story schema description. A model simply stressing the

application of a preconceived higher-order structure which shapes the processing of a passage would not suffice as an explanation for the differential comprehension effects obtained here. The lack of any order effects upon inferencing or recall also suggests limitations to story schema explanations.

Amount of story material available. Seven-year olds' ability to answer inference questions was unaffected by the timing of the questions, regardless of causality version. This finding is consonant with that of Graesser and his co-workers (Graesser, 1981; Graesser, et al., 1980), and was expected insofar as 7-year olds were dealing with the story materials included in this study in a fashion similar to that seen in adult comprehension. Younger children, however, when listening to the enablement version, which provides the least causal information, were better able to answer inference questions when given more story information, i.e., in the end-of-story question condition. It was expected that a facilitating effect of increased story information would be apparent for the younger children in all causality versions. The finding that this was an accurate description of 4-year olds' inferencing abilities only when provided the least causality information, however, is certainly consistent with the expectation that inferences

related to story development would be enhanced when the child had more information available. As detailed above, the children apparently did not need this added information given stronger causality chains.

Recall analyses indicated that the timing of questions about story events influenced the manner in which text-connecting inferences were employed. At both ages the number of elaborations made during recall was greater in the conditions where questions were asked than in the no-question condition. For 7-year olds, comprehension was rated highest in the no-question condition, significantly higher than in the on-line question condition. Four-year olds' recall protocols were rated slightly higher in comprehension in the question conditions and lowest in the no-question condition, almost the reverse of the 7-year old data. Questions apparently cause disruption of the processing of story materials only for the older children. Perhaps the inference questions simply do not correspond well with those the children are most likely to be generating at this age level. If they have developed an independent strategy for incorporating information relevant to the story, and if these "private" questions, so to speak, are not the same as those being asked by the experimenter, it

is perhaps not surprising that the standard inference questions were a hindrance. In any event, it is clear that interruptions of the story impair the older children's processing of that story material for later recall--while the same interruptions for story-related questions if anything, enhance the processing of story material for younger children.

Role of specific inference types. Children at both ages were quite willing to provide answers to unconstrained inference questions, indicating no lack of willingness to embellish the story line, even at the youngest ages. Older children were significantly slower in responding to these unconstrained inferences, however; indicating that by the age of seven, children tend to restrict their range of inferences, so that information not strongly dictated by the story is increasingly difficult to integrate.

Logical inferences represent basic causal connections between story events, and while 7-year olds were better able to answer these questions than 4-year olds, the performance of 4-year olds indicated that these types of inferences were well within reach. Since comprehension in a wide range of tasks has been linked to simple cause and effect relations, it is perhaps not surprising that the younger children should be able to utilize this knowledge and provide these inference

bridges. Even with logical inferences, however, there was some improvement by age 7, reflecting the older children's ability to incorporate relevant story information regardless of which causality version they heard.

The ability of children to answer constrained inference questions provides further delineation of the nature of story comprehension. Roland Barthes (1977) has suggested that, "to understand a narrative is not merely to follow the unfolding of the story, it is also to ... project...the narrative 'thread'...to listen to a narrative is not merely to move from one word to the next, it is also to move from one level to the next". Constrained inferences embellish the narrative 'thread', and enable the listener to find consistent ties, not only within the story, but to aspects of their knowledge outside the story as well. The contrast in ability to apply knowledge pertinent to the story materials at the two ages is striking. The relative inability of younger children to correctly answer constrained inferences may be indicative of several inadequacies. It is possible that 4-year olds simply did not remember the story; however their almost perfect recall of premise information belies this interpretation. More likely, 4-year olds may simply fail to apply information that is available to them. It

may be that they just do not have sufficient world knowledge to use to connect up story events. Seven-year olds were able to employ this type of construction, although their performance was clearly not at the level for logical inferences. Obviously, the development of constrained inferencing abilities follows a longer time course than was examined in this study.

