2005

Children's ability to use time-lines to recall the order and duration of single and repeated actions

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Bachelor of Arts in Psychology, Brock University, 2003

THESIS
Submitted to the Department of Psychology in partial
fulfillment of the requirements of a Master of Arts degree
Wilfrid Laurier University
2005

Your file Votre référence
ISBN: 0-494-09903-8
Our file Notre référence
ISBN: 0-494-09903-8

Abstract

This study examined the ability of children aged 4-8 to recall temporal information verbally and using a visual "time-line". Forty-five children participated in an activity (making a picture of the sky at night) with the researcher, followed by a series of recall tasks. Children were asked to recall location, duration and sequencing information about single autobiographical events that parents provided, as well as single and repeated events from the activity. Results demonstrated developmental increases in children's ability to provide temporal information. The 7-8 year olds were always more accurate than the 5-6 year olds, followed by the 4 year olds. With respect to children's ability to provide recall of time information using a time-line or verbal recall, children were always able to provide more accurate details when using the time-line, with the exception of one of the sequencing tasks. In addition, children were able to sequence single actions with more accuracy than repeated actions.

Acknowledgements

First, I would like to thank my advisor Dr. Kim Roberts for her support and encouragement throughout my master's degree. I am forever grateful to Dr. Roberts for her guidance and training within the area of developmental psychology, and I will always be indebted to her for the opportunities she has provided for me within her lab as well as within the field of children's memory.

I would also like to thank my committee members Dr. Anne Wilson and Dr. Mark Pancer, who have been generous with their time and provided an immense amount of support while designing and revising my thesis. It is comforting to know that I had their door to knock on when I was in need of support.

Next, I would like to thank my colleagues, specifically Angela Evans, for creating a supportive lab environment. This research would never have been possible without the support of friends and colleagues, as it is these people that I discussed my many dilemmas surrounding my research design with, as well as received support when desperately trying to recruit participants. I believe it is our colleagues that create the most productive learning environment, in which everyone grows and in turn produces the best possible research. It is people like Angela that we meet within the field with the same desire to produce the best possible work that make our endeavours more enjoyable. Thank you.

Finally, I would like to thank my family, my friends back home and especially Jeff. I am above all grateful to Jeff for understanding why there where so many times when my work had to come first. I am also grateful to Jeff, because my accomplishments would not be as exciting or enjoyable, if I did not have him to share them with.

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Children's Ability to Use Time-Lines to Recall the Order and Duration of Single and Repeated Actions

The purpose of the present research is to further our knowledge of temporal understanding in children. This is an important endeavour as children are often the only witnesses to crimes such as child sexual assault and they may be questioned about the timing, duration, and sequence of actions in the events they witnessed. In order to gain knowledge of temporal understanding in children, the present research will examine developmental changes and consistencies in children's ability to recall single and repeated events. Furthermore, this research will extend previous knowledge by examining whether a symbolic time-line assists children to recall the time and the duration of single and repeated events, compared to verbal recall techniques. Currently, the time-line is being used by police and social workers to help children recall events, yet there has been very little empirical research done to assess the effectiveness of this technique (Poole & Lamb, 1998), and there has been no research that has examined the effectiveness of the time-line with repeated events.

This paper will begin with an overview of the current theories of temporal understanding. Developmental changes in children's temporal understanding will then be discussed, followed by research using time-lines. This introduction section will end with an outline of the exact predictions of the present research.

Theories of Temporal Memory-Overview

Various theories of temporal memory have been proposed that would explain how children recall the time of an event. Currently, despite the number of theories, there is not a single theory that will consistently predict memory for time in children. In fact, several

theories are often needed to explain and predict how children recall an event. Further, the type of theory that predicts recall will vary depending on the way in which the memory is recalled and the type of temporal memory. In the following section four main types of temporal theories will be outlined. These theories will consist of a) distance-based theories such as strength theories, b) location-based theories such as the reconstructive theory of memory, c) fuzzy-trace theory and d) the source-monitoring framework.

Distance-based theories such as chronological organization theory predict that our memories are organized in sequential order and we examine the event that we are trying to recall, in relation to other events in order to determine when it occurred. Furthermore, memories that contain less information must be further away than memories that contain more information, because information is forgotten over time. Distance-based theories of temporal memory such as strength theory rely on the strength of a memory to determine the memory's location in time. Distance-based theories predict that a memory will be judged as more recent if the memory trace is more vivid than another memory trace (Friedman, 1991). These theories of memory do not require information about the content of an event or the specific time-frame it occurred in to remember it. Recall is specifically based on the strength and the position of the memory in relation to our other memories. A distance-based approach to memory is used specifically when we want to recall how long ago an event occurred (distance), without information about the time-frame during which it occurred (location). For example, if we were to remember if we built a snowman a long time before we went tobogganing we would be making a distance judgment, whereas, if we were to recall the day of the week we made a snowman we would be making a location based judgment (Friedman, 1991).

In contrast to distance-based theories, *location-based theories* of temporal memory do not rely on the strength of a memory to determine when an event occurred. Location-based theories rely on information that is established at the time of encoding and later retrieved when the memory is recalled (Friedman, 1993). For example, when trying to recall when someone went on a picnic he/she would consider the weather at the time of the picnic, who he/she was with, or possibly the clothes he/she was wearing. These pieces of information would provide cues to when the event occurred. This process is similar to how a work of art can reveal information about the period it was made during by studying the materials it was made of, as well as the theme of the art. The two location-based theories that will be presented here are time-tagging theory and reconstructive theory of memory.

Time-tagging theory states that time information is added at the time an event is encoded and is later retrieved to determine when an event happened, therefore, if we want to recall the time of an event we must recall the tag associated with it (Friedman, 1993). One shortfall of this theory is it does not speak to what information is used as a tag. It does not differentiate between temporal (time of day) and contextual information (the colour of a person's shirt or hair) as a tag. If we are unsure of what information is used as a tag then it is difficult to determine what information can be used to help recall a memory. Contextual information, such as the colour of a person's shirt can be used as a tag because if we can remember the colour of a person's shirt on a given day, this information may cue us to other details that will allow us to recall the time of the event. For example, remembering the colour of a shirt may remind us that the person was also wearing a sun hat that matched their shirt, which will remind us it was sunny out.

The second location-based theory that will be examined is the reconstructive theory. The reconstructive theory for memory of time rests on the assumption that information about the environment, for example that a new activity has just begun or that it is hot outside and information about a person's internal state is coded along with the particular item that is to be remembered. During recall of a particular event, environmental information and/or information about a person's internal state at the time of the event is retrieved to help reconstruct the time of the event (Friedman, 1991). The reconstructive theory also rests on the assumption that to correctly recall the time of an event we must have an understanding of temporal patterns. Temporal patterns can be formal patterns such as the day of the week or less formal patterns such as a daily routine for getting ready for work, depending on what time-frame the memory is to be recalled in. Knowledge of temporal patterns is necessary for memory because we recall the contextual details of an event and then examine our schema or temporal patterns using this contextual information to make sense of when an event occurred (Friedman, 1991).

It has been hypothesized that both distance-based theories and location-based theories are working in unison in adults and children to assist with the recall of different types of information (Friedman, 1991). It has also been hypothesized that location-based approaches of memory are the least likely to be developed in young children and show the most developmental change (Friedman & Kemp, 1998). Furthermore, Friedman and Kemp (1998) have predicted that the largest change in children's ability to recall temporal information will occur after the age of seven as this is when they are beginning to understand long term time-patterns and can use location-based approaches to recall the time of an event more effectively. Without the ability to use temporal patterns, children

are only able to judge the strength of an event in relation to another, they are unable to judge the time of an event effectively. The present study will use location based theories to make predictions, as the tasks in this study are location recall tasks.

