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# THE EFFECT OF EVENT STRUCTURE ON YOUNG CHILDREN'S ABILITY TO LEARN AN UNFAMILIAR EVENT

by

Elizabeth A. Slackman

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

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Abstract

THE EFFECT OF EVENT STRUCTURE ON
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by

Elizabeth A. Slackman

Advisor: Katherine Nelson

When they are asked to report "what happens" about events that are familiar to them, young children demonstrate the ability to produce consistent and well-sequenced accounts not only for events that are logically related in terms of an overall goal, such as the steps in making cookies, but also for events that have an invariant but temporal sequence, such as singing "Happy Birthday" before blowing out the candles on a birthday cake (Nelson & Gruendel, 1981). This may mean that children do not distinguish between invariant sequences that are causally connected and sequences that are invariant for reasons of social convention. An alternative possibility is that causal structure is no more important than other factors such as age, event familiarity, or degree of participation in the event (Nelson, 1979(a)).

To address this issue, 41 preschoolers (mean age 4,6) and 43 first graders (mean age 6,6) were given practice trials over a 3-day period in either a causally or temporally sequenced version of the same

unfamiliar event, "what happens in the day of a toymaker". The event was presented to children as a story and was also modelled by the experimenter using toys and props. Some children enacted and verbalized the event immediately after the experimenter's demonstration each day (active condition), while others simply related it verbally (passive condition). After the third practice session, children were asked to recall the event immediately after it was related verbally to them.

Children who acted out the event recalled more overall than children who did not, and were also more likely to recall cause and effect as a unit (cause immediately followed by its effect). However, they did not recall the causal event better than the temporal event. On the other hand, children of both ages remembered actions that had a greater degree of causal entailment between them better than actions that were less causally related. In addition, they sequenced the causal event more accurately than the temporal event, especially preschoolers.

These results indicate that children between the ages of 4 and 6 clearly differentiate between causality and invariance but that causal structure is not the only influence on event representation. Active participation and degree of causal relatedness influence how much children remember about an event while causal structure is more important in representing event order.

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# Introduction

Certain real world events that children experience are more causally organized than others in that the order in which the event occurs is a reflection of the causal or enabling relations between actions in the event. For example, in making cookies, the preparation of cookie batter enables the cookies to be placed in the oven and turning on the oven causes them to bake. In this type of event, the overall goal determines the event structure.

Other real world events have a temporal but invariant sequence such as singing Happy Birthday before blowing out the candles on a birthday cake. While the Birthday Party event may have an overall goal such as "having fun," the order of occurrence of the event is not in a unidirectional and linear relation to the goal in the same way that the steps in making cookies are.

When they are asked to report what happens about events that are familiar to them, children demonstrate an ability to produce consistent and well-sequenced accounts for both of these types of events. This may mean that children do not distinguish between invariant sequences that are logically organized around a goal and those that are invariant for reasons of social convention. An alternative possibility is that while event structure does influence event representation, it is no more important than other factors such as age, event familiarity, or degree of participation in the event.

The present research was specifically designed to address the question of whether such event structure influences event representation in young children. In addition, because the cognitive representation of an event is not simply a reflection of the external event but is mediated by the amount and nature of the child's experience with the event, the research was designed to minimize the effects of prior experience by presenting children with an unfamiliar event.

The research was based on the assumptions of the schematic processing model and thus had as its basic premise that the ability to perceive causal structure derives from the fact that the relation between actions in an event is framed by some schema, or script, and that the formation of an event schema is facilitated when an event is meaningfully organized by the existence of causal or enabling connections between component actions. Thus, the extent to which children's performance was enhanced by the presence of causal or enabling connections between actions was expected to reveal their perception of causality.

What follows is a discussion of the structural and processing characteristics of schemas and a review of the evidence demonstrating schematic representation in children and adults, particularly as it relates to causal perception. Following this review, the present research is discussed.

Children's perception of causality in the context of schemas. A schema is defined as a spatially and/or temporally organized set of expectations about what things look like or the order in which they will occur (Mandler, 1979). These expectations are in the form of variables or slots which can be filled in a given situation by values that have greater or lesser probability associated with them. Since the variables form an organized whole, what fills any one slot constrains what can fill the remaining slots.

Schemas may be formed for anything that has been experienced often enough to be familiar, including objects, pictures, scenes, and events. A commonly cited example of an event schema is the set of expectations people have about what happens when you go to a restaurant (Schank, 1977). The restaurant schema includes information about required variables such as types of actors (e.g., customers, waiter), actions (e.g., ordering, eating, paying), and props (menus, tables). It also includes information about probable slot fillers for each of these variables. That is, if you go to McDonald's, a hamburger is a potential slot filler for what may be ordered, whereas a filet mignon is not. Finally, the schema specifies the order of occurrence, such as that you have to order your meal before you can eat it.

These organizational properties of schemas imply various processing characteristics. The selection of a schema to fit a particular situation as well as the activation of the schema has been described as a top-down or conceptually-driven process, in which input material is structured and given meaning in accordance with preexisting expectations. Whenever input material contains insufficient information about which value of a particular variable is appropriate, knowledge one has about the range of probable values for a given situation as well as slot fillers assigned to other variables enables default values to be generated.

Comprehension of conversation, narratives, and interpretation of the actions of others depends on inferences based on such preexisting schemas. Schank & Abelson (1977) give an illustrative example of how the restaurant schema would fill in the gaps in a simple story. If we read that after seating himself at a table in a restaurant, a story character suddenly realizes that he has forgotten his reading glasses, our restaurant schema enables us to infer the significance of the reading glasses in relation to reading the menu even though the menu has not been explicitly mentioned.

Schemas are held to be automatically activated in familiar situations and guide processing in a characteristically economic fashion. Instead of attending to all elements of a familiar situation, a schema rapidly selects and encodes the gist or overall sense of the situation. It also provides automatic start and stop points for memory search and thus provides an implicit mechanism by which "natural" or "incidental" memory occurs. Such automatic encoding may lead to distortions, to the extent that we process what should be there rather than what is there. Finally, although the conceptually driven aspect of schemas is assumed, it is also true that bottom-up or data-driven processing may occur in schematic processing, to the extent that a schema is highly general, variable, or newly acquired.

Evidence for the existence of schematic representation derives from research demonstrating constructive comprehension and memory. Constructive processing is a means of cognitive assimilation which involves the addition of information to incoming material in accordance with a pre-existing frame of expectations. Bartlett's (1932) early work on story recall in adults showed the importance of constructive processing by demonstrating that adults' memory for stories was not characterized by accurate recall, but rather by reconstructions of information in which elaborations, omissions, and other transformations typically occurred. This research demonstrated that comprehension and memory involve dynamic processes in which the surface structure of information is transformed in accordance with prior knowledge rather than being stored and retrieved as an exact copy.

Subsequent research has further revealed the influence of constructive processing on comprehension and memory. Semantic integration is one type of constructive processing that has been observed in both adults (e.g, Bransford, Barclay, & Franks, 1972) and children (see Paris, 1978 for a review). Evidence for semantic integration comes from performance on recognition tasks in which subjects typically confuse original items seen in the context of sentences or paragraphs with items which are semantically consistent with the previously seen items. This suggests that the overall meaning of sentences is semantically integrated into a wholistic representation in which syntactic information is forgotten.

Semantic integration has also been found in children as young as preschool age in studies of pictorial narrative sequences (Brown, 1975; Brown & French, 1976). In this research, children have been found to falsely recognize pictures that were consistent with what they had seen before, but were actually different from the pictures they had actually seen. This is because what is stored is the meaning of the temporal sequence as a whole, rather than each discrete picture within the sequence.

Further, semantic integration has been found to be enhanced when events are meaningfully or logically related. For example, Brown (1975) found that 5 to 7-year-olds had difficulty remembering a series of pictures which were temporally and causally unrelated; however, when they were organized into a narrative, children improved in the amount recalled and in accuracy of temporal sequencing. Similarly, Brown & Murphy (1975) found that 4-year-olds could remember event order when it tapped their semantic memory and was essential to the meaning of a story sequence. This provides further evidence for the existence of an underlying schema that organizes incoming information in accordance with pre-existing notions of meaningfulness.

Other evidence for constructive processing comes from research on the ability to draw various types of inferences. Two basic classes of inferences have been idenified. <u>Propositional inferences</u> are based on formally specified rules such as transitivity or class inclusion and are independent of content and context. <u>Invited inferences</u> are content- and context-based and rely on an individual's prior knowledge in the interpretation of incoming information.

In general, children have been found to improve with age on both types of inferences. However, while children as young as 5 years of age may perform as well as 8 to 11-year-olds in drawing invited inferences, older children perform better than younger children in drawing propositional inferences (Hildyard, 1979; Hildyard & Olson, 1978). Propositional inferences appear to be inherently more difficult because they require that children deploy logical deductive skills that go beyond the application of prior knowledge to incoming information. Thus, apparently what develops is the ability to extend inferential operations to events which are not readily assimilable on the basis of pre-existing schematic structures.

Among invited inferences, it has been found that children as young as 7 years of age are able to derive inferences about implied causal information, such as instruments of action, consequences, and presuppositions (see Paris, 1978 for a review). However, even among invited inferences, younger children may fail to spontaneously draw inferences when appropriate. For example, one study found that when children from age 7 to 11 heard sentences in which information was implied or stated explicitly, children of both ages were able to use explicit cues for later memory retrieval, but only the older children were able to use implicit cues (Paris & Lindauer, 1976). However, such age differences disappeared when children were asked to act out the sentences as they were presented, or to make up stories about them (Paris & Lindauer, 1976; Paris, Lindauer, & Cox, 1977). Thus, younger children are apparently capable of drawing inferences as well as older children but may fail to do so spontaneously.

Finally, in a recent investigation, another type of inference referred to as "script-based" has been identified (Slackman & Hudson, 1984). Script-based inferences are those that are made on the basis of organized event knowledge in the form of event schemas. Similar to invited inferences, script-based inferences require the application of prior knowledge based on the context and content of incoming material. However, in script-based inferences, the actions of the particular event referred to and the relations between those actions are already represented. Because such organized knowledge is held to be automatically activated in familiar situations, script-based inferences should be easier for even preschool children to draw. This was found to be the case: Preschoolers were able to perform as well as first-graders on script-based inferences but less well on invited inferences.

It appears then that children as well as adults are capable of constructive processing in the comprehension of meaningful input. Further, the findings indicate that schemas are powerful vehicles for the perception of causality. Pre-existing schemas enable the integration of logically, temporally, and causally organized relationships and the consequent ability to infer antecedents and consequents of action within the mental representation of an event. They similarly enable the inference of implied causal information. To the extent that input material is made meaningful by means of explicit logical relationships between events, it is more readily assimilated to schemas, thus enabling the perception of causality.