Response times to inference questions are supportive of this general analysis. Children at both ages responded very and equally rapidly to the logical inference questions, which represent basic causal connections. It is not surprising that this is the case, as little effort should be necessary to integrate such important inferences into the story line. Four-year olds responded at about the same speed to all types of inference questions. Since it has been shown that their ability to answer constrained inference questions is much less than that of older children, it is unlikely that their rapid response times for these questions are a reflection of ease in making these inferences; rather, it seems to be more indicative of a general willingness to embellish the story in ways not clearly determined by the text. Seven-year olds show a clear progression from the rapid response time to logical inference questions to a much slower response time with constrained inference questions, and still slower

response times to unconstrained inference questions. This response time pattern is ordered in a fashion reflecting the inference taxonomy and the "relevancy hypothesis" suggested by Trabasso and his colleagues (Warren, et al., 1979). Both of these notions point out that those inferences which are most important to the developing story line are most likely to be made. As the inferencing requirements move further from elements dictated by the story, or from self-imposed inferencing strategies, information is increasingly difficult to integrate.

The present study has pointed to a number of specific components of story materials and emphasized their importance to the comprehension process. A great deal of the data presented here argue for the necessity of employing some concept such as coherence (Trabasso, Secco, & van der Broek, 1983) for understanding the role of text material in providing the reader (listener) a clear text representation. Trabasso, and Omanson, among others, have argued that the attempt to understand an event is an attempt to discover the causes of the event and the events that result from it. This process leads to an experience of a sequence of events which allows for the development of a cohesive representation. Trabasso suggests that networks of causal fields are likely to be established and

allow for the development of context, and to serve as the basis for developing story events. The description of causality connections within story development which Trabasso provides is a logical outgrowth of his earlier emphasis on the event chain model, and his attempt to describe the role of inferences in story comprehension.

Importantly, at this point, Trabasso has also attempted to reconcile this approach with the more global description provided by story grammars. Story grammars have, as has been discussed earlier, led to some fairly robust findings with respect to order and likelihood of recall. Trabasso has attempted to illustrate the findings of story grammar analyses by examining the relative amount of causal connections which are included in each of the categorical divisions suggested in the story grammar analyses. In general, he finds a great deal of overlap in the grammatical and the causality characterizations, but argues that process factors will emerge only when a causal analysis is examined. The emphasis of the story grammar approach has never really been on causal connections between events, however, and whenever any allusion to causal chains has been made, a linear unfolding of events has been stressed. A major message from both Trabasso's work and the present study is that the story grammar approach is limited in ability to analyze processing

factors in story comprehension.

A further perspective is provided by Barthes (1977) who reminds us of the active, continual, quality of the search for understanding, suggesting that "meaning ... is not at the end of the narrative, it runs across it". Through an experimental test of some elements of the inference taxonomy, and consideration of issues related to the event chain model and the use of inference questions, the present study has clarified some components of the development of those processes enabling extraction of information, and connection of separate events in stories. A number of findings make it obvious that some meaning is less difficult to cull from a story and to apply to later story events. Thus, inferences are clearly easier when strongly driven by logical causality, and even very young children draw inferences of this type to bridge the gaps between story events. Selective production of other inferences, limited to those mandated by the story constraints, is a much later developing ability, however, far from complete at the age of the older children included in this study. Inferences that are superfluous or irrelevant are no longer as readily elicited, however, indicating partial refinement of this skill.

All attempts to study story comprehension, including

the story grammars, the scriptal based conceptualizations, and those based on causal connections, start with the assumption that story events are interconnected in some fashion. This study makes it apparent that the nature of these interconnections may be very complex, and very different in character at different stages of development.

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APPENDIX A
Stories

Warm-up story 1

George was a monkey in the zoo.
One day, when the keeper was not looking,
George took the key for his cage
and ran away.

Questions:

1. What kind of an animal was George?
2. Where did George live?
3. Why did George take the key?
4. Was the zoo keeper a man or a woman?

Warm-up story 2

Policeman Small is a traffic cop
who tells the cars when to stop and go. (Q-1)
One day, a farm truck went by
and a milk can fell out the back onto the road. (Q-2)
They put the can back on the truck. (Q-3)
When they turned around,
they saw two kittens licking the road. (Q-4)

Questions:

1. What does Policeman Small do?
2. What color do you think the truck is?
3. Who do you think put the can back?
4. Why were the kittens licking the road?