Fuzzy-trace theory is similar to distance-based theories of temporal memory in that fuzzy-trace theory also relies on the strength of memories to make predictions, although the similarities end there. According to fuzzy-trace theory, memories are dually encoded as two separate but related representations: verbatim and gist. Verbatim traces are well-defined and hold the specific details such as the exact time (e.g., the car accident happened at 10:00 am on Wednesday) or location of the event (e.g., I saw the car accident happen in front of the grocery store). Gist memories on the other hand are vague and do not contain any exact information; instead they contain information about the overall impression of an event (e.g., the car accident happened sometime during the work day and I saw it happen while I was driving in town) (Brainerd & Reyna, 1990). Thus, retrieval of verbatim memories will provide exact time information, whereas retrieval of gist memories will provide vaguer temporal information. With fuzzy-trace theory, verbatim and gist memories are independent and stored parallel to each other. One of these memory types will be recalled over the other depending on the factors present during recall. For example, when recalling an event if a person is cued to think about how they felt during the event they will more likely recall gist details, whereas if they are cued to think about the weather they are more likely to search for verbatim details. It is also the case that verbatim traces decay at a faster rate than gist traces, especially in young children (Reyna & Brainerd, 1995), and young children also have a difficult time separating gist and verbatim memories (Reyna, 1995). Because young children have

difficulty recalling verbatim traces and they decay at a faster rate, young children will be more likely to use gist traces when recalling an event. This is problematic when trying to recall the time of an event because time details are stored in verbatim traces, rather than gist. The ability to use verbatim details increases with age and recall for temporal information, will therefore increase with age. Fuzzy-trace theory will assist in predicting age differences in the present study.

The final 'theory' of memory that will be used in this research is the *source-monitoring framework.* The source-monitoring framework specifies that memories of events contain perceptual, contextual, affective, and semantic information that can later be retrieved and used to identify the source of events. Although not explicitly stated in the framework, we can assume that temporal information is one aspect of contextual information. The framework predicts that the more discriminating information (contextual and temporal) that is encoded with an event, the more likely the source will be correctly attributed to the event (Johnson, Hashtroudi, & Lindsay, 1993). Rather than directly recalling the time of the event (as would be predicted by fuzzy-trace theory, for example), the encoded contextual information would be used to attribute the event to a specific time (e.g., "I remember fireworks, so it was probably Canada Day"; "I remember it was a really hot day, so it was August"). The more information that is present at the time of encoding and retrieval, the more likely a child will be to associate the correct time period with the event in question. That is, there are more cues to source. Techniques that assist children by providing cues may help children to recall the source of an event with greater accuracy; therefore the source-monitoring framework can be used to make predictions about children's ability to use a time-line. A time-line may assist children in

recalling events because it will provide children with some visual cues to the beginning and end of events, which will focus the children's thinking on the time-frame in question. It will prime children to think about the exact time-frame during which an event occurred. If the time-frame is of a day, this may prime children to consider whether it was still dark when something happened, did they just have something to eat, or was it at home or at school. Source monitoring framework will also be helpful in making predictions about children's ability to recall single and repeated events. Recall of single and repeated events differ because of the number of discriminating contextual details contained in each and source.

Age Differences in Temporal Memory

Based on the theories previously discussed in this paper, it is realistic to expect age differences in children's ability to recall the time of an event. Each of the theories presented in this paper predict that as children age, their ability to recall details from an event, represent time frames, recall verbatim memories or recall source improves. Furthermore, research has demonstrated age differences in three abilities that are relevant to the current research: The ability to sequence events, judge the duration of an event and localize an event in time.

There are some distinct developmental changes that occur between the ages of three and five with respect to the ability to judge the forward (order picture cards of breakfast, lunch, dinner and going to bed, starting with breakfast) and backward order (order picture cards of breakfast, lunch, dinner and going to bed, starting with bed) of daily activities, as well as the ability to determine duration of events (Friedman, 1990). In Friedman's study, children were presented with picture cards depicting daily activities such as eating

breakfast and going to bed and they had to order the cards as well as judge the amount of time that elapsed between activities. When determining the amount of time that had elapsed between activities, children were provided with a linear scale with 10 squares on it with a picture of a full hour glass at one end of the scale to represent a lot of time and a partially full hour glass at the other end to represent less time. Children were then presented with sets of picture cards that represented different durations (breakfast to lunch vs. breakfast to bedtime) and the children were asked to place the pictures on the scale and consider the length of time between the events and use the scale to represent this time.

The results of this study demonstrated that children begin to sequence events from their day in forward order from age four, and in backward order from age five. Also, at age four, children can sequence events from their day when starting at different reference points and, by the age of six, children become able to sequence events from their day in backwards order when starting at difference reference points (Friedman, 1990). Furthermore, results by Friedman (1990) indicate that children as young as three and four have knowledge of the duration of an activity and are able to represent this along a time-line. In addition, a developmental increase in the ability to represent duration was found. As children aged they were better able to distinguish between the events that had a long time between them and the events that had a short time between them. This research is important as it shows children's ability to sequence events from their daily lives, thus providing evidence that children understand order, sequence and duration from relatively young ages.

A second set of studies have also demonstrated young children's ability to sequence events, this time familiar and novel event sequences (Bauer & Mandler, 1989; Bauer, Hertsgaard, Dropik, & Daly, 1998; Wenner & Bauer, 2000). In these studies, children as young as 13.5 months are able to reproduce sequences of events that are familiar (taking off a bears shirt, putting the bear in a bath tub, washing the bear) and novel (attaching cars together, putting the cars on a track, putting a doll in one of the cars) after modeling by an adult (Bauer & Mandler, 1992). After children were shown a sequence of actions they were provided with the materials to complete the actions on their own and over 75 percent of the children could reproduce the sequences for up to two action sets. In the case of this research children were shown event sequences that they would otherwise not have been exposed to, therefore adding to the research completed by Friedman (1990) that did not examine novel events.

In addition to developmental increases being demonstrated in the ability to sequence events and judge the duration of events, developmental changes are also present in children's ability to judge the recency of past events and to localize an event within a specific time-period (Friedman, 1991; Friedman, 1992). Friedman (1991) asked children 4-, 6-, and 8-years-old to recall which event was most recent from a series of two events, one that occurred seven weeks ago and one that occurred a week ago. Then children were asked to recall the time of day, the day of the week, the month and the season the event occurred during. The 4-year-olds were less accurate at recalling which event was more recent (70% correct), than the 6-year olds (97% correct) and 8-year-olds (100% correct). In regards to placing the seven-week event in the correct time-frame (time of day, day of week, month or season), the 4-year-olds did not exceed chance on any of the four frames,

while the 6- and 8-year-olds did on all of the time-frames other than the day of the week. Finally, children at each of the age groups were able to recall a number of non-temporal details about the event. Almost all of the children were able to recall the gender of the person who did the event as well as the location of the event (outside on the playground) (Friedman, 1991). These results demonstrate that children as young as 3-4-years old have difficulty recalling the time of an event, yet they do not have difficulty recalling contextual details from the event. This may demonstrate the inability of young children to understand or use specific time frames to recall the time of an event. According to reconstructive theory, while young children can recall contextual cues, they do not have the knowledge of particular time-frames and therefore cannot localize the time of events. As children begin school around the age of 5 they will begin to develop an understanding of time-frames and this is when we can expect an increase in the ability to localize events in time.