The perception of causality has similarly been investigated in another line of research which includes more detailed descriptions of the structural and processing characteristics of specific structures such as story schemas and event schemas. In this research, the importance of the overall structure has been demonstrated as an important source of causal inference.

Story schemas. Building on Bartlett's (1932) work demonstrating the importance of schematic processing in story understanding, researchers have subsequently attempted to define in greater detail what the structural characteristics of the prototypical story are as well as the relationship between the external structure or grammar, and its cognitive analogue. Several story grammars have been written in an attempt to capture the essential structural characteristics of stories (Black & Bower, 1980; Johnson & Mandler, 1980; Mandler & Johnson, 1977; Rumelhart, 1975, 1977; Stein & Glenn, 1979; Thorndyke, 1977).

In general, story structure as characterized in these various grammars is a hierarchical network of categories (or propositions or nodes) that specifies the logical relations that exist between those categories, and the consequent logical order of occurrence. According to the Stein & Glenn (1979) grammar, a story is divided into the two categories of setting and episode. The episode is a higher order unit which itself contains categories of initiating event, internal response (which includes the goal), attempts, consequence, and reaction. The links between these categories are either causal or enabling such that one category sets up the preconditions for the next.

These structural characteristics enable certain predictions to be made. If the constituent units and relations in story structure correspond to internal representation, then a high degree of similarity between input and later recall would be expected, regardless of content and to the extent that the story follows the grammar. To the extent that it does not, there would be distortions and corrections toward the canonical form.

The research findings have confirmed these expectations for both children (e.g., Stein & Glenn, 1979) and adults (e.g., Mandler & Johnson, 1977). Subjects tend to recall sentences from each of the major story categories and in correct temporal sequence. When presented in noncanonical form, subjects restructure story input in accordance with an ideal story schema, even when specifically asked to maintain the order of presentation (Mandler, 1978).

The degree of developmental continuity in the essentials of the grammar is remarkable; however, there is also a developmental progression in the ability to extend the story schema flexibly to integrate information which violates assumptions. For example, younger children are even less able than older children and adults to recall stories presented in noncanonical form (Mandler, 1978). Similarly, younger children are less able than older children to recover story structure from distorted versions (McClure, Mason & Lucas (1979).

Story grammar is not the only source of causal inference in stories, however. The interpretation of stories and other textual materials depends on inferences made on the basis of content as well.

In research that has focused on the perception of causality at the sentence level, it has been shown that when sentences are related by causal links, they are recalled better than temporally linked sentences by both adults and children (e.g., Mandler & Johnson, 1977; Black & Bern, 1981). Moreover, in a study with adults (Black & Bern, 1981), it was found that causally linked sentence pairs were often recalled as a single sentence by means of a conjunctive or summary statement. This in addition to the finding that narratives were read faster than those not causally related (Haberlandt & Bingham, 1978) suggest that causal connections are more readily assimilated to a schema than temporal connections. Finally, one study with adults has shown that not only are causally connected sentences recalled better than temporally connected ones, but the degree to which sentences are causally related also influences comprehension (Keenan, Baillet, & Brown, 1984). The stronger the link in terms of how probable a cause is for a particular event, the more quickly the event is comprehended.

In summary, children and adults infer causality in stories by virtue of an abstract story syntax, and have also been shown to use causal connections to enhance comprehension and recall at the sentence level.

Another line of investigation has focused on the development of real world schemas by investigating how children organize their knowledge about routine and familiar events. This research has provided evidence suggesting that children's internal representation of everyday events reflects the degree of causal event structure.

Event schemas. According to the script model proposed by Schank & Abelson, (1977), an event schema is a temporally organized representation of stereotypic situations or action routines which is organized around an overall goal and specifies standard actions, actors, props or objects, and the sequence in which one action causes or enables the next. As discussed above, the expectations people have about going to a restaurant are one example of an event schema. The script model specifies major scenes for each event that are made up of subsequences of actions. Within an event, "main acts" are more important than others. For example, in the restaurant event, major scenes include ordering, paying, and leaving. The ordering scene subsumes such actions as getting the menu, deciding what to eat and giving the waitress your order, and giving your order to the waitress is the main act of the ordering scene. Main acts constitute subgoals that must be realized in order to achieve the overall goal. One of the main acts may constitute the event goal. For example, in the restaurant event, the main act "to eat" constitutes the overall goal around which other main acts are organized.

In a landmark study that tested the assumptions of the Schank & Abelson (1977) model, Bower, Black & Turner (1979) collected normative data about how adults organize their knowledge of everyday events such as going to a restaurant or visiting the dentist. They found a surprising amount of agreement among people on the sequence and components (actions, actors, props) of these familiar situations, and also on how to segment the activities into major scenes. The importance of the goal was shown by the finding that subjects recalled obstacles or deviations that impeded pursuit of the overall goal better than actions that were unrelated to it. Finally, it was found that people used this familiar event knowledge to guide story comprehension. In a memory task using script-based stories, people falsely recognized script-consistent actions which had not been mentioned in the story and tended to revert temporally misordered acts to their canonical order. Together, these findings provide convincing evidence for the psychological validity of the model.

The script model has also been applied in the study of children's familiar event representations (Nelson, 1978; Nelson & Gruendel, 1981; Nelson, Fivush, Hudson & Lucariello, 1982). Even very young children organize their event knowledge similarly to adults and in accordance with the model. Specifically, when interviewed about familiar events, they report a common set and sequence of acts and demonstrate a hierarchical organization in that they most frequently mention the beginning and final anchor acts of a script as well as the central or goal act. The event is reported in a generalized form by the use of the second person pronoun and the present tense (e.g., "You do X"), showing that the report is based on a schematized representation of the event rather than on memory for a particular incident. Further, script accounts are consistent in these measures across time and children.

This evidence for organized event representation has been found in children from 3 to 8 years of age and in addition to interview data, has included picture sequencing, enacting with props, and story recall. In recall of script-based stories, children similar to adults, have been found to omit misordered acts from their recall (Hudson & Nelson, 1983), and to intrude script-relevant information (Slackman & Nelson, 1984; McCartney & Nelson, 1979).

Before considering how causality is represented in event schemas, it is necessary to distinguish three levels of the representation system which are implicated in organized event knowledge (Nelson & Gruendel, 1981). The first is the event structure, or how events are organized in the real world. Events differ in how tightly organized they are in terms of causal or enabling relations between component acts. However, because differences in real world event structure are not simply mapped onto memory but must be constructed on the basis of experience, another important level of the representational system is the event representation, or how events are represented in memory. Finally, assumptions about the form and nature of the event representation are made on the basis of the script, which is the verbal or actional externalization of event knowledge. In the research to be discussed next, the relationship among these various levels of the representational system has been explored with both adults and children.

Real world event structure. Schank & Abelson (1977) argue that the elements of a script are linked by means of the five following types of causal connections: (a) action results in a new state, (b) states enable actions, (c) states disable actions, (d) states or acts initiate mental states, and (e) mental states lead to actions. As an example of the first two (most basic) relations, entering a restaurant results in (or is the cause of) the new state of being inside, and the state of being inside enables you to move to a table in the restaurant. Thus, event knowledge is linked in terms of not only strictly causal connections, of the form "A causes B", but also includes enabling relations in which A sets up the necessary preconditions that allow B to happen but are not sufficient for its occurrence. In general, whether strictly causal or enabling, these causal connections are the means by which events are organized in a logical sequence.

As it has subsequently been noted, however, scripts may not necessarily be organized in terms of causal connections. Abelson (1981) has differentiated between two major types of scripts that vary in terms of the type of relations between component actions. "Strong" scripts are those that are meaningfully related because of "causal enablements" between events. Thus, strong scripts include expectations about order as well as the occurrence of particular events. For example, in a restaurant you must get your food before you can eat it. At the other end of the continuum, "weak" scripts contain stereotyped sets of actions but lack consistent sequencing properties. For example, which set of events occurs at a circus is predictable, but the order of occurrence is not.

There is a further type of event structure suggested by Nelson's (1979) analysis of children's scripts, in which actions are temporally organized but in which the sequence is fixed by convention rather than by logical necessity. An example of this is a day at the typical day care center in which such activities as snack and nap could theoretically occur in any order, but tend to be invariant for reasons other than inherent event structure. In both of these types of "weak" script, the relation of component actions to an overall goal is different from that for "strong" scripts. While there may be an overall goal in weak scripts, it is not as well defined as for strong scripts and does not determine the sequence of the event. For example, it is not clear how an overall goal for an event such as the school day would provide any information as to the order in which activities such as math and reading should occur.

The degree to which events in the real world are causally or temporally organized may be related to how children comprehend and remember events. Preliminary findings on children's scripts suggest that this is the case.

<u>Effect of real world event structure on event representation</u>. One way in which the influence of event structure has been examined is by coding the types of event relations between acts in children's scripts. In general, temporal order may be expressed by the order of mention. In addition, links between acts may be expressed linguistically by the use of relational terms such as "and then," and "before". Relations between acts may be indicated as being purely temporal, temporal and spatial (indicating a change in location), or temporal and causal. In addition, connecting links may express invariant or variable sequences.

When Nelson (1979(b)) analyzed the types of connecting links in lunch and dinner scripts of 3- and 4-year-olds, she found that spatial/temporal relations were the most common, accounting for over half of all relationships. Causal links were also important and were of relatively greater importance for the younger children. Finally, of the simple temporal relations, invariant relations were much more frequently represented than variable ones. It was concluded that spatial, causal and invariant relations are basic in young children's event representations.

Support for this interpretation was provided in a study demonstrating an appreciation of event order among 20 to 36-month-olds (O'Connell & Gerard, 1984). Children's ability to imitate a model's sequencing of familiar events that were invariant because of either causal or conventional constraints was compared to their ability to sequence unrelated actions. Children of all ages imitated more actions for the canonical versions than for the unrelated actions. The 2 to 3-year-olds (but not the 20-month-olds) showed reliable sequencing of the canonical sequences and also showed signs of trying to correct sequences that the model demonstrated in reverse sequence, by recalling them in their correct canonical form.

Only the oldest children (3-year-olds) were able to sequence the unrelated actions. The finding that the youngest children (20-month-olds) could imitate the canonical versions better than the unrelated ones but could not reliably sequence them was interpreted as evidence that children may learn what goes with what before they learn the order in which things go together. That the older children could sequence familiar events before unfamiliar ones suggests that children move from a reliance on logical or pragmatic structure to the ability to sequence events that have no apparent structure.