Jennifer

One day Jennifer's parents gave her a dollar because she wanted to buy a turtle. (Q-1)

But as she was walking to the petstore she turned a somersault and lost it. (Q-2) (physical causality version)

she became very excited and lost it. (Q-2) (psychological causality version)

she lost it (Q-2) (enablement version)

Jennifer was worried that her parents would be angry with her,

so she decided to search every bit of the sidewalk. (Q-3)

For ten long minutes she looked in all the cracks and grass. (Q-4)

Finally she found the dollar. (Q-5)

When she got to the store she was told that the last turtle had been sold just one minute ago. (Q-6)

Questions for "Jennifer"

Logical

Constrained

Unconstrained

(Q-2) What made Jennifer lose her dollar?

(Q-1) How old do you think Jennifer is?

(Q-4) What color hair do you think Jennifer has?

(Q-3) Why would Jennifer's parents be angry with her?

(Q-5) Do you think Jennifer has a dollar bill or a dollar in change?

(Q-6) Was the person in the petstore a man or a woman?

Premise Questions:

1. What did Jennifer want to buy?
2. Who gave Jennifer the dollar?

Tom

One day Tom decided to play with his brother's new kite. (Q-1)

Soon the kite was flying high in the sky,
but after just a few minutes

he dropped the string and it disappeared.

(Q-2) (physical causality version)

he became very excited and it disappeared.

(Q-2) (psychological causality version)

it disappeared. (Q-2) (enablement version)

Tom knew that the kite was his brother's favorite toy,
so he decided to buy another just like it. (Q-3)

He looked in many stores. (Q-4)

After awhile, he found a new kite. (Q-5)

When he got home, Tom found that his brother had also been
to a store,

and had bought Tom his very own kite. (Q-6)

Questions for "Tom"LogicalConstrainedUnconstrained

(Q-2) What made
the kite dis-
appear?

(Q-1) What time
of year did
do you think
this story
happened?

(Q-4) Was Tom a
tall boy or was
he short?

(Q-3) How did
Tom know that
the kite was
his brother's
favorite?

(Q-5) Do you
think the new
kite was the
same as the
old kite or
were they different?

(Q-6) What do
think Tom's
brother's name
was?

Premise questions:

1. Whose kite did Tom play with?
2. Did the kite fly high?

Carol

One day Carol's friend asked her if she wanted to learn how to ice skate. (Q-1)

But as she was walking to the pond

she started to run down the hill and twisted her ankle. (Q-2) (physical causality version)

she became very excited and twisted her ankle. (Q-2) (psychological causality version)

she twisted her ankle. (Q-2) (enablement version)

Carol was upset that she would have to miss the ice-skating,

and decided to get home as soon as she could. (Q-3)

Slowly she limped along the path. (Q-4)

At last she was safely home. (Q-5)

Later that day all of her friends came over

and had cookies and hot chocolate while they sang songs. (Q-6)

Questions for "Carol"LogicalConstrainedUnconstrained

(Q-2) What made Carol twist her ankle?

(Q-1) Does Carol have ice skates?

(Q-4) Did Carol have blue eyes or did she have brown eyes?

(Q-3) Why did Carol decide to go home?