A second follow-up study was carried out with a larger sample of 4-year-olds in order to detect smaller differences. Friedman (1991) concluded that a sample size of 14 for the nursery children may have contributed to low power and therefore a smaller chance of detecting differences, instead of the inability to determine the recency or location of the event. Children at the age of 4 should at least be able to judge the recency of an event because they are able to use distance based approaches to memory at this age. When Friedman combined the 14 children from study one with 15 more in study two a binominal test of significance revealed that the nursery school children were able to judge the recency of an event at a level above chance, yet were still unable to make location

judgments (Friedman, 1991). A summary of the studies in Friedman (1991) can be seen in Table 1.

The results of this study by Friedman (1991) indicate that children at the age of four have the ability to judge duration but not the ability to localize events in time. Thus, young children have the ability to use duration-based approaches to understanding time but not location-based approaches. Because the younger children performed as well as older children at recalling non-temporal details, we may expect that children cannot localize events in the past because they do not have as refined an understanding of daily time patterns. Source-monitoring framework can also explain the results of the older children. Possibly the older children were unable to determine what day of the week the event occurred because there is less discriminating information between the days of the week than for any of the other time-lines used in this study. The older children were probably able to recall the time of day, month and season because they were able to recall some discriminating information about these time-frames. In contrast, the younger children were probably not able to encode or to recall any discriminating information.

Another way to assess children's ability to locate events in time is to ask children to recall memories from specific times in the past such as 'yesterday', 'the weekend' and 'last summer'. Friedman (1992), asked 4-to-9-year-olds to recall memories from the aforementioned time periods and all of the memories were then verified with a teacher or parent for accuracy. All of the children including the 4-year-olds were able to recall accurate memories from these times regardless of their understanding of specific temporal patterns and there was only a minimal increase in ability with age. Although children often do not have an understanding of temporal patterns at the age of four, all of

the children must have had some understanding of what usually happens at these specific times, to be able to complete this task. Distance-based theories would not have provided support for the children's ability to recall the strength of a memory for what happened last summer because it was so far away; clearly the children had to reconstruct some of what happened to provide them with cues.

The research presented in this section demonstrated that children as young as 13.5 months are able to sequence events, when the actions follow a logical sequence. Children as young as 48 months have an understanding of the duration of an event, can judge the distance from one event to another and have some abilities to reconstruct specific events. But it is not until 80 months that children can locate events in time and have an understanding of some temporal patterns.

Time-Line Research

One method for assisting children under age 7 to recall temporal details of an event may be to provide them with a time-line. A time-line is a visual aid that provides children with a line that has anchors of whatever time-frame the memories are being recalled in. In a study by Friedman (1991) previously discussed in the above section on age differences in temporal memory, children were asked to locate an event on two separate visual time-lines; time of day, and season. The study in which Friedman (1991) included the time-line was the third study in a series of three that were presented in one paper. The decision to include a time-line was made because Friedman hypothesized it would help young children who did not have a mature vocabulary for temporal words, localize the time of events, which the children were unable to do in his first study verbally. For the purpose of the following section of this paper, only the results for the verbal recall of a day from

Friedman's study one and the results for the time-line recall in Friedman's study three will be discussed as these are the most relevant to the present study. It is also important to note that while we will be making a comparison of children's performance on the time-line and verbal recall, these results are across two studies with different children. While Friedman made this comparison in his paper and ultimately concluded that young children could localize events on time-frames as small as a day, it was not Friedman's intention to measure children's ability to use a time-line; therefore the examination of time-line use was not properly controlled, the comparison between time-line and verbal recall is between studies and the implications of the results were not extensively discussed in his paper.

Again, as described previously, Friedman (1991) had demonstrated that children were not able to localize events until they were 6-years-old. The third study that was completed as part of this article again examined this ability in 4-, 6-, and 8-year-olds, except this time the children used a time-line for the time of day and the season task. A time-line was not used for the day of the week or for the month estimates of time, as these were hypothesized to be difficult to represent visually; these were still provided verbally. The time-line of the day consisted of anchors of waking, eating lunch, eating dinner and going to bed, while the time-line of the seasons had pictures of the four seasons (Friedman, 1991).

In contrast to study one that did not use a time-line, the 4-year-olds in study three were able to reach a level above chance when they used the time-line of the day, yet were still at levels below chance for each of the other three time scales, indicating that they only have knowledge for short time-lines. Time-lines that represent short time

frames such as a day may assist young children while time-lines of longer time frames such as seasons may not be of value. In contrast to the preschool children, the 6 and 8-year-olds who had performed above chance when identifying the time of day when not using a time-line in study one, did not perform at a level above chance while using the time-line in study three. All of the 8-year-olds were able to judge the current time, on all of the scales while the 4-year-olds could not judge the current time on the scale of the season or day of the week.

Friedman (1991) attributes the decline in performance of the older children in judging the location of the event on a time-line to confusion over recess. The older children may have had difficulty with the time-line of a day because they had two recesses during the day and the preschool children only had one recess. The older children may have confused the morning recess for the afternoon one. With regards to the younger children, their performance increased but it could be because of the way the time-line was scored. Children were scored as correct if they pointed anywhere between wake and lunch for the time of day and the event occurred during morning recess. This may have been too liberal of a time-frame, yet the younger children still did better than the older. Friedman (1991) does not directly attribute the differences in results to the time-line and it is clear that more research is necessary to determine if in fact this may be a useful procedure for helping younger children to report on the location of events and how it may affect the performance of older children. In fact, the purpose of Friedman's research was to determine age differences in the ability to determine the recency of two events as well as the ability to localize events in time. The time-line was used simply as a tool and the implications of its use were not addressed. Furthermore, the participants that

used the time-line in Friedman's study were different than the ones that recalled the events verbally and a within subjects design may allow for a more accurate comparison between tasks.

Time-lines have been used in other studies; however these have examined different types of time judgments. For example, Friedman and Kemp (1998) used a time-line without anchors to represent a "short time" and a "long time". The children in this study were told that the near end of a ruler represented the recent past and the far end represented the distant past. The children were asked to place cards on the time-line according to if they happened a short or long time ago. In this study 5-, 6-, and 7- year-old children were able to use a time-line to judge the difference between a short time ago and a long time ago when placing pictures of events such as their birthday on the time-line. In this particular study, time-lines were used as a visual aid for representing distance. Because the time-lines used in this study did not include picture anchors that represent the beginning and end of the activity, the time-lines did not provide any extra cues that may assist in recall. In addition, the time-line used in this study is examined children's ability to provide distance information, while the one used by Friedman (1991) and the one that was used in the present study are aids to assist children in identifying the location of events in time. These two uses of a time-line examine different abilities in children.

In sum, very little research has been done that demonstrates that children can use time-lines and at what age can they use time-lines (Poole & Lindsay, 1998). The few studies that examined time-line understanding, have only used time-lines that represent time of day and season, or the time-line has not had specific anchors and has represented

length of time like the one used by Friedman and Kemp (1998). It is quite possible that children can use time-lines and we have not examined in detail what types of time-lines can be used. Furthermore, the studies that have used time-lines have not specifically been examining the validity of time-lines and in turn may not have focused on important details. In addition, the few studies that have used time-lines have not always found consistent results (Friedman, 1991), as demonstrated in the Friedman (1991) study showing that younger children performed better when using a time-line while the older children did not improve and in fact their performance decreased. In addition, there has not been a clear comparison between children's ability to use time-lines and report verbally about an event. This comparison may provide the most accurate assessment of children's capabilities. If children show superior knowledge of temporal information using time-lines compared to their verbal recall, it will demonstrate that children understand temporal concepts before they are able to verbally use this information. If there is no difference in their knowledge across the two techniques, however, then time-lines are not needed to enhance children's competence.