Event structure has also been shown to be important in the acquisition and use of logical and temporal terms. According to the contextual hypothesis of language acquisition (Nelson, 1974; Macnamara, 1972), linguistic terms must be acquired in situations which provide contextual support before they can be applied in settings in which such support is not provided. Activities familiar to children provide such support in that the relationship between events is already understood; relational terms have only to be mapped onto those known relationships. Moreover, such contextual support is enhanced to the extent that real world events are invariantly sequenced.

Nelson & Gruendel (1981) report that with age, the use of verbal markers in descriptions of familiar activities begins with "and then". This is followed by the temporal and causal terms "after," "before," "when," and "because" which are used first in causal or enabling contexts. French & Nelson (1981) similarly found that children ranging in age from 3,9 to 5,6 correctly used the causal connectives "if," "so," and "because" in describing familiar events. This early correct use conflicts with laboratory research in which full competence in the use of causal terms has not been shown until age 7 or 8 (Emerson, 1979; 1980). However, it is consistent with findings of spontaneous productions of causal terms by 2-year-olds (Hood & Bloom, 1979).

The effect of event structure on the use of logical connectors has also been demonstrated in a more experimental approach (Carni & French, 1981). When 3- and 4-year olds were asked before and after questions about familiar (pictured) events that had an invariant real world order (for example, the Restaurant event), and those that had an arbitrary sequence (for example, a Walk in the Park), children of both age groups performed better on the invariant than the arbitrary sequences.

Finally, the effect of event structure in more complex events has also been examined. Hudson & Nelson (1983) compared preschoolers' and first graders' ability to recall familiar events that differed in the extent to which their sequence was based on logical necessity, such as the steps involved in making cookies, as opposed to cultural convention, such as the order of events at a birthday party. Thus, the two events represented examples of "strong" and "weak" scripts. As expected, children of both ages sequenced the logically organized Making Cookies event better than the temporally organized Birthday Party.

On the other hand, Fivush (1981) has presented evidence showing that the degree of logical structure of real world events does not necessarily determine the organization of the event representation. In a picture sequencing task, 7-year-olds showed a high degree of agreement on the relatively less constrained Birthday Party event. These findings may reflect a higher degree of familiarity or salience to the child for some events such as Birthday Party, which then leads to well-organized representations regardless of event structure.

Similarly, when Nelson (1979(a)) interviewed young children about various events which varied along dimensions such as event structure, frequency of experience, amount of child's participation, and affectivity (or interest value of the event to the child), event structure was not found to be more important than the other factors;

rather, each contributed to the organization of event knowledge. In addition, she found that representation was differentially affected by different experiential factors. For example, affectivity tended to result in longer scripts being produced, whereas greater familiarity resulted in more consistent scripts. Script consistency is the degree to which the same actions are reported about a given event at different interview times and reflects the degree to which the event representation is reliable and established.

It appears then that to the degree that real world events are logically structured, they are more readily perceived, better represented in memory, and provide a context for the understanding and appropriate use of temporal and causal terms. The fact that the effect of event structure diminishes with age suggests that older children are less dependent upon such structure in their event representations than younger children. At the same time, however, the research shows that event structure is only one significant influence in the formation of event schemas. Other factors such as age, affectivity, and degree of participation also figure importantly in the process.

There is a problem of inferring the effect of event structure on the basis of familiar scripts, which derives from the fact that the conditions under which the scripts were formed are unknown. For example, if causal connections are simply more frequently encountered in the real world, this could explain their greater frequency in event descriptions by children as young as age 2. Another source of confusion derives from the fact that temporally ordered events may be invariantly sequenced, as causal events are. Thus, although it has been found that causal connections are more salient than temporal ones, particularly for younger children and that temporal markers are used earlier in the context of invariantly sequenced events, it is not clear whether these findings derive more from the causal connectedness of events or the attendant feature of invariance.

Inferring the role of event structure by examining scripts also obscures effects of age and experience. Any age comparison on the effects of event structure may, at one level, simply reflect older children's better representation of real world events in general as a result of their greater fund of experience. At another level, age differences are associated with different levels of cognitive processing. For example, research on story schemas indicates that adults are better able than children to recall the input order of stories that have been presented in a noncanonical form (Mandler, 1978), and younger children are not as able as older children to recover story structure from distorted versions (McClure, Mason, & Lucas, 1979). Similarly, in the research reported above (O'Connell & Gerard, 1984; Hudson & Nelson, 1983), older children were better able than younger children to recall actions from a familiar event in a misordered sequence. Together these suggest a greater degree of cognitive flexibility among older than younger children, in particular as it relates to the ability to perform tasks that violate expectancies about invariant or causal sequences.

However, greater flexibility in cognitive processing may also result from greater familiarity with an event. That is, it has been suggested that the amount of experience one has with an event may be associated with qualitatively different stages of schema development (Taylor & Winkler, 1980). In the basic rudimentary or episodic stage, knowledge of a particular example is used to make inferences about similar instances (e.g., assuming that all restaurants are like fast food restaurants based on a limited experience of only eating at McDonald's). A stereotypic phase follows, in which the most common or representative features are included (e.g., that in all restaurants you eat, pay, and leave). In the third "relative expert" stage, there is greater attention paid to inconsistencies, such as, for example, that in some restaurants you pay before you eat; and finally, the last stage of schema development is characterized as "automatic" or "mindless" such that the steps involved in ordering, eating, and paying are usually not reflected upon, but automatically guide behavior in a restaurant.

Although these stages were identified in research with adults, there is evidence that they apply to children's schema development as well. One study shows that, characteristic of the first stage, children formed a general schema for what happens in a fire drill after only one experience with it (Nelson, 1980). Similarly, Fivush (1984) observed that kindergarteners would use the term "sometimes" to refer to an event that occurred only once. In addition, with increasing experience, the kindergarteners' reports about the event became more complex in ways that are consistent with the third stage.

Present research: Purposes and predictions

Although a significant amount of research has been conducted on children's understanding of causally structured events, two issues remain relatively unexplored. The first relates to the specific effect of overall event structure on event representation. Previous research has shown that children often sequence logically organized events better than temporal ones; and children as young as 2 include more causal than temporal links in their descriptions of events. This suggests that logical event organization is perceived by children as young as 2 years of age, and that such structure organizes the underlying event schema.

On the other hand, for some familiar events, children may sequence temporal as well as logically organized events. For example, although the school day routine follows a relatively regular and invariant sequence, there is no logical reason why math should follow reading, and yet the kindergarteners in Fivush's (1984) study formed well-sequenced school scripts by the second day of school. Thus, the effect of event structure on event representation is unclear and the findings raise an important theoretical question: Do children differentiate invariant causally organized events from events that are invariantly sequenced for reasons other than causal coherence? A related question is whether causal connections, if perceived, enhance children's ability to form event schemas.

One purpose of this dissertation therefore was to observe the effect of event structure on event representation while systematically manipulating variables of age, type of event, degree of participation in the event, and the amount of experience with the event. As discussed above, age and event familiarity have been found to affect the formation of event schemas as well as the inference of causality. Similarly, as shown by the research of Paris and his colleagues (e.g., Paris & Lindauer, 1976) referred to above, a greater degree of involvement with an event appears to enhance constructive processing and make logical relations more salient, especially for younger children.

In addition to these variables, a delayed recall condition was included. Previous research has demonstrated that while incoming material that is inconsistent with pre-existing schemas may be retained in immediate recall, with increasing time, such material tends to be omitted or regularized in the direction of a more canonical version (e.g., Bartlett, 1932; Stein & Glenn, 1979). Analogously, to the extent that an event sequence is causally constrained, it should be better assimilated and hence retained by the schema. Thus, it was expected that if children in the present study perceived the causal connectedness of the causal event, they would perform better on the causal than the temporal event after a delay.

In order to control for type and amount of experience, children were trained over three sessions in two different versions of the same unfamiliar event, a typical day in the life of a toymaker. In the causal event, the goal was to produce and send out a particular toy, and it was the relationship of the actions in the event to that goal which produced the causal sequence of the event. The term causal here is meant in the enabling sense included by Schank & Abelson (1977); that is, it is a temporal succession of actions in which an enabling condition must be met for each subsequent action to occur. For example, the completion of the toy (rabbit) enabled the toymaker to put the toy in a box to send out. In the temporal event, on the other hand, the actions of the causal event were rearranged so that actions were no longer related in an enabling sense. For example, the toymaker put one toy in a box and then proceeded to work on another toy of the same type. Thus, while both events were invariant over the three practice trials, only one had a causally constrained sequence.

In addition to exploring the effect of overall event structure, another purpose was to examine the effect of causal structure at the basic level of cause and effect in the context of a more complex event. Previous research on children's causal reasoning ability has revealed that children appropriately use specific cues such as temporal contiguity to attribute causality (Bullock, Gelman, & Baillargeon, 1982).

On the other hand, while research on children's event schemas has investigated the ability of children to distinguish between logical and temporal events, logical events in this research are broadly defined in terms of the degree to which actions are related in familiar real world events. That is, the logical event category has included events that are sequenced according to social convention, such as ordering dessert in a restaurant after rather than before the meal, as well as those that actually follow causal constraints.

Thus, another purpose of this research was to define meaningfulness more specifically in terms of cause and effect relations that have been investigated in the context of causal reasoning tasks. In particular, within-event causal relations were varied according to temporal contiguity and level of causal relatedness. Actions in the event were either temporally contiguous or were separated by a single intervening act. In addition, actions were related in terms of two different levels of causal relatedness: Causal actions had both necessary and sufficient conditions between them; for example, winding up the rabbit to make it walk, and enabling relations had necessary but not sufficient conditions between acts, such as the placing of a key in a toy that would enable it to walk when wound up.

The basic assumption underlying the research was that children would perceive causality as a result of schematic knowledge representation in which cause and effect would be integrated by means of constructive processing. Further, it was anticipated that constructive processing and thus causal perception would be enhanced when causal relations were made explicit by such means as overall event structure, temporal contiguity, the inclusion of both necessary and sufficient conditions between events, or more active participation by the child in the event.

Specifically, the predictions concerning the effect of between-event structure related to whether the overall causal structure would be perceived. If so, then performance would be expected to differ on the two events and conditions as follows:

(1) The amount recalled and sequencing accuracy would be better for the causally organized event.

(2) Causal perception would be more likely in the active condition, in which the greater degree of participation was expected to make causal relations more explicit, particularly for the younger children (as found by Paris and his colleagues, 1976; 1977).

(3) Any differential effects resulting from overall event structure would be more pronounced in delayed recall, as reconstructive processing would increasingly guide retrieval.

Within-event differences were expected to reveal the importance of causal relatedness and temporal contiguity on causal perception and memory. In general, the following within-event effects were predicted:

(1) Children in the active condition would be more likely to recall cause and effect as a unit (that is, to recall cause followed by its appropriate effect) than children in the passive condition.