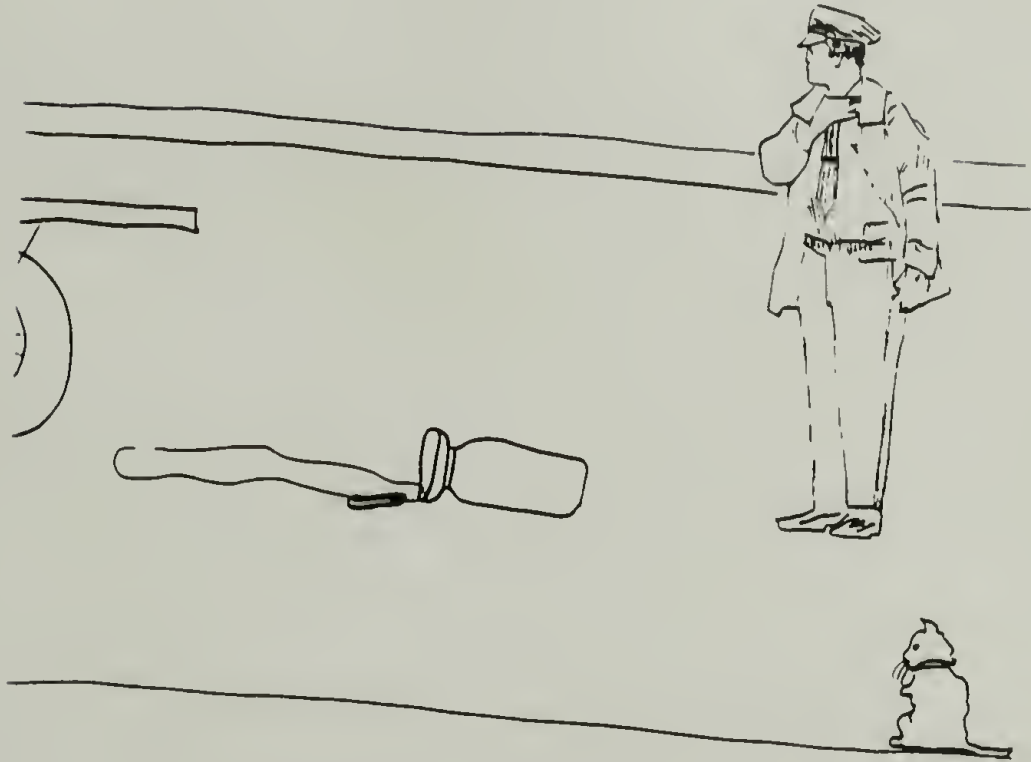
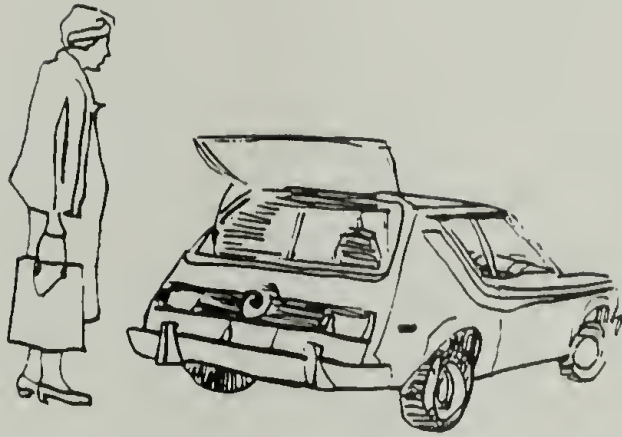
(Q-5) Do you think Carol lives in the city or in the country?

(Q-6) What kind of cookies do you think Carol ate?

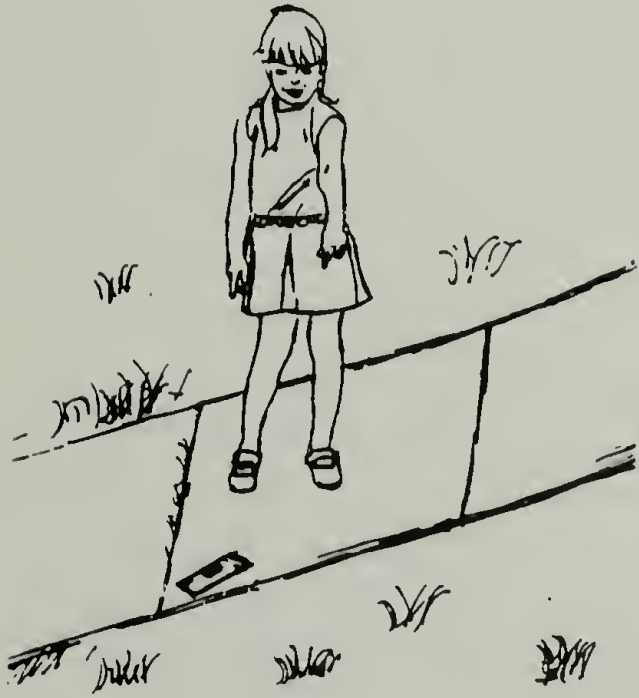
Premise Questions:

1. What did Carol's friend ask her?
2. Where was Carol going?

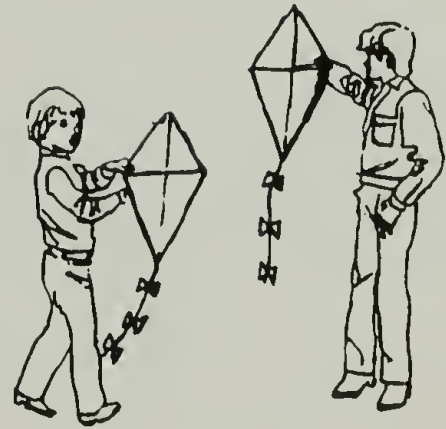
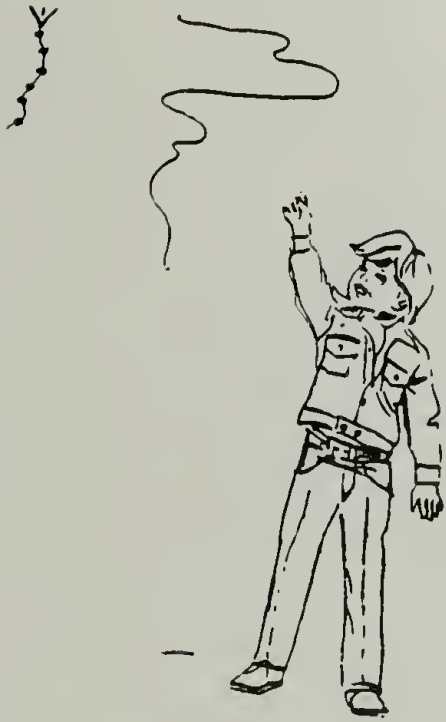
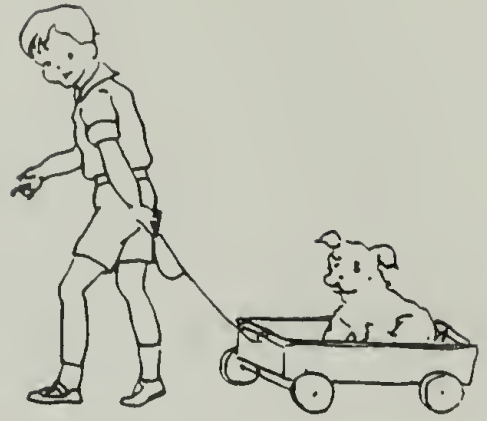
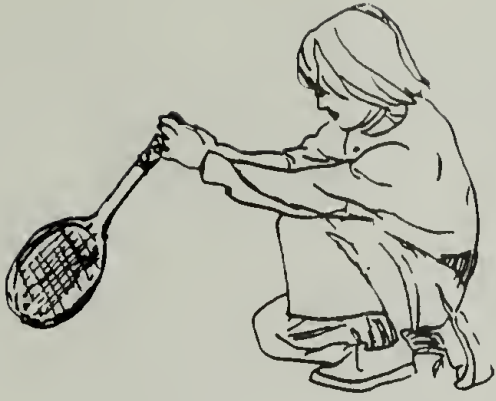
APPENDIX B
Picture and Vocabulary Stimuli



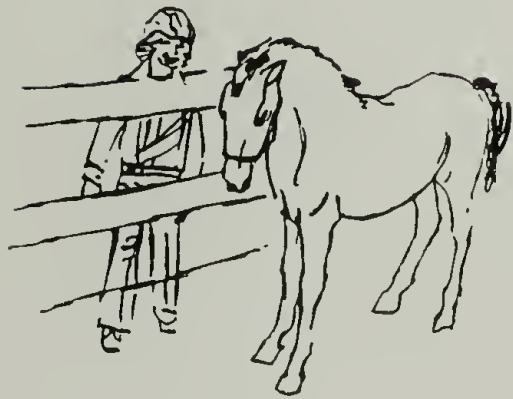
Pictures for warm-up story 2



Pictures for "Jennifer"



Pictures for "Tom"



Pictures for "Carol"