Recent time-line research (Gosse & Roberts, 2005)

In response to the lack of research on the use of time-lines, a study was conducted that examined a variety of temporal skills to determine whether or not young children can use time-lines (Gosse & Roberts, 2005). The goal of this study was to measure children's ability to use time-lines and determine if there are age differences in this ability. Furthermore, the goal of this research was to examine a series of temporal skills such as the spontaneous mention of temporal words, the ability to sequence events and recall a task in forward and backward order to determine if children as young as 3-4 years old

have these abilities and whether these abilities are significantly different from those of 7-8 year olds. Table 2 provides a list of all of the skills measured and the tasks used to measure these skills.

Twenty 3-4 year-olds and twenty 7-8 year-olds participated in two activities (made a fish tank and a picture of a sky at night) with a confederate. They were then interviewed and asked to a) freely recall events in forward and backward order (children were asked to recall everything that happened before or after they sat on the blue mat), b) recall the duration of the two activities, c) sequence single and repeated actions from the two activities from memory, d) parents provided events from the previous week that children were required to place on the time-line of a day to measure children's ability to localize remembered events in time using a time-line, e) sequence a series of pictures that did not require memory, and f) use a time-line in a task that did not require memory (place picture cards on a time-line according to a story). The goal of examining time-line and sequencing abilities with and without demands on memory was to determine if children could sequence and use the time-line without the demands of memory. The time-line that was used in this research was a time-line of a day and the anchor at one end was breakfast and the anchor at the other end was bedtime. The events that were provided by parents had occurred during the previous week, but all had a distinct time within the day. In addition, the time-line was only used for two of the six tasks. This provided a representation of the skills that young children do or do not possess, such as the ability to sequence and freely recall temporal words, as well as the ability to use the time-line. If the time-line was used for all tasks, we could not determine if temporal understanding was always a function of ability to use a time-line.

The results of the free recall section in the research by Gosse and Roberts (2005) revealed that children seldom used temporal words (e.g., first, last and before) or made reference to temporal aspects when recalling the activities. On average the 3-4 year-olds used 0.1 temporal references, indicating that most did not use any, and the 7-8 year-olds used an average of 5 temporal references. This would be consistent with the research that has shown developmental differences in children's ability to understand time and time patterns (Friedman, 1991). If young children do not have an understanding of time-patterns they would probably not use temporal words such as 'before' and 'after'. While the children were unable to spontaneously recall temporal details, the results of this task did indicate that 7-8 year-olds were able to understand the words before and after as they were able to recall the same number of correct details when asked to recall the events using either of these terms. However, the young children on average recalled so few details this comparison was not possible to make.

When asked about the duration of the two activities (children were asked to recall which event was longer), the 3-4 year-olds were correct less than half of the time (36.84%), whereas the 7-8 year-olds were correct over half of the time (65%). Overall there was not a significant difference between the performance of the 3-4 year olds and the 7-8 year-olds; however, there was a significant trend.

In regards to the children's ability to sequence events, there were significant differences in the children's ability to sequence six sets of cards from the picture arrangement task in the Wechsler Intelligence Scale for Children-Third Edition (WISC-III). The picture arrangement task includes a series of pictures that depict a sequence of actions, for example, a boy looking at how to cross a river, picking up a board, placing

the board on the river and walking on the other side of the river. The cards are presented in the order suggested by the WISC manual and the children are required to correctly sequence them. For this research the first four sets of cards were used as well as two developed specifically for this research and the 3-4 year-olds only sequenced 2 cards as there were no standardized sets for this age group. For this WISC sequencing task, the younger children sequenced 4.57 out of 6 sets (2 cards per set), and the older children sequenced 5.85 sets accurately (4 cards per set). Although there were significant differences between the two age groups, the younger children still performed well at this task, indicating that they have the ability to sequence actions when they are not required to recall items from memory.

The second sequencing task was a memory sequencing task. For this task, children were required to sequence a series of actions from the two activities. There was a set of single actions (e.g., placing a sun on the picture and putting a fish in the fish tank…), sets of repeated actions (e.g., putting different stickers on a bag, or using different coloured pens…), and sets of actions, one taken from each repeated set (e.g., the sun sticker, and the red pen…). The repeated sets contained five instantiations each and the single set and the sets of one action from each of the repeated sets contained six instantiations. Table 3 contains a list of all the sets of actions the children were asked to sequence. Single and repeated sets of actions were used because it was expected that the children would be the most accurate when recalling the single actions and less accurate with the repeated actions as there is less discriminating information with repeated events.

Results of the sequencing task did demonstrate developmental differences. The older children sequenced the single and repeated actions significantly better than the

younger children did. The younger children often sequenced less than half of the items correctly, while the older children were almost entirely correct for the single actions and correct almost half of the time for the repeated actions. When the children were required to sequence one item from each repeated set, all of the children had difficulty. Actions taken one from each set of repeated events (e.g., one red pen, and one cow sticker) should be easier to discriminate between than repeated events because the actions are different from each other and contain more discriminating information, but not as easily discriminated between as single events. The source-monitoring framework would not have predicted the results found on the memory-sequencing task in this study. The children should have performed better at sequencing one item from each set as these items are not as similar as a set of repeated items, yet they had the most difficulty with these items. A possible explanation for the results found here is that the children were confused when sequencing the one repeated action from each set because they had to consider the whole activity as well as each repeated set (each set was spread throughout the activity) in order to determine the order of the items. Overall the children performed better with the single sets than they did with one item from each of the repeated sets.

The results of the sequencing tasks in this study support the claim that children have the ability to sequence events, but may have difficulty when they have to recall the events and sequence them. Even the younger children were able to sequence the WISC cards, while they had difficulty sequencing even the single items from each of the memory sets. One limitation of this study was the memory sets required the children to sequence 5-6 items. It may be possible that young children cannot sequence more than two or three items from memory.

The final two tasks required the children to complete the non-memory time-line and the memory time-line tasks. For the non-memory time-line, the children were read a story corresponding to the WISC cards they had sequenced earlier, and they were asked to place a card on the time-line in the place that it belongs according to the story (e.g. Sally played on the slide after breakfast). The 7-8 year-olds were highly successful (77%) and most often they were able to place the card in the correct place, whereas the younger children were successful less than half of the time (43%). A comparison group of adults, who also completed this task, were significantly more accurate (92%), than the children. Overall only one adult was inaccurate, but the sample size is small so this is reflected in the percent correct. The children were also asked check questions to determine if they could recall that part of the story that contained the temporal information. It was important to determine if the children cannot use the time-line, or if they are not encoding where the card belongs according to the story. On average, only 5 of the 20 3-4 year-olds gave correct responses to the check questions for each story, while 14 of the 20 7-8 year-olds gave correct responses. This makes it rather difficult to interpret this task. We cannot tell if the younger children simply had difficulty using the time-line or if they did not encode the temporal information from the story.

Reconstructive theory of memory would support our findings, in that 7-8 year-olds appear to be able to use the time-line and they would be the children that do have an understanding of temporal patterns. According to the reconstructive theory, we would not expect the 3-4 year-olds to do well as they have yet to develop an understanding of temporal patterns. Yet Friedman (1991) did find that the time-line of the day did help 4-year-olds. Thus, possibly 3-year-olds are too young to benefit from time-lines and it

would be more accurate to separately examine the skills of 3- and 4-year-olds rather than treat them as a combined "younger group".