(2) Events that were more causally connected and/or temporally contiguous would be more likely to be recalled as a unit than events that were less causally related and noncontiguous.

No predictions regarding age differences were made. While children as young as 3 have been found to appropriately apply causal principles (Bullock, Gelman, & Baillargeon, 1982), older children may perform better than younger children in drawing logical inferences in unfamiliar or more abstract contexts (Paris, 1978). Because the content of the narratives in the present study involved familiar objects and activities, it was anticipated that the task would optimize the opportunity for children of both ages to perceive causality, both at the level of cause and effect and between event types.

## Method

### Design

The study employed a story recall design in which 10-11 children at each age were randomly assigned to one of four conditions. The conditions were formed by crossing the two types of narrated events (causal and temporal) with degree of participation (active and passive) and were as follows: causal active, causal passive, temporal active, and temporal passive.

As illustrated in Table 1, children participated in 3 practice sessions, one on each of three consecutive days. Children in the two active conditions were asked to enact and verbalize the story (E/V), while children in the passive condition were asked simply to retell it (V). All children were asked for verbal recall on the third day after completion of the last practice session, and again four days later.

### Subjects

Eighty-four children participated in the study, 41 preschoolers (mean age 4,6; age range 3,8 - 5,5), and 43 first graders (mean age 6,6; age range 5,10 - 7,5). Children were recruited for the study from public and private nursery schools in a middle-class community in New Jersey, and the study was conducted at the schools the children attended. Approximately equal numbers of boys and girls participated at each age. In addition to the preschool children who completed the experiment, 5 preschoolers were replaced because they were unable to perform the warm-up task.

Table 1

Schedule of practice and test sessions

| Event | Practice Phase | | | Test Phase | |
|---|---|---|---|---|---|
| | Day 1 | Day 2 | Day 3 | Day 3 | Day 7 Delayed recall |
| Causal | | | | | |
| Active (Enactment/Verbal) | E/V | E/V | E/V | V | V |
| Passive (Verbal) | V | V | V | V | V |
| Temporal | | | | | |
| Active (Enactment/Verbal) | E/V | E/V | E/V | V | V |
| Passive (Verbal) | V | V | V | V | V |

Materials

Two stories were constructed for the purposes of this study, a causal and a temporal version. Both related the same activities of an event: A typical day in the life of the toymaker, and consisted of a total of 22 statements, each of which described one action. (In two of the statements, it was necessary to include an additional action in order to make the story coherent.) Eight of the actions were causes, and eight were corresponding effects. In half of the cause and effect units, the relation between acts was causal in that there were both necessary and sufficient conditions between acts, for example, winding up a toy (cause) to make it walk (effect). In the other half, the relation between acts was enabling in that although the cause was a necessary condition for the effect to occur, it was not sufficient. For example, it is necessary for the toymaker to remove his apron (cause) in order to hang it up (effect), but it is not sufficient.

In addition, for half of the causal and half of the enabling units, the cause and effect were contiguous in the story, and in the other half they were separated by an intervening act. Thus, there were four categories of causal act units as follows: Causal contiguous (CC), causal noncontiguous (CNC), enabling contiguous (EC), and enabling noncontiguous (ENC), and each category consisted of two units. Of the intervening acts, two were related to toymaking in general (for example, putting a tail on a rabbit), and two were unrelated (for example, having a cup of coffee). Finally, the last two statements were the setting and ending statements of the story. (See Tables 2 and 3.)

Table 2

Causal event narrative

| | | |
|---|---|---|
| 1. | First the toymaker goes to the toyshop. | Setting |
| 2. | Then he puts some tools in his apron pockets. | |
| 3. | And he takes his tools to the workbench. | E C* |
| 4. | He tells his helper he needs some supplies. | |
| 5. | He washes his hands. | Intervening Act |
| 6. | And the helper brings supplies. | C NC |
| 7. | Next he puts a bell in the chest of the rabbit. | |
| 8. | He puts a tail on the rabbit. | Intervening Act |
| 9. | Then he closes the chest up with a heart. | E NC |
| 10. | Then he puts the jacket on the rabbit. | |
| 11. | He has a cup of coffee. | Intervening Act |
| 12. | And then he ties the belt. | E NC |
| 13. | After that, he puts the key in and winds the rabbit up. | |
| 14. | And the rabbit walks. | C C |
| 15. | Then a mother and father call on the telephone to order a rabbit. | |
| 16. | The toymaker puts a carrot around the rabbit's neck. | Intervening Act |
| 17. | And he puts the rabbit in a box to send out. | C NC |
| 18. | Next the toymaker blows his whistle for the delivery truck to come. | |
| 19. | And then the truck comes and he puts the box in. | C C |
| 20. | Then the toymaker takes his apron off. | |
| 21. | And he hangs his apron up. | E C |
| 22. | Then he goes home. | Ending |

*CC = Causal contiguous
CNC= Causal noncontiguous
EC = Enabling contiguous
ENC= Enabling noncontiguous

Table 3

<u>Temporal event narrative</u>

| | | |
|---|---|---|
| 1. | First the toymaker goes to the toyshop. | Setting |
| 2. | Next the toymaker blows his whistle for the delivery truck to come. | |
| 3. | And then the truck comes and he puts the box in. | C C* |
| 4. | Then he puts some tools in his apron pockets. | |
| 5. | And he takes his tools to the workbench. | E C |
| 6. | After that, he puts the key in and winds the rabbit up. | |
| 7. | And the rabbit walks. | C C |
| 8. | Next he puts a bell in the chest of the rabbit. | |
| 9. | He puts a tail on the rabbit. | Intervening Act |
| 10. | Then he closes the chest up with a heart. | E NC |
| 11. | Then he puts the jacket on the rabbit. | |
| 12. | He has a cup of coffee. | Intervening Act |
| 13. | And then he ties the belt. | E NC |
| 14. | Then the toymaker takes his apron off. | |
| 15. | And he hangs his apron up. | E C |
| 16. | Then a mother and father call on the telephone to order a rabbit. | |
| 17. | The toymaker puts a carrot around the rabbit's neck. | Intervening Act |
| 18. | And he puts the rabbit in a box to send out. | C NC |
| 19. | He tells his helper he needs some supplies. | |
| 20. | He washes his hands. | Intervening Act |
| 21. | And the helper brings supplies. | C NC |
| 22. | Then he goes home. | Ending |

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*CC = Causal contiguous
CNC= Causal noncontiguous
EC = Enabling contiguous
ENC= Enabling noncontiguous

Both event versions consisted of the same content. However, in the causal event, the act units were organized around the goal of producing a particular toy while in the temporal event, they were arranged so that the sequence was not clearly related to the production of a particular toy but rather to toymaking in general. For example, in the causal event, the toymaker went through the steps to make a toy and then put it in a box to send out. In the temporal event, he put the toy in a box to send out, and then proceeded to work on another toy of the same type. The two events differed from each other, then, only in the degree to which the component act units were logically organized around an overall event goal.

Procedure

Practice phase. The same female experimenter trained children in the event over a three-day period with one practice session per day. Children were shown the model toyshop and the toymaker and "helper" dolls and told that they would hear a story about how the toymaker made toys (See photographic depictions of toyshop and props in Appendix A). At each session, the experimenter told the story while acting it out with toys and props. Children in the active condition were asked to retell the story while acting it out, and children in the passive condition were asked simply to retell the story. The specific instructions were:"Can you tell me (active condition: "...tell me and show me") what the toymaker does?" They were also instructed that they did not necessarily have to remember the entire story but that they should try to remember as much as they could. Children sometimes either acted out the event without verbalizing it (active condition) or pointed to objects (passive condition) instead of verbalizing the intended object or action. In both cases, they were asked to verbalize the object or action referred to (e.g., "What is the toymaker doing now?," or "What do you call that?")

Prior to the first practice session on day 1, there was a warm-up task to put children at their ease and to make sure they understood what was required to do the task. In the warm-up session, children were asked to remember a story about an event unrelated to that in the actual experiment. The story was about the daily routine of a farmer, and consisted of only 5 acts. Children were asked to perform the task in the same manner in which they would perform the experiment; that is, those in the active condition enacted and verbalized the story whereas children in the passive condition only related it verbally. Five preschoolers were replaced for failure to recall the story. All other children could do the warm-up task without any apparent difficulty and seemed to understand what was required by the end of the session.

Test Phase. After the practice session on day 3 was completed, the model toyshop and props were draped so that they were hidden from view, and children were asked to perform a distractor task before beginning the test phase. In the distractor task children were asked to provide frequency judgments for actions that occur in two familiar events - waking up in the morning and having a birthday party. Specifically, children were asked to make judgments about 8 items from each event by answering with one of three response choices (always, sometimes, or never) after the experimenter read each of the particular items. The task took approximately 3-4 minutes to complete.

In the day 3 session that followed the distractor task (test phase), the experimenter related the story verbally, without acting it out, and then children in both the active and passive conditions were asked to retell the story verbally. Specifically, they were instructed as follows: "This time I'm going to just tell you what the toymaker does. I'm not going to show you." After hearing the story, children were asked, "Can you tell me that story?" This question was then followed by probes such as "Anything else?," "Then what happened?," "Is that the end?" until children could not recall any more of the story. Occasionally, when they were distracted during recall of the story, the experimenter reiterated the last thing they had said. If children claimed they could not remember, they were reminded that they did not have to remember the whole story, but only as much as they could. However, most children in both age groups seemed to have relatively little difficulty in recalling the story.

Four days after the day 3 session, children were asked to recall the story again. Specifically, they were told, "Today, I'd like you to just tell me what the toymaker does. Can you remember?" The same procedure was then followed as on day 3. Both the practice and the test phases of the study were conducted at the school the child attended. The children were seen individually in an area in the school that remained the same for the duration of the study.

Coding

Recall sessions on day 1 of practice, and during the test phase were tape recorded and transcribed for coding and analysis. The purpose of recording recall on day 1 was to have a baseline measure that would assess the degree to which children initially perceived the organization of the causal event. If children are sensitive to event structure, then they should perform better on the causal event as of day 1. If they do not perceive the causal connectedness of the event initially, it is possible that they may come to realize its logical structure with practice, and take advantage of that structure to enhance and organize recall.

Children's protocols were coded for amount recalled for the four different categories of causal acts: Causal contiguous (CC), causal noncontiguous (CNC), enabling contiguous (EC), and enabling noncontiguous (ENC), as well as for recall of the 4 intervening acts and the two anchor (setting and ending) statements. (See sample coded protocols in Appendix B.)

In 20 of the story statements, there was only one action described in each statement. However, in two statements, in order to fill out the narrative, there were two actions described. (See statements 13 & 19 in the causal event.) Because children variously recalled either one or both of the actions, they were given one point for recalling each action. Thus, for the 22 statements in the story it was possible to receive a score from 0 to 24 for the measure of total amount recalled.