In order to analyze the results of the memory time-line task, difference scores were obtained between the parents and the children's time-line placements, and then the difference scores for the 3-4 year-olds were compared to the difference scores for the 7-8 year-olds. The 7-8 year-olds performed better and had more accurate placements on the time-line when compared to their parents than the 3-4 year-old children. The time-line had 21 possible placements and the older children on average had smaller difference scores (M=2.31, SD=1.91) than the younger children (M=5.06, SD= 2.21).

Overall, the results from Gosse and Roberts (2005) indicate that there are developmental differences in children's ability to provide temporal information. The 7-8 year-olds were more accurate than the 3-4 year-olds on all of the temporal tasks (e.g., free recall, duration, sequencing and ability to use a time-line). Furthermore, this research supports the need for more research with time-line use in young children, as this study was unable to clearly identify if children below the age of seven can use a time-line (irrespective of their memory abilities), due to the fact that for the non-memory time-line, many young children did not accurately answer the check questions. Therefore, we cannot determine if they had difficulty encoding the story that explained where the card should go on the time-line or using the time-line.

Present Study

The present study will advance research on children's ability to recall events using a time-line. First, it is important to clarify the results found by Friedman (1991) on the use of the time-line. Second, because the time-line is used forensically and we do not

have empirical evidence of its effectiveness, we need to examine it as a technique used to help children recall the temporal information of an event. Friedman (1991) found that children were able to use the time-line better when they were younger rather than older. These results do not make sense theoretically as theories such as location-based theories predict developmental increases in the ability to recall temporal information. Furthermore, the source monitoring framework suggests that the ability to identify the sources of memories increases with age (Roberts, 2000) and, because temporal information is used in source judgments, we would expect the ability to recall the time of an event to increase with age. Four age groups were examined (3, 4, 5-6 and 7-8 year-olds) to assess developmental differences and consistencies in the ability to use a time-line. The examination of the use of the time-line with these four age groups will add to the literature in that previous research has not specifically examined time-line use across various ages.

One outstanding issue is whether the time-line provides children with any more opportunity to recall temporal information than does a standard verbal technique. The current research was the first to make a direct comparison of time-line use versus verbal recall within the same sample when recalling temporal information about past memories. When Friedman (1991) compared children's ability to recall the location of an event he discussed the verbal recall of participants in one study and the recall of participants using a time-line in another study. This was the first study to make this direct comparison using a within-subjects design.

Finally this study compared the use of the time-line and verbal recall with single and repeated events. Currently there has not been any research that has examined if

children can report on the sequence, location and duration of repeated events using a time-line. Reporting information about the time and place of one event in a sequence of events is critical when providing testimony about a sequence of repeated events (S vs. R., 1989 as cited in Pearse, Powell, & Thomson, 2003). We already know that children, especially young children, have difficulty sequencing events that are repeated because the events are similar and therefore become confused more easily (Powell, Thomson, & Ceci, 2002; Roberts & Blades, 1999). Researchers have been trying to develop techniques that will allow children to better provide information about one event in a sequence.

Pearse, Powell, and Thomson (2003) provided children with contextual cues when recalling events in a repeated set and found that children were better able to recall a specific instantiation when they were provided with contextual cues along with temporal cues to recall. Basically, the children were better able to recall the correct details if the children were provided with details about what they were wearing during the final occurrence in a series as well as asked to recall *the last time*. The time-line may create the same increase in performance because it will allow the children to visually examine the beginning and end of the time-frame the event is to be recalled in.

As previously discussed, a series of temporal theories are required to support the hypotheses presented in this paper. Currently, there is not one unified theory that can predict differences in the ability to locate the time of events, the ability to sequence events, as well as use a time-line. The three main theories that the hypotheses in this paper are based on are: reconstructive theory, fuzzy-trace theory and source monitoring framework. Reconstructive theory will be used specifically to predict age differences and time-line ability in children, fuzzy-trace theory for age differences, and source

monitoring framework to predict age differences, time-line ability and sequencing. While each of these theories can make similar predictions, each contributes a unique explanation as well as identifies a significant ability necessary for children to recall the time of an event. For example, in predicating developmental differences in children's ability to report temporal information, source monitoring framework focuses on children's ability to recall contextual details and determine the source of the event, while reconstructive theory incorporates an understanding of temporal patterns with recall of contextual cues to provide recall. Currently, research has not examined what factors are most critical for temporal recall and which theory is most inclusive in predicting children's temporal recall.

Location-based theories such as the reconstructive theory would predict age differences in the ability to use the time-line because young children, specifically children below the age of 7 will have difficulty understanding the temporal patterns needed to use the time-lines. We would expect there will be some benefit to 4-6 year-olds as they have some understanding of short term temporal patterns demonstrated by Friedman (1991), and the benefit will increase with age, to a point where children do not need assistance. Based on the reconstructive theory the time-line will assist children in recalling events because the anchors will provide visual cues to the children about the contextual information they have encoded as well as provide cues about the specific temporal patterns they are using. The time-line will assist children in recalling events more than verbal questions as the children will constantly have the time-line in front of them and therefore, be provided with constant visual reminders of the specific time-pattern. Furthermore, the younger children may simply have difficulty verbalizing their

responses to time questions and the time-line will allow the children to recall the time of an event without verbally reporting it.

Age predictions can also be made based on fuzzy-trace theory. Fuzzy-trace theory would predict that the traces that young children have that contain memories of temporal order (verbatim traces), would decay faster than gist traces that usually do not contain temporal order information. Therefore based on fuzzy-trace theory, we would expect age differences in recalling temporal memories. We may also expect that the accuracy of these memories would be increased with the time-line (compared to verbal recall) as the time-line would provide cues to the verbatim memories that are harder to access. Young children may also have difficulty figuring out if they should retrieve verbatim or gist information and the time-line would provide cues to the specific information that needs to be retrieved.

The source-monitoring framework would also predict age differences in the ability to use a time-line as the location-based theories predicted. Source-monitoring theory would predict that the more discriminating information (contextual and temporal) that is encoded with each event and the more information available at retrieval, the more information is available to use in making an attribution about the timing of events (Johnson, Hashtroudi, & Lindsay, 1993). When recalling the time of an event we do not specifically encode the actual time (10:00 on Thursday); therefore the more general information we have about that event (it was cold, we were at school, and we were wearing the pink shirt), the more likely we will be able to reconstruct the event and determine the time. Thus, the time-line may provide the children with some general visual cues to source that will allow them to accurately recall further contextual

information that may result in a time judgement, better than if they were asked to recall it verbally. We would also expect age differences in the ability to use the time-line and to recall events verbally in that younger children are more likely to confuse cues that lead to source information (Roberts, 2000). That is, even if young children can use the time-line, they may be more likely than older children to recall the wrong event.

The source-monitoring framework also makes predictions about the differences in the ability to recall single and repeated events. Instantiations from repeated events (sets of different coloured pens, or different stickers) should be harder to discriminate between because they are more similar than unique, single events. Thus, there is little distinctive contextual information associated with each instance of a repeated action leaving fewer cues to use in a source judgment. Actions taken one from each set of repeated events (e.g., one high five, and one blue pen) should also be easier to discriminate between than repeated events because the actions are different from each other and contain more discriminating information, but not as easily discriminated between as single events.

Based on the preceding theories, the following hypotheses were made:

1. There will be a developmental increase in children's ability to recall temporal information about the a) correct sequence and b) location of events, as well as the c) correct duration between actions with both the time-line and verbal recall. Reconstructive theory predicts this result as children are more likely to understand temporal patterns as they become older and it is necessary to have an understanding of temporal patterns in order to locate events in time.
2. Children will more accurately recall the location of an event and the duration between actions (single and repeated) when using the time-line than when

recalling memories verbally. This effect will be strongest in 5-6 year-olds as they will have a partial understanding of time and will be able to use the time-line, but limited verbal skills and so will benefit from the time-line. Children 3-4 years-old may not have enough of an understanding of temporal patterns to use a time-line, and 7-8 year-olds may not need the time-line as their sense of time may be developed enough to recall events verbally.

3. We are also predicting that the ability to sequence temporal events will increase with the use of a time-line compared to verbal recall in younger children, because the time-line will assist with verbal deficiencies in younger children. There will also be an increase in the ability to sequence events with age.
4. Single events will be sequenced better than repeated events, and sequencing one action from each repeated set will be the most difficult task. Source monitoring theory predicts that single events are easier to sequence than repeated events because there is more discriminating information. Sequencing one action from each repeated set should be easier than the repeated sets according to source monitoring theory, but we are predicting the opposite based on previous research. It is possible that while one action from each set contains more discriminating cues than repeated actions, they are actually harder to recall because children have to recall the time of the item in relation to the activity as well as to the repeated set each item came from. There will be a larger difference in the children's ability to sequence single and repeated events with age. The older children will perform better than the younger children. This age effect will not be observed with the sets

of one action from each repeated set as all the children will perform with low accuracy.

Method

Design

Participants came to the Child Memory Lab at Wilfrid Laurier and participated in a 10-minute activity (making a picture of a sky at night on a felt board) with a researcher. Then they took part in four memory recall tasks. The memory tasks assessed children's ability to recall and sequence a series of single and repeated actions based on the sky at night activity and parent-provided autobiographical events using a time-line and a verbal recall method. This study was a within-subject design in that all of the participants received all of the conditions (verbal and time-line), except for age which will be a between subject factor.

The first two memory tasks required participants to recall six events that happened during the past week. The events were provided by parents, and three of these events were recalled using a series of verbal recall questions and three of these events were recalled using a time-line. All of the verbal questions and the time-line assessed participants' understanding of time in relation to a day.

The last two memory tasks required participants to recall six sets of single and repeated actions (each containing four instantiations) from the sky at night activity. The children recalled three sets of actions using a series of verbal recall questions and three sets of actions using a time-line of the activity. All of the questions and the time-line for the activity assessed participants' understanding of time in relation to the activity, as well

as the children's ability to sequence the sets of actions, and identify the duration between the actions.

The recall task based on the parent-provided autobiographical events took place directly after the sky at night activity as it provided a ten minute break before the children recalled the actions from the activity. The order of the time-line and verbal recall within the two types of memory recall was counterbalanced.

Participants

Sixty children were recruited from local daycares and the Waterloo community to come to the memory lab at Wilfrid Laurier for their participation. Of the sixty children, eleven were 3 years old[1], eighteen were 4 years-old (M =54.36, SD = 3.65), fifteen were 5-6 years-old (M =68.87, SD =7.68), and sixteen children were 7-8 years old (M =92.47, SD =7.05). In total, 15 children were removed from the analyses for the following reasons: Six children did not complete the session, one child was removed because he had previously participated in a similar time-line study, and eight three year olds were removed because they were unable to focus on the task.

Materials

Parent provided autobiographical event recall task: Parents were required to provide eight events that have happened in their child's life in the week prior to their participation. Parents were asked to provide events that had a distinct time during the day, were at different times during the day, were pleasant, and were unique. Some parents had difficulty recalling unique events, so events such as swimming lessons were used. Children were asked to recall six of these events, and two were extra in case the children

[1] The 3 year old group was not included in the analysis because they were unable to finish or concentrate for the duration of the interview. The 3-year olds had difficulty with the half hour interview, and the sample was not completed as it was not fair to ask children to complete a task that was too long for them.

could not recall an event. When the parents provided the events to the researcher they were asked to write these events down on a piece of paper labeled one to eight, and the even numbers were asterisked. Half of the participants were asked questions about the time of the asterisked events, and asked to show the time of the non-asterisked events using a time-line. The reverse instructions (i.e., use time-line for asterisked events) were given to the remaining parents. Also, the order in which the parents provide verbal recall and use the time-line was also counterbalanced.

For non-time line events, the parents were asked: *when did _____ (the event) happen?,* followed by: *when in the day did _____ (the event) happen?, did _____ (the event) happen before or after lunch?,* and *was _____ (the event) a short time or awhile after lunch?* The parents were asked to record their responses to these questions on a sheet of paper. The parents could not say their answers out loud as the children were in the room. For time-line events, the parents were asked *using the time-line show me when _____ (the event) happened?* and were given an arrow to point to the time of day for each of the relevant events. The researcher recorded the parents' responses on a separate sheet of paper.

The parents and the children used the same time-line which depicted a day with three anchors (waking, lunch, and bedtime) placed on a horizontal line (Appendix A). These anchors were chosen as they provided the most accurate representation to the beginning, the middle and the end of the day. There were 21 tick marks between each anchor. The waking anchor was placed on the left edge of the time-line and the bedtime anchor was placed on the right edge of the time-line. Parents and children pointed to the anchors but it was made clear that they could not place anything before the first anchor

(waking) and after the last anchor (bedtime). A small arrow was made available for the parents and children to use to identify the time of the event they are recalling.

When the children were asked to recall the events named by their parents they recalled three events verbally and three events using the time-line. Before children began each task, they were provided with two practice recalls for both verbal and time-line recall. For the practice recall the children were told/shown when an event happened to the researcher and they were asked to repeat the information and then provide an explanation as to why they reported the event happening when they did. Due to time constraints, criterion was not reached for all children; each child only received two practice recalls for both verbal and time-line recall and they were only corrected twice for each.

After the practice recall, children were asked a series of questions for each event. For the verbal recall, the questions began with very general temporal recall questions: *do you remember _____ (the event)?, when did _____ (the event) happen?,* and progressed to more specific questions such as: *when in the day did _____ (the event) happen?, did _____ (the event) happen before or after lunch?,* and *was _____ (the event) a short time or awhile after lunch?.* When recalling events with a time-line two questions were asked for each event: *do you remember_____ (the event)?* and *show me on the time-line when_____(the event) happened?.* The order in which children were asked to provide the verbal recall and use the time-line were counterbalanced. A list of all the instructions and questions used for the parent provided event task can be seen in Appendix B, and a summary of the questions can be seen in Table 4.

Sky at Night Activity: For the sky at night activity children placed a series of items that go in the sky at night (e.g., moon and stars) on a black felt board with the researcher.

Throughout this activity children were required to do two sets of four single actions that are unrelated to each other (e.g., draw a circle for a sun, place felt on the back of a moon…), and four sets of four actions that are repeated (e.g., receiving a cow sticker, a bear sticker, an alligator sticker and a rabbit sticker) A list of all the sets of single and repeated actions can be seen in Table 5. The four instantiations in each set were positioned throughout the activity so that two were farther from the middle anchor and two were closer to provide variability when the children were questioned about the distance between the instantiations and the middle anchor. Furthermore, none of the repeated actions were tied to a specific task while making the picture; therefore, the cues for each type of action were equivalent.