However, in coding recall of the different categories of causal acts, it was necessary to adopt a different scoring procedure in which these two statements were coded according to both a strict and a weak criterion. The strict criterion required that children recall "Winds the rabbit up" in statement 13 since it is the winding action in that statement rather than putting the key in that is actually the cause of "And then the rabbit walks." Similarly, they had to recall "Then the truck comes" in statement 19 in order to receive credit for recalling an effect. However, according to the weak criterion, children received credit for recalling either or both of the actions in each statement. The weak criterion was included because it is essentially ambiguous as to whether recall of one part of a complex sentence implies the whole sentence or not. This is especially problematic when the important action in the sentence is in the second part of the sentence, as was the case in statement 13.

Children were credited with correct recall if they recalled statements verbatim or if it seemed evident that they were recalling the correct item. That is, if a child said "Then he called the truck" instead of "Then the toymaker blew the whistle for the truck to come," they were credited with a correct response. There were a few statements with which children, particularly preschoolers, had special difficulty. For example, the statement, "Then a mother and father called to order a rabbit" was transformed in various ways, such as, "Then the toymaker called someone on the phone." In such cases, if a significant number of children seemed to have difficulty with the statement, a more lenient criterion was adopted in scoring that particular statement. However, in general, children's recall of most of the story statements was fairly accurate, with little question about which particular item was being referred to.

A sample of approximately 20% of the protocols from day 1, day 3 and delayed recall was randomly selected from a cross section of all groups and conditions and given to a second judge to code. The interjudge agreement, which was based on the number of items both judges agreed on divided by the total number of items, was 94%. One coder coded the remaining protocols.

# Results

## Overall event structure

Total amount recalled. The total number of acts children recalled (out of a possible 24) was subjected to a mixed-design four-way analysis of variance with age (preschool and first grade), event (causal and temporal), and mode (active and passive) as between-subject variables and time (day 1, day 3, and delayed recall) as a within-subject variable.

As shown in Table 4, first graders recalled more acts than preschoolers (means: 15.09 for first graders and 9.39 for preschoolers, $F(1,76)=91.15$, $p < .001$), children in the active condition recalled more acts than children in the passive condition (means of 13.46 and 11.03, $F(1,76)=16.48$, $p < .001$), and there was a main effect of time ($F(2,152)=5.28$, $p < .007$) showing that children recalled more actions on day 3 than on day 1 (means of 12.91 and 11.71, $p < .05$).[1]

There were also two interactions found: Age by time ($F(2,152)=6.69$, $p < .002$), and mode by time ($F(2,152)=9.59$, $p < .001$). The first interaction showed that whereas the amount recalled did not improve over time for preschoolers, and in fact decreased from day 3 to delayed recall (means of 9.94 for day 3 and 8.64 for delayed recall, $p < .05$), first graders recalled more on day 3 and in delayed recall

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1. The Newman Keuls test was used to test all post hoc comparisons between means.

than on day 1 (means of 13.82 on day 1; 15.88 on day 3; and 15.59 in delayed recall, $p < .001$).

However, as shown in Table 4, the reason that the difference was not significant for preschoolers as well was because preschoolers in the active condition recalled more on day 1 than on day 3 or in delayed recall. On the other hand, preschoolers in the passive condition, similar to the first graders, tended to recall more on day 3 and in delayed recall than on day 1.

The mode by time interaction indicated that whereas children in the passive condition recalled significantly more on day 3 and in delayed recall than on day 1 (means of 12.13 on day 3; 11.42 in delayed recall; and 9.55 on day 1, $p < .001$) for children in the active condition the differences were not significant. On the other hand, children in the active condition still recalled significantly more than children in the passive condition in delayed recall (means of 12.80 and 11.42, $p < .05$), showing that ultimately, children's recall was more enhanced when they enacted the event than when they did not.

These findings show that children's story recall improves with age and activity. Children of both ages tended to recall more in the passive condition as a result of practice. However, in the active condition, first graders showed less improvement in amount recalled, and preschoolers actually performed better on day 1 than after practice. This may be a reflection of the importance of active

Table 4

Mean numbers and standard deviations of acts recalled by age, event, mode, and time

| | Causal | | Temporal | | |
|---|---|---|---|---|---|
| | Active | Passive | Active | Passive | Mean |
| | **Day 1** | | | | |
| Preschool | 13.40<br>(2.50) | 7.00<br>(3.80) | 11.20<br>(2.86) | 6.82<br>(2.64) | 9.60 |
| First grade | 16.00<br>(2.86) | 11.20<br>(3.39) | 14.91<br>(2.43) | 13.18<br>(2.93) | 13.82 |
| | **Day 3** | | | | |
| Preschool | 11.80<br>(3.26) | 9.70<br>(4.45) | 10.00<br>(2.54) | 8.27<br>(3.67) | 9.94 |
| First grade | 16.64<br>(3.11) | 15.10<br>(5.28) | 16.36<br>(2.42) | 15.45<br>(3.27) | 15.88 |
| | **Delayed Recall** | | | | |
| Preschool | 10.70<br>(3.59) | 7.90<br>(3.18) | 8.70<br>(3.94) | 7.27<br>(3.35) | 8.64 |
| First grade | 17.09<br>(3.30) | 14.80<br>(3.46) | 14.73<br>(3.77) | 15.73<br>(3.90) | 15.59 |
| Overall Mean | 14.27 | 10.95 | 12.65 | 11.12 | |

Note: Standard deviations are shown in parentheses.

participation for children in this age range, in that their performance was more enhanced from the beginning in the active than in the passive condition.

Contrary to expectation, there was no difference in amount recalled on day 3 compared to delayed recall. This may either indicate that the learning experience was so effective that the temporal event was assimilated better than anticipated, and/or that the time delay of four days was insufficient for reconstructive processes to guide retrieval.

While younger and older children in the passive condition improved on both events over time, they did not perform better on the causal event. Because the day 1 measure was taken during practice and therefore in the presence of the props, it is possible that children did not recall the causal event better because recall of the temporal event was enhanced over what it might have been. This does not seem likely, however, since there was also no significant difference between the two versions either on day 3 or in delayed recall, in which no props were present. If recall of the temporal event is boosted by the presence of visual cues, then some decrease in amount recalled for the temporal event relative to the causal event might be expected, in delayed recall if not on day 3. Thus, it might be concluded that children schematized the two events based on their feature of invariance over time, and did not recall the causal event better because they failed to perceive the inherent meaningfulness of the event.

On the other hand, for children in the active condition only, all the means for the causal event were consistently higher than those for the temporal event (see Table 4), which suggests that causal organization did influence children's ability to retain information. Perhaps when children are active participants, they are more likely to notice causal coherence and use it to enhance memory.

Temporal organization. In order to assess how closely the organization of children's event representation reflected the actual sequence of the event, the temporal organization of children's story recall was determined by constructing a Kendall's rank order correlation between the order of their recall and the actual order of acts in the story. Correlation coefficients were then computed for each child for each of the conditions, and a four-way analysis of variance was performed on the correlation scores with age (preschool and first grade), event (causal and temporal), and mode (active and passive) as between-subject variables and time (day 1, day 3, and delayed recall) as a within-subject variable.

As Figure 1 illustrates, first graders sequenced their recall better than preschoolers (means of .81 and .53, $F(1,76) = 48.57$, $p < .001$), the causal event was sequenced more accurately than the temporal event (means of .80 and .54, $F(1,76)=41.73$, $p < .001$), and there was a main effect of time ($F(2,152)=3.29$, $p < .04$) showing that children sequenced their recall better on day 3 than on day 1 of practice (means of .70 and .60, $p < .05$).

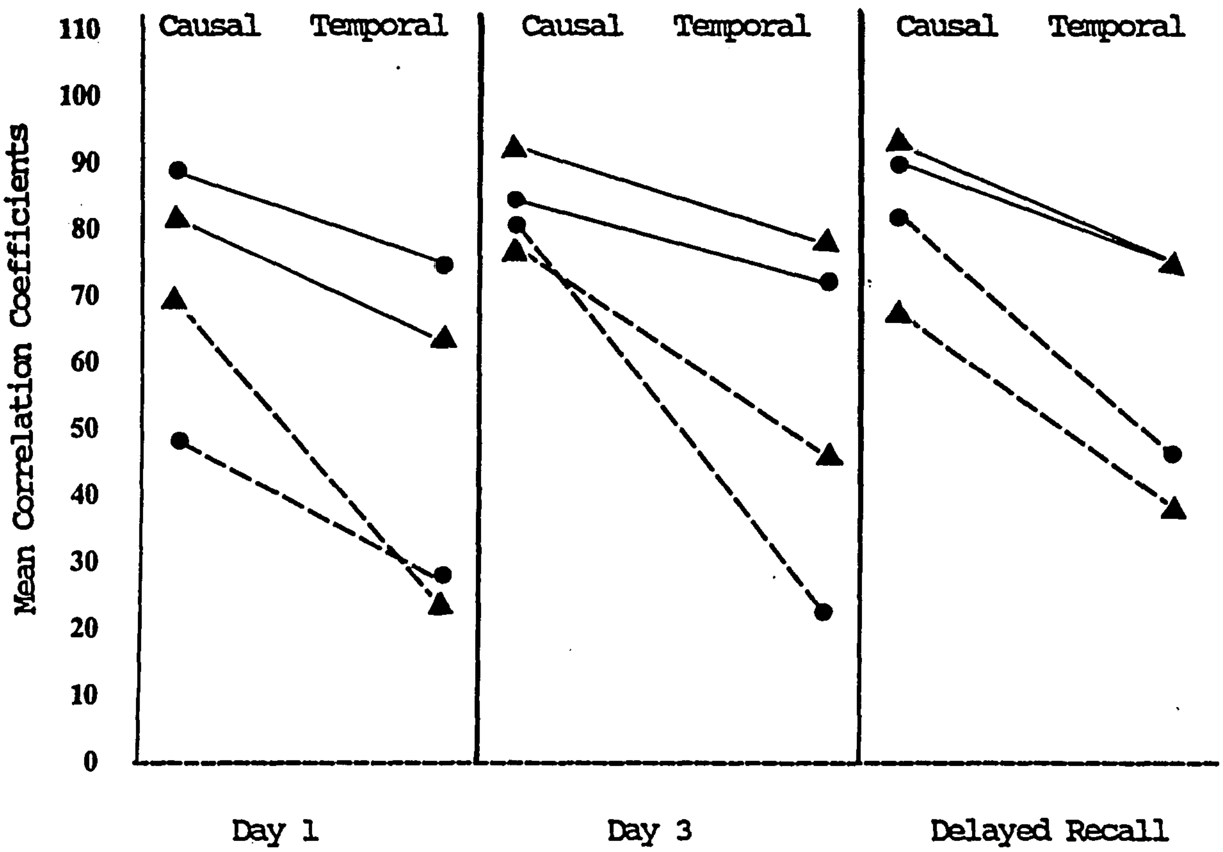
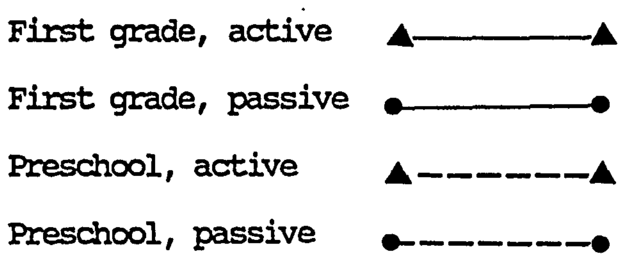



Figure 1. Kendall's Rank Order Correlations comparing the sequence of actions in the story to the sequence of children's recall



In addition, there was an age by event interaction ($F(1,76)=6.83$, $p < .01$) showing that while preschoolers and first graders did not differ significantly in their performance on the causal event (means of .89 for first graders and .71 for preschoolers), preschoolers sequenced the causal event better than the temporal event (means of .71 and .35, $p < .01$) whereas for first graders the difference was not significant. As was the case for amount recalled, there was no difference in performance on day 3 compared to delayed recall.