Sky at night Activity Recall Task: Children were asked to recall the four actions in the two sets of single actions. Additionally, children were asked to recall the repeated actions in one of two ways: For repeated-set recall, children were asked to recall the four instantiations from two of the repeated sets (e.g., recall that they received a cow sticker, a bear sticker, an alligator sticker and a rabbit sticker); for one-from-each-set recall, children were asked to recall one instantiation from each of the four sets of repeated actions (e.g., putting scissors in the box, doing a 'low five' with two hands, receiving an alligator sticker, and stretching their leg). For the one-from-each-set recall, a counterbalancing system was used so that each item in one set (e.g., stretching leg) appeared in a set with each item from another set (e.g., each sticker). The order of all the sets (single, repeated and one from each set) was counterbalanced using a Latin Square technique when presented to the children during the recall task.

In addition, each child was asked to recall two sets of each type of action (single, repeated-set, one-from-each-set), one was recalled verbally and one using a time-line. The order in which each child uses the time-line or verbal recall was counterbalanced, with the exception of some verbal questions that were always asked last as they provided cues to the information we are looking for and may influence time-line results. For the verbal recall task, children were first shown a picture of the instantiation to be recalled (e.g., an alligator sticker) and asked *do you remember the _____ (instantiation)? and do you remember when we_____ (the instantiation)?* Following a yes response, the picture will be removed and the child was asked *when during the picture of the sky at night did _____ (the instantiation) happen?* After these questions were asked for all of the instantiations in a set, and after the time-line recall the following questions were asked for each of the four instantiations in the verbal recall sets, *Ok, so you remember doing _____, _____, _____ and _____. Which one did you do first? Was _____ before or after _____ (middle anchor)? Was _____ a short time or long time after _____ (middle anchor)?* All of these questions were repeated for each of the three sets to be recalled verbally.

A time-line that depicts the sky at night activity was used to recall the actions from the activity. The time-line had three anchors (sitting down on the blue mat, the alarm clock ringing, and putting the blue mat away corresponding to the beginning, middle, and end of the activity, respectively). The anchors were evenly spaced and the children's placements were measured by placing a clear sheet over the time-line that has lines on it spaced according to cm's. Children were provided with a picture of each instantiation and they placed these on the time-line, one at a time. Children were able to

place the picture of the item on the anchors but it was made clear that they could not place anything before the first anchor and they could not place anything after the last anchor.

For the time-line recall, each child was shown a photograph of the action and asked two questions for each instantiation, *do you remember_____ (the instantiation)?* and *show me on the time-line when we_____ (the instantiation)?*. The child then placed the picture on the time-line. An entire list of the instructions and the questions for the activity recall can be seen in Appendix C, and a summary of all the questions can be seen in Table 4. As with both the verbal and the time-line recall each instantiation from each set was recalled individually. The order of the verbal recall and the time-line recall was presented in the same counterbalanced order that the parents were administered the tasks.

As with the parent recall task, all of the children were given two practice recall questions for the activity recall task. The children were provided with two pictures of items that were not target items from the activity for both the time-line and the verbal recall and asked to show/tell the researcher when the item happened. Again, the children were first told the correct answer, asked to repeat it and then provide an explanation for their answer.

Procedure

Children came into the lab with their parents for 45 minutes. First the parents were given the consent form (Appendix D) and asked to read it over and sign it if they wished to participate. Second, the parents were asked to provide the eight events from their child's life during the past week. The children were then escorted into a separate room divided by a one way mirror where they were asked to sit on a blue mat on the floor. The

parents were able to view the entire session through the one-way mirror. The sessions were video and audio recorded for coding purposes.

After the children sat on the blue mat they completed the picture of the sky at night activity. During the activity an alarm clock went off in the middle and the researcher stood up to turn it off and this was used as the middle anchor for the recall tasks. After the activity was finished the children stood and put the blue mat they were sitting on away on a table.

After the activities, the children moved to a table where they were asked to recall the events named by their parents using the verbal questions or the time-line, as outlined above. This task also served as a distracter task to allow some decay of memories of the sky at night activity. For both the verbal and time-line tasks, the researcher explained the procedure, provided an example and gave the children a practice recall before asking about the parent-provided events. The children were then asked to recall the sets of actions from the Sky at night activity. After the session, the children were escorted back to their parents and debriefed.

Results

The results will be separated into two main sections. First the results for the autobiographical events (parent recall task) will be discussed, followed by the results for the activity recall. Within each section the results will be discussed for when the events or actions occurred, if the events or actions occurred before or after the middle anchor, and if the events were a short or long time before or after the middle anchor, respectively. For the activity recall task, these results will be followed by the sequencing results, as the

children were only asked to sequence actions from the activity and not autobiographical events.

Inter-rater reliability was calculated for the autobiographical recall task as well as activity recall, and overall agreement between coders was high. Inter-rater reliability for the autobiographical time-line task was 99 percent, and 97 percent for the autobiographical verbal recall task. In the case of the activity time-line and activity verbal recall task, inter-rater reliability was 98 percent and 97 percent respectively.

Autobiographical recall task

Time-line accuracy. Differences between parents' and children's scores on the time-line were analyzed using a one-way ANOVA, with age as the independent variable. Difference scores were calculated for the parent time-line task by subtracting the number of centimeters of the child's placement from the parent's placement (time-line ranged from 1-56). Next a mean difference score was calculated across the three time-line placements, one for each of the three autobiographical events provided by the parent that was recalled using a time-line. The mean difference scores ranged from .67 to 22.83.

The results of this ANOVA revealed a significant finding for age, $F = (2, 42) = 12.61$, $p < .001$. The difference scores for all three age groups were significantly different from each other with smaller scores representing more accurate placements by the children. Furthermore, there were 21 centimeters between each anchor on the time-line; therefore the larger the difference score, the more likely that the parent and the child placed the events in different halves of the time-line. Mean difference scores for 7-8 year olds ($M = 4.82$, $SD = 3.24$) were the lowest, which indicates more accurate time-line placements, 5-6 year olds scores were higher ($M = 9.00$, $SD = 5.48$) and 4 year olds had

the highest mean difference scores (M =13.38, SD = 4.98). LSD post hoc analyses were significant at p< .019.

Time-line vs. verbal recall: Location (autobiographical recall). Children's ability to accurately recall the time of day of parent-nominated events was analyzed using a repeated measures ANOVA, with age (3 levels) and response format (2 levels: time-line vs. verbal recall) as independent variables. Children's recall of the events were coded as correct (1) if they were accurately able to identify when the events occurred (parents responses were used as a comparison), or incorrect (0) if the children were unable to accurately describe when the events happened. The three accuracy scores for time-line recall were totaled, as well as the three accuracy scores for verbal recall to create an overall time-line accuracy score as well as an overall verbal accuracy score. Higher scores represent greater accuracy in identifying the time of day of the events. Total scores ranged from 0-3.

The only significant finding for this analysis was for age, F= (2, 42) =10.63, p<.001. Seven to eight year olds (M =2.07, SD= .91) were significantly more accurate in identifying the time of day of the events, than 5-6 year olds (M = 1.40, SD = .93), and 4 year olds (M =1.03, SD = .93). LSD post hoc analyses were significant at p< .01. There was no significant difference between the performance of 4 year olds and 5-6 year olds. Means and standard deviations can be seen in Table 6. In addition, there was no significant difference in the performance of children when using a time-line to recall the events compared to verbal recall. No significant interactions were observed.

Time-line vs. verbal recall: 'Before and after' (autobiographical event). Children's responses were analyzed to determine their accuracy in identifying if the

events named by their parents happened before or after lunch. Children's time-line placements and responses to the before/after lunch verbal questions were coded as correct (1) if they were able to accurately identify the half of the day the event occurred during, or incorrect (0) if they were unable to accurately provide this information. For both time-line and verbal recall total scores were calculated that ranged from 0-3, with higher scores representing greater accuracy.