These findings show that age, causal structure, and practice improve sequencing accuracy. Younger children were much more affected by the lack of causal structure than older children. Thus, while previous research has shown that older children may perceive causality when younger children do not, these findings show that when younger children do perceive causal structure, they may rely more on that structure to guide comprehension and recall than older children. This suggests that both the ability to perceive causality, and the ability to process information in the absence of causal structure develop in this age range.

If children had performed the same on the two events on this measure as they did on the measure of overall amount recalled, it might be assumed that they were unaware of causal organization. However, the fact that children of both ages tended to sequence the causal event better both initially and after practice indicates that children are not only aware of causal event structure, but take advantage of that structure to organize their knowledge of the event, particularly younger children.

In general, the finding that overall event structure did not influence the amount recalled while it did affect sequencing accuracy suggests that the significant influences on event representation do not operate on the same aspects of the representation. While activity is important for enhancing overall recall, causal structure is important for representing event sequence.

Within-event structure

Recall of causal and enabling acts. Children's recall of causal and enabling acts was coded for the total number of acts recalled as well as the number of acts recalled as units. A unit was defined as recall of a cause followed by the appropriate effect. For example, if a child said "Then he winds the rabbit up, and the rabbit walks", this was scored as recall of a unit, since the child recalled both the cause and the effect, and in the correct order of occurrence. For noncontiguous units, recalling cause and effect with or without an intervening act between was counted as a unit. That is, if a child said "He puts the jacket on the rabbit, he has a cup of coffee, and then he ties the belt," this was considered recall of a unit. If the intervening act (has a cup of coffee) was omitted, or if an incorrect intervening act was recalled, the response was still coded as a unit.

Table 5 shows a breakdown of the mean numbers and proportions of causal and enabling acts that were recalled as units by age, event, mode, and time. The total number of causal and enabling acts also shown in the table is the number of causes and effects recalled, whether as units or not. The maximum number of causal and enabling acts possible was 16.

It was anticipated that children would be more likely to perceive causal relations between acts the greater the number of external cues present, including in this case a higher degree of causal connectedness and contiguity of cause and effect. Further, if children do perceive causal relations between acts, they should be more likely to recall them as units.

In order to explore this possibility, a count was made of the number of cause and effect units recalled by each child for each category of causal or enabling act (CC, CNC, EC, ENC). For each of these categories, it was possible to recall two units. In general, it was anticipated that causal contiguous (CC) units would be the best recalled because they are temporally contiguous and are the most causally related. By the same token, enabling noncontiguous (ENC) units should be the least memorable because they lack temporal contiguity and are the least causally related. The relative memorability of the other two units, enabling contiguous (EC) and causal noncontiguous (CNC) could not be predicted and would reveal whether level of causal relatedness (CNC) or temporal contiguity (EC) are equally important cues for children in this age range or whether one is more important.

Since the number of units a child recalls is partially a reflection of the total amount recalled, and since this varied significantly with age, mode, and time, proportion scores were also calculated for each child for each category of causal or enabling act.

Table 5

Mean numbers and proportions of causal and enabling acts recalled as units by age, event, mode, and time

| | Causal | | | | Temporal | | | |
|---|---|---|---|---|---|---|---|---|
| | Active | | Passive | | Active | | Passive | |
| | $\overline{X}$ | Prop | $\overline{X}$ | Prop | $\overline{X}$ | Prop | $\overline{X}$ | Prop |
| **Day 1** | | | | | | | | |
| Preschool | 4.4 (8.9) | .49 | 1.8 (4.5) | .40 | 3.8 (7.5) | .51 | 1.3 (4.3) | .30 |
| First grade | 7.6 (11.0) | .69 | 3.8 (7.5) | .51 | 5.6 (9.7) | .57 | 4.2 (8.8) | .48 |
| **Day 3** | | | | | | | | |
| Preschool | 5.0 (8.7) | .82 | 2.9 (7.2) | .40 | 4.0 (6.9) | .58 | 1.8 (5.2) | .35 |
| First grade | 8.0 (11.4) | .70 | 7.8 (11.0) | .71 | 7.4 (10.6) | .69 | 7.6 (10.4) | .73 |
| **Delayed Recall** | | | | | | | | |
| Preschool | 3.2 (7.4) | .43 | 2.2 (5.5) | .40 | 3.6 (6.3) | .57 | 2.5 (5.4) | .46 |
| First grade | 7.4 (12.0) | .62 | 6.2 (10.2) | .61 | 6.2 (10.0) | .62 | 7.4 (10.5) | .70 |

Note: Acts as units=recall of cause followed by its appropriate effect. Total number of causal and enabling acts recalled shown in parentheses. Maximum number of causal and enabling acts=16.

The proportion scores were derived separately for day 1, day 3, and delayed recall, as follows: For each recall session, the number of acts recalled as units for each category was divided by the total number of acts recalled. To illustrate, if a child recalled 11 acts on day 1 and recalled the four acts in the causal category (in accordance with specifications on recall of acts as units, as discussed above), the score would be (4/11=.36). The same procedure was followed for day 3 and delayed recall.

Arcsin transformations were computed on these proportion scores (Winer, 1971), and the arcsin transformed scores were analyzed in a six-way analysis of variance with age (preschool and first grade), event (causal and temporal) and mode (active and passive) as between-subject variables, and time (day 1, day 3, and delayed recall), level of causal relatedness (causal and enabling) and temporal contiguity (contiguous and noncontiguous) as within-subject variables. (One preschooler was eliminated from this analysis for failure to recall any units).

As shown in Tables 6 and 7, first graders recalled more cause and effect units than preschoolers (means of .63 and .38, $F(1,75)=39.48$, $p < .001$), children in the active condition recalled more units than children in the passive condition (means of .57 and .45, $F(1,75)=9.28$, $p < .004$), noncontiguous units were recalled better than contiguous units (means of .58 and .44, $F(1,75)=14.15$, $p < .001$), and causal units were better recalled than enabling units (means of .55 and .47, $F(1,75)=4.00$, $p < .05$). Finally, there was a main effect of time ($F(2,150)=7.68$, $p < .001$) showing that recall tended to be better on day 3 than on day 1 (means of .57 and .44, difference approached significance, $p < .10$).

These results indicate that age, enactment of an event, and causal relatedness enhance children's perception of causality, as reflected in the greater tendency to recall cause and effect as a unit in the presence of these factors. As shown in Table 5, first graders in both the active and passive conditions recalled causal acts as units over 50% of the time, while preschoolers only did so if they were in the active condition. This highlights the importance of activity in the perception of causality for younger children.

Surprisingly, noncontiguous units were more memorable than contiguous units. Three interactions that qualified the main effect of temporal contiguity were as follows: Age by temporal contiguity ($F(1,75)=8.92$, $p < .004$), age by time by temporal contiguity ($F(2,150)=4.82$, $p < .01$), and event by temporal contiguity ($F(1,75)=5.49$, $p < .02$).

The first interaction indicated that while first graders recalled more noncontiguous units than preschoolers (means of .39 for preschoolers and .76 for first graders, $p < .05$), for contiguous units, the difference was not significant (means of .37 for preschoolers and .51 for first graders).

Table 6

Mean proportions and standard deviations of causal and enabling acts recalled as units by age, event, mode, and time

| | Causal Event | | | | Temporal Event | | | |
|---|---|---|---|---|---|---|---|---|
| | Active | | Passive | | Active | | Passive | |
| | $\bar{X}$ | $\bar{X}_1$ | $\bar{X}$ | $\bar{X}_1$ | $\bar{X}$ | $\bar{X}_1$ | $\bar{X}$ | $\bar{X}_1$ |
| **Day 1** | | | | | | | | |
| Preschool | .11 (.07) | .45 | .07 (.08) | .25 | .11 (.08) | .44 | .05 (.06) | .18 |
| First grade | .17 (.05) | .69 | .11 (.09) | .44 | .14 (.05) | .58 | .11 (.05) | .46 |
| **Day 3** | | | | | | | | |
| Preschool | .15 (.09) | .58 | .10 (.06) | .39 | .13 (.07) | .50 | .07 (.06) | .27 |
| First grade | .17 (.04) | .71 | .17 (.05) | .71 | .17 (.05) | .71 | .18 (.05) | .73 |
| **Delayed Recall** | | | | | | | | |
| Preschool | .10 (.06) | .42 | .08 (.08) | .30 | .13 (.06) | .47 | .09 (.09) | .35 |
| First grade | .15 (.05) | .68 | .14 (.08) | .58 | .15 (.05) | .62 | .17 (.05) | .72 |

Note: $\bar{X}_1$ indicates the mean after the arcsin transformations. Standard deviations are shown in parentheses.

Table 7

Mean proportions of causal and enabling acts recalled as units by age, event, mode, level of causal relatedness and temporal contiguity

| | CC | | CNC | | EC | | ENC | |
|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | $\bar{X}_1$ | $\bar{X}$ | $\bar{X}_1$ | $\bar{X}$ | $\bar{X}_1$ | $\bar{X}$ | $\bar{X}_1$ |
| | Causal Event | | | | | | | |
| Preschool | | | | | | | | |
| Active | .13 | .51 | .09 | .36 | .08 | .33 | .18 | .71 |
| Passive | .08 | .29 | .09 | .35 | .02 | .07 | .15 | .54 |
| First grade | | | | | | | | |
| Active | .15 | .68 | .15 | .69 | .07 | .33 | .28 | 1.08 |
| Passive | .20 | .80 | .13 | .57 | .03 | .16 | .19 | .77 |
| Overall Mean | .14 | | .11 | | .05 | | .20 | |
| | Temporal Event | | | | | | | |
| Preschool | | | | | | | | |
| Active | .19 | .70 | .08 | .31 | .08 | .30 | .16 | .58 |
| Passive | .16 | .56 | .03 | .14 | .05 | .18 | .05 | .20 |
| First grade | | | | | | | | |
| Active | .16 | .69 | .17 | .68 | .07 | .33 | .20 | .83 |
| Passive | .15 | .61 | .21 | .80 | .09 | .43 | .17 | .70 |
| Overall Mean | .16 | | .12 | | .07 | | .14 | |

Note: $\bar{X}_1$ indicates the mean after the arcsin transformations.

The second interaction reflects the fact that first graders only recalled more noncontiguous than contiguous units on day 3 and in delayed recall ($p < .05$), and not on day 1 (means for contiguous and noncontiguous units, respectively: .51 and .57 on day 1; .53 and .90 on day 3; and .47 and .82 in delayed recall). Finally, for the event by temporal contiguity interaction there were no significant differences between means.

Thus, older children recalled more noncontiguous but not more contiguous units than younger children, and were better able to recall noncontiguous than contiguous units as a result of practice.

Two interactions modifying level of causal relatedness were also found: Mode by time by level of causal relatedness ($F(2,150)=4.23$, $p < .01$), and event by time by level of causal relatedness ($F(2,150)=3.89$, $p < .02$). The first interaction reflected that on day 1, more enabling units were recalled by children in the active than in the passive condition (means of .63 and .26, $p < .05$), whereas among causal units, the difference was not significant. For the second interaction, there were no significant differences found between means.

Finally, there were three interactions found including level of causal relatedness and temporal contiguity as follows: Level of causal relatedness by temporal contiguity ($F(1,75)=48.58$, $p < .001$), mode by time by level of causal relatedness by temporal contiguity ($F(2,150)=4.70$, $p < .01$), and event by mode by time by level of causal relatedness by temporal contiguity ($F(2,150)=4.11$, $p < .01$).

The level of causal relatedness by temporal contiguity interaction indicated that while children recalled more causal contiguous (CC) than enabling contiguous (EC) units as anticipated (means: .60 and .27, $p < .05$), the difference between enabling noncontiguous (ENC) and causal noncontiguous (CNC) units was not significant. They also recalled causal noncontiguous (CNC) units better than enabling contiguous (EC) units (means: .49 and .27, $p < .05$), showing a precedence of causal relatedness over temporal contiguity (see Table 7).

The mode by time by level of causal relatedness by temporal contiguity interaction reflected that among enabling units, noncontiguous units were virtually always recalled better than contiguous units ($p < .05$), while among causal units, the pattern was different: contiguous units were most often recalled as well as noncontiguous units. The meaning of the 5-way interaction was unclear.

As shown in Table 7, enabling noncontiguous (ENC) units were among the most memorable units when they should have been the least memorable. Perhaps there was something about these two units in the story other than their status as enabling and noncontiguous that made them inherently easier to recall. The fact that they related to actual production of the toy may have highlighted them and enhanced their recall because they were perceived as the central or goal actions of the event as a whole. Of all of the activities in the event, those related specifically to toy production per se are probably the closest to what would be considered the objective event goal (whether to produce one toy as in the causal event, or toys in general, as in the temporal event). Prior research has shown that children's scripts are more likely to include goal-relevant actions than other types of event information (e.g., Nelson & Gruendel, 1981).

The speculation that high recall of enabling noncontiguous (ENC) units may be an artifact is given support when the ambiguous cases are also included in an analysis of variance (Causal contiguous (CC) acts scored according to the weak criterion; see Coding section). In this analysis, post hoc tests on the temporal contiguity by level of causal relatedness interaction showed that causal contiguous (CC) units were recalled better than causal noncontiguous (CNC) units (means of .72 and .48, $p < .05$) (in addition to being recalled better than EC units (mean of .27 ).[2] Together, the results from these two analyses highlight the enabling noncontiguous (ENC) units as falling outside the general pattern of recall.

In general, these findings suggest that children as young as 4 years of age are sensitive to cause and effect relations as shown by their recall of cause and effect as units. Older children were more likely to recall cause and effect as related, and while older and younger children were more likely to do so when they acted out the

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2. A time by level of causal relatedness interaction ($F(2,150)=5.55$, $p < .005$) was also found showing that causal units were recalled better than enabling units on day 3 and in delayed recall, $p < .05$, but not on day 1. In addition, a mode by time interaction was found ($F(2,150)=3.91$, $p < .02$) showing that while more units were recalled on day 3 and in delayed recall than on day 1 for the passive condition ($p < .05$), for the active condition the difference was not significant. As in overall amount recalled, however, this is because children in the passive condition initially recalled less than those in the active condition and not because their recall surpassed those of children in the active condition on day 3 recall.

event, for younger children, activity made the difference between whether they recalled cause and effect as units more than 50% of the time.

Not only did children recall cause and effect as related, but they indicated a sensitivity to causal relatedness. The effect of temporal contiguity was somewhat masked by the high recall of enabling noncontiguous (ENC) units; however, (when the ambiguous cases are included), superior recall of causal contiguous (CC) over causal noncontiguous (CNC) units shows that temporal contiguity did influence children's recall. On the other hand, temporal contiguity was found to be not as important as causal relatedness, as shown by the superior recall of CNC over EC units.

Noncontiguous units: Recall of schematic intrusions. In the analysis of children's ability to recall causal units, the category of noncontiguous units included recall of either cause and effect only, or cause and effect separated by an intervening act. This provided a measure of children's ability to perceive cause and effect as a schema. However, it is also of interest to know whether children recalled noncontiguous units with or without the intervening act as a measure of their ability to recall intrusions in the context of that schema.

An analysis of variance was therefore performed on the frequencies of noncontiguous units recalled for each age, event, and mode (see Table 8). The analysis showed that first graders recalled more noncontiguous units than preschoolers (means of 4.14 for first graders and 2.85 for preschoolers, $F(1,76)=25.00$, $p < .001$), and children of both ages recalled more units without intervening acts than with intervening acts ($\underline{F}(1,76)=167.44$, $\underline{p} < .001$). There was also an event by type of recall interaction ($\underline{F}(1,76=4.59$, $\underline{p} < .03$; however, there were no significant differences on post hoc comparisons.

More importantly, there was an age by type of recall interaction ($\underline{F}(1,76=11.60$, $\underline{p} < .002$), showing that while preschoolers and first graders recalled the same number of units without intervening acts, first graders recalled more units with intervening acts than preschoolers (means of 2.72 for first graders and .42 for preschoolers, $\underline{p} < .01$).

Thus, preschoolers not only recalled fewer noncontiguous units overall than older children, but were also less able than older children to recall intervening acts in the context of cause and effect. This suggests that while the ability to recall cause and effect as a unit represents one level of causal perception, the ability to recall schematic intrusions in the context of causal units is a later achievement.

Table 8

Mean frequencies and standard deviations of noncontiguous units recalled with and without intervening acts by age, event, and mode

| | Causal Event | | Temporal Event | |
|---|---|---|---|---|
| | With Intervening Act | Without Intervening Act | With Intervening Act | Without Intervening Act |
| Preschool | | | | |
| Active | .80 (1.03) | 5.70 (1.77) | .60 (.84) | 5.40 (1.51) |
| Passive | .30 (.48) | 4.90 (1.91) | .00 (.00) | 5.09 (2.81) |
| Overall Mean | .55 | 5.30 | .30 | 5.24 |
| First grade | | | | |
| Active | 3.91 (1.64) | 4.81 (1.17) | 1.82 (1.47) | 6.45 (2.21) |
| Passive | 2.80 (2.35) | 5.20 (2.90) | 2.36 (1.80) | 5.73 (2.10) |
| Overall Mean | 3.35 | 5.00 | 2.09 | 6.05 |

Note: Standard deviations are shown in parentheses.
A unit = two acts (cause and effect).

## Discussion

This study explored children's understanding of causality at two different levels: The level of the overall event, in the relation of actions to an overall event goal, and the level of within-event structure, or the basic relation of cause and effect. Both levels were examined in the present study as a function of age, event structure, activity, and time.

### Overall event structure

Overall event structure was manipulated in this study by presenting children with two versions of the same event. In the causal version the actions all led to the achievement of a particular goal: The production of a particular toy. In the temporal event, the event actions were not ordered in terms of a specific goal and could therefore be performed in any order. Thus, the two event versions differed in the degree of causal structure. On the other hand, they were both invariantly sequenced throughout the child's three encounters with the event, and they shared the same general context of toymaking.

The basic question underlying the analysis of overall structure was whether children would be able to perceive the difference between events that are invariant because of causal constraints on event order as opposed to those that are invariant for other conventionally defined reasons, as exemplified by the conventional order of events at a birthday party. It was predicted that the amount recalled and sequencing accuracy would be better for the causal than for the temporal event; that causal perception would be more likely in the active condition, particularly for the younger children; and that superior recall for the causal event would be enhanced in delayed recall compared to day 3.

While event structure did not significantly influence amount recalled, preschoolers sequenced the causal event better than the temporal event, and first graders tended to do so as well. This shows that even the preschoolers in this study were affected by causal structure as of their first encounter with the event, and is consistent with other findings in the literature indicating that logical organization enhances sequencing accuracy in children as young as four years of age (e.g., Brown & Murphy, 1975). While older children did not sequence the causal event significantly better than younger children, they did sequence the temporal event better. This indicates that when younger children are able to perceive causal structure, they rely more on that structure in the organization of event knowledge than older children do.

In general, these results show that children in this age range do in fact distinguish between events that are invariant and causally constrained and events that are simply invariant. Further, while children sequenced both events better after practice, the sequence scores on the temporal event did not come up to the level of those for the causal event, suggesting that even when two events share the feature of invariance, children may still sequence causally organized better than temporally invariant events.

Lack of logical organization might be expected to depress overall amount recalled as well, and yet even the youngest children in this study did not differ significantly in the amount recalled either as a result of practice (day 1 versus day 3 and delayed recall), or over time (day 3 versus delayed recall). The finding that children were able to recall the temporal as well as the causal event after practice is consistent with findings of script research showing that children are able to recall events that are temporally invariant as well as events that are causally organized (Fivush, 1981; Nelson, 1979(b)).

On the other hand, it is surprising that children were able to recall the temporal event as well as the causal event as of the first day. As discussed above, one possible explanation for this finding is that since the day 1 measure was based on the first practice session, and was consequently in the presence of the toys and props, performance on the temporal event might have been enhanced over what it would have been without benefit of visual cues. This does not seem likely, however, since there was still no advantage of the causal event either on day 3 or in delayed recall when the props were no longer in view. In this connection, the fact that the expected event by recall interaction showing superior performance on the causal event in delayed recall was not found may either be because the practice was so effective that it compensated for the lack of inherent organization of the temporal event, and/or that the four-day time delay was insufficient to engage reconstructive processes.

While overall amount recalled did not reflect between-event differences, the finding that preschoolers had much more difficulty sequencing the temporal than the causal event suggests that they may have achieved the level of their recall of the temporal event at the expense of accurate sequencing. Perhaps when children encounter an event with little internal structure, they may begin by recalling the component actions in any order, and with increased experience, learn to attend to the order of occurrence as well. This interpretation is given some support by the finding that 2-year-olds apparently learn what goes with what in routine events before they learn the correct sequence of the event (O'Connell & Gerard, 1984). This stage may be recapitulated by older children when there is no logical organization to guide sequencing, as was the case in the present study.

When the effect of active participation is examined, another possibility becomes apparent. While active participation did not interact with causal structure to enhance overall amount recalled as expected, active participation alone improved recall for both younger and older children. This finding suggests, as prior research also indicates (Nelson, 1979(a)) that different factors may influence event representation differently. Nelson's (1979(a)) study suggests that the salience or degree of interest of the event to the child results in longer scripts while greater familiarity results in greater consistency (the degree to which the same script actions are mentioned across script interviews). The present research confirms that causal structure is associated with better sequencing, and also shows that active participation, similar to salience of the event, may result in longer scripts.

Taken together, the findings regarding overall event structure indicate that while children as young as four years of age are sensitive to causal relations, the formation of an event schema is not solely affected by the degree of event structure, or meaningfulness of the event. The combined findings of Nelson's study and the present research indicate that both affectivity and active participation may similarly enhance event representation in terms of overall amount recalled.

Within-event structure

The purpose of manipulating within-event structure was to assess the degree to which children were aware of causality at the level of cause and effect and under different conditions, such as the level of causal relatedness between conditional actions, and whether cause and effect are temporally contiguous or not. It was anticipated that recall of cause and effect as a unit would be more likely for the children in the active than in the passive condition, and to the extent that actions were causally connected and/or temporally contiguous.

Interestingly, while active participation did not improve overall recall of the causal event over the temporal event, it did enhance children's ability to recall cause and effect as a unit. Moreover, the only time when preschoolers recalled a larger percentage of causal acts as units rather than as unconnected acts was when they acted out the event. That activity enhances causal perception is consistent with the research cited above (Paris & Lindauer, 1976) showing that 7-year-olds are better able to draw causal inferences implied in sentences when they are asked to act out the sentences as they are presented.

The influence of activity may operate at the point of comprehension by enhancing constructive processing and thereby the perception of causal relations by making causal relations between actions explicit. Because younger children do not always spontaneously apply inferential operations even though they may be capable of doing so (Paris & Lindauer, 1976), acting out an event may take the place of more strategic processing activities characteristic of older children and adults. Another possibility is that children initially infer causality in both active and passive conditions but active participation enhances memory either because of the additional time and energy expended or because it involves an additional mode of learning; that is, actional as well as verbal. This possibility cannot be ruled out by the present research.

Children not only demonstrated an appreciation of causality by recalling cause and effect as units, but as predicted, and similar to findings of research conducted with adults (Keenan, Baillet, & Brown, 1984), they also distinguished between levels of causal relatedness. Temporal contiguity also enhanced recall of causal units, as shown by the finding that causal contiguous (CC) units were better recalled than causal noncontiguous (CNC) units. This finding is consistent with previous studies showing that children in this age range use temporal contiguity as a causal cue in causal judgment tasks (e.g., Kun, 1978). On the other hand, superior recall of causal units that were noncontiguous over enabling units that were contiguous shows that causal relatedness influenced recall more than temporal contiguity.

A possible explanation for the unexpected high recall of enabling noncontiguous (ENC) units is that they were perceived as the central or goal actions of the event, thereby enhancing their recall over other actions in the event. To the extent that this explanation is correct, it indicates that while causal structure may guide comprehenion and recall, other factors related to the event as a whole, such as the overall goal, also influence event representation. This is in fact similar to the findings of both Stein & Glenn (1979) and Glenn (1980) showing that causal inferences in stories are made on the basis of both story schemas and story content.

Finally, it was found that the ability to recall cause and effect as a unit increased with age. Older children were more likely than not to recall causal units while preschoolers recalled cause and effect as units less than half of the time. The pattern of recall of intervening acts further supports the suggested developmental progression of causal perception. Older children were better able to recall noncontiguous units overall but more importantly, they were also better able to recall intervening acts in the context of cause and effect while preschool children were rarely able to do so. This suggests that children are able to recall cause and effect as a unit before they are able to recall intrusions in the context of that unit, and is reminiscent of the findings of story schema and script research showing that younger children are less able than older children and adults to recall schema-based stories in noncanonical form (Mandler, 1978; Hudson & Nelson, 1983).

Summary and conclusions

The findings regarding overall event structure reveal that children between the ages of 4 and 6 clearly distinguish between events that are temporally invariant and events that are invariant because of causal constraints. Children of both ages but especially younger children rely on causal structure in the organization of event knowledge. This suggests that the ability to sequence events that lack causal structure improves with age. However, the within-event structure findings indicate that the ability to perceive causal relations at the level of cause and effect also improves with age. Together these findings suggest that while younger children may not perceive causality in all situations or to the same extent that older children do, when perceived, causal structure is more important in the organization of event knowledge for younger than for older children.

One of the striking findings of the study was that even when children are affected by causal structure, its effects may be captured by some measures and not others. In the present study, causal structure affected temporal sequencing but not the number of story statements recalled. This is an important methodological point because it suggests that certain measures may not reflect perception of causal relations. It is also an important theoretical point because it shows that even when children are capable of perceiving meaningful relationships among events, causal structure is only one among several potentially influential factors in the formation of event schemas. As shown by the present findings, activity may enhance children's ability to retain information in any order, or it may operate in tandem with causal event structure to enhance the representation of causal relations.

Thus, while exploring children's perception of causality in the context of a schematic processing model offers an important means of understanding how children are affected by event structure, it still leaves a number of questions unanswered, not only about how experiential factors such as the degree of active participation influence causal perception, but how they may interact with different measures, such as overall amount recalled and sequencing, to produce different effects on representation. To achieve a better understanding of how the growth of schemas affects causal perception, we need to take into account the complex relationship between the level of the child's understanding, the nature of the event, and the nature of the child's experience with the event.

# Appendix A

## Photographic depictions of model toyshop and props

# Appendix B

## Sample recall protocols

Key to coding scheme: Types of acts recalled

S = Setting

E = Ending

IA = Intervening act

| | |
|---|---|
| CC = Causal contiguous | Causal and enabling acts |
| CNC = Causal noncontiguous | |
| EC = Enabling contiguous | |
| ENC = Enabling noncontiguous | |

A bracket ([) indicates recall of causal and enabling acts as units.

Preschooler, Causal Active, Day 3

S First goes in the toyshop.

CNC And um he calls the toymaker. (He does what?)

He calls his helper. (He calls his helper, uh-huh.)

CNC And...so he could bring...so he'll bring supplies over. (Right.)

IA Then he gets...then he washes his hands.

IA He has a cup of coffee.

ENC And...and then puts a bell in the rabbit's tummy. (uh-huh)

ENC And then he puts...covers it up with a heart. (uh-huh)

ENC And then he um puts on his jacket - the rabbit's jacket.

CNC And then he...his parents call him up and say they want to order a rabbit.

CNC And um...he puts the rabbit in the box so he could send out the rabbit. (uh-huh)

CC Then the...then he blows his hor...whistle so the delivery truck will come. (um-hum)

E Then he goes home. (very good. Anything else happen?) (shakes head no)

IA Had a cup of coffee. (uh-huh)

CC ┌ Then he...and then he blows his whistle
for the delivery truck to come. (um-hum)

CC └ And then it comes.

EC Takes the nap off.

ENC Calls on the phone and order a rabbit. (good)

CC ┌ Then he puts the key in the rabbit (uh-huh)
to wind his back up. (uh-huh)

CC └ And then he walks. (good)

ENC And then he um...he puts his coat on.

ENC And puts a heart on his chest.

ENC And puts a bell in his chest. (uh-huh)

CNC And then puts the rabbit in the box. (good. Can you remember anything else that happens?)
That's it.

First grader, Causal Active, Day 3

S First the toymaker comes to work.

EC ┌ Then...then he puts some tools in his pocket.

IA │ And then...then he washes his hands.

EC └ And then...then he goes to the workbench.

CNC Then then he calls for his helper to bring some supplies.

And then he goes to the workbench.

And he takes a rabbit.

ENC ┌ And then he puts a bell inside it.

IA │ And then um...then he puts a tail on.

ENC └ Then he puts a heart on, to cover up the bell.

ENC ┌ And then and then he puts a coat on it.

IA │ And then and then he has a cup of coffee.

ENC └ And then he um he ties he ties the belt up.

CNC ┌ And then um his mom and dad calls for a...calls for a ca..a rabbit.

IA │ And then...then he puts a necklace on it.

CNC └ And then he...and then he puts him in a box.

CC And then a delivery truck comes.

And takes him off.

EC And then and then the toymaker hang up his apron.

E And then he goes home. (very good. anything else?)

Huh-uh.

First grader, Temporal Active, Day 3

| | |
| --- | --- |
| S | First the toy...the toymaker goes to shop. (uh-huh) |
| CC | ┌ Then he blows the whistle for the delivery truck to come. |
| CC | └ The truck comes. |
| | And he puts the box in the truck. (uh-huh) |
| CC | ┌ Then he puts a key in the back of the rabbit. |
| CC | └ And the rabbit walks (uh-huh) |
| IA | Then he puts a tail on the rabbit. |
| ENC | Then he puts a bell in the chest of the rabbit. (uh-huh) |
| ENC | Then he puts a jacket on the rabbit. |
| CNC | ┌ Then his mother and father call to order a rabbit. |
| IA | │ He puts a carrot around the rabbit's neck. |
| CNC | └ And puts the rabbit in a box to send out. |
| IA | He has a cup of coffee. |
| IA | Washes his hands. |
| CNC | ┌ And tells helper he needs some supplies. |
| CNC | └ And the helper brings some supplies. |
| EC | He hangs up his apron. |
| E | And then he goes home. |

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