A repeated measures ANOVA, with age (3 levels) and response format (2 levels: time-line vs. verbal recall) as independent variables, was run to analyze children's ability to recall if the events happened before or after lunch. An age effect was observed, F= (2, 42) =7.54, p=.002, with 7-8 year olds (M = 2.53, SD = .63), performing significantly better than 5-6 year olds (M = 2.20, SD = .85), and 4 year olds (M =1.67, SD = .99), in addition, 5-6 year olds performed significantly better than 4 year olds. LSD post hoc analyses were significant at p< .023. A trend for response format was also observed F= (1, 42) = 3.56, p=.066 (2-tailed). When providing recall using the time-line (M = 2.29, SD = .76), children were more accurate in identifying if the events occurred before or after lunch than when recalling the events verbally (M = 1.98, SD = 1.01). No significant interactions were observed. Means and standard deviations can be seen in Table 7.

Time-line vs. verbal recall: Short/ long time, 'Before and after' (autobiographical event). Children's responses were analyzed to determine their accuracy in identifying if the events named by their parents happened a short or long time, before or after lunch. Again, each event was coded as correct (1) if the child was able to identify if the event was a short or long time before or after lunch, or incorrect (0) if they were unable to accurately provide this information. A total score was created for both time-line and

verbal recall and the total scores ranged from 0-3 with higher scores representing more accurate recall.

A repeated measures ANOVA, with age (3 levels) and response format (2 levels: time-line vs. verbal recall) as independent variables, was run to analyze children's ability to recall if the events happened a short or long time, before or after lunch. An age effect was found, $F= (2, 42) = 5.01$, $p=.011$, with the 7-8 year olds ($M = 1.87$, $SD = .78$) performing significantly better than the 4 year olds ($M = 1.17$, $SD = .87$). LSD post hoc analysis was significant at $p = .003$. In addition the 5-6 year olds ($M = 1.57$, $SD = .90$) were better than 4 year olds but not as accurate as 7-8 year olds. This difference was non significant. A significant effect was also observed for response format $F= (1, 42) = 11.11$, $p=.002$. Overall children were more accurate in identifying whether the event was a short or long time before or after lunch when they were using the time-line ($M = 1.80$, $SD = .79$) compared to verbal recall ($M = 1.27$, $SD = .91$). No significant interactions were observed. Means and standard deviations are included in Table 8.

This section examined the results for the autobiographical recall task. Overall, there were developmental differences in children's ability to recall temporal information about autobiographical events for all of the tasks, with 7-8 year olds always performing better than 5-6 year olds, and better than 4 year olds. In addition, significant differences were also observed for recall format, but only on one task. When asked to recall if the event occurred a short or long time before or after lunch, children were more accurate when using a time-line than verbal recall.

Activity recall task

Time-line vs. verbal recall: (activity). Children's accuracy scores for recall of the actions in the sky at night activity were analyzed using a repeated measures ANOVA, with age (3 levels), response format (2 levels: time-line vs. verbal recall), and action type (3 levels: single, repeated, and one repeated action from each set) as independent variables. For this analysis, each action (4 for each set of single, repeated, and one from each set) was coded as correct (1) if the child was accurately able to identify using a time-line and verbal recall when during the activity the action happened. Children were incorrect (0) if they were unable to provide this information. Scores for each set of actions (i.e., single, repeated, and one from each set) range from 0-4 with higher scores representing greater accuracy.

For this analysis, a significant age effect was observed, F= (2, 42) =8.06, p=.001, with 7-8 year olds (M = 2.04, SD = .66) significantly identifying the time of the actions with more accuracy than both the 5-6 year olds (M = 1.50, SD = .66) and the 4 year olds (M = 1.08, SD= .66). LSD post hoc tests for age were significant at $p < .029$. There was no significant difference between the performance of the 5-6 year olds and 4 year olds. A significant effect was also found for action type F= (2, 84) =4.39, p =.015. Means and standard deviations can be seen in Table 9. Overall children were better, although not significantly, at identifying the time of single actions (M = 1.80, SD = .45), than repeated actions (M =1.54, SD = .64), and significantly better at identifying the time of single actions compared to one action from each repeated set (M = 1.28, SD = .54), $p < .001$. No significant effects were observed for response format and no interactions were found.

Time-line vs. verbal recall: 'Before and after' (activity). Children's identification of when the actions occurred within the activity were analyzed using a repeated measures ANOVA, with age (3 levels), response format (2 levels: time-line vs. verbal recall), and action type (3 levels: single, repeated, and one repeated action from each set) as the independent variables, to determine if children were able to place the actions in the correct half of the activity. Children's time-line placements and responses to the before/after alarm clock verbal questions were coded as correct (1) if the children were able to accurately identify the half of the day the activity the action occurred during, or incorrect (0) if they were unable to accurately provide this information. For both time-line and verbal recall total scores were calculated that ranged from 0-4, with higher scores representing greater accuracy.

Results of this analysis revealed a significant interaction for response format and action type, F= (2, 84) =13.13, p<.001.The time-line assisted children in recalling single actions more than repeated actions or one action taken from each set. See Table 10 for means and standard deviations and Figure 1 for a graph of the interaction.

Main effects were also found for age, F= (2, 42) = 12.04, p<.001, response format F= (1, 84) = 11.43, p=.002, as well as for action type F= (2, 84) =13.56, p<.001. There was a significant difference between all age groups, with 7-8 year olds (M = 2.79, SD = .58) being more accurate, than 5-6 year olds (M = 2.32, SD = .58), followed by 4 year olds (M = 1.74, SD = .58), p< .034. When providing recall using the time-line (M = 2.50, SD = .38), children were more accurate in identifying if the events occurred before or after lunch than when recalling the events verbally (M = 2.07, SD = .45). In addition, children performed significantly better when identifying the location of single actions (M

= 2.74, *SD* = .53) than repeated actions (*M* = 2.17, *SD* = .47) and significantly better when identifying the time of single actions compared to one taken from each set (*M* = 1.94, *SD* = .47) $p < .001$.

Time-line vs. verbal recall: 'Short/long time, before and after' (activity). Children's ability to identify if each action happened a short or long time before or after the alarm clock went off during the activity was also analyzed using a repeated measures ANOVA, with age (3 levels), response format (2 levels: time-line vs. verbal recall), and action type (3 levels: single, repeated and one repeated action from each set). Each event was coded as correct (1) if the child was able to identify if the event was a short or long time before or after the alarm clock, or incorrect (0) if they were unable to accurately provide this information. A total score was created for both time-line and verbal recall and the total scores ranged from 0-4 with higher scores representing more accurate recall.

Results of this analysis demonstrated an age effect, $F = (2, 42) = 7.07$, $p = .002$, with the 7-8 year olds (*M* = 1.72, *SD* = .62) performing better than the 5-6 year olds (*M* = 1.28, *SD* = .62) and significantly better than the 4 year olds (*M* =.87, *SD* = .62). LSD post hoc tests were significant at $p = .001$.There was also an effect for response format $F = (1, 42) = 16.21$, $p < .001$. See Table 11 for means and standard deviations. Overall children were more accurate in identifying whether the event was a short or long time before or after the alarm clock when they were using the time-line (*M* = 1.47, *SD* = .40) compared to verbal recall (*M* = 1.11, *SD* = .40). In addition, there was a main effect for action type, $F = (2, 84) = 9.02$, $p < .001$. Children were able to identify when single actions (*M* = 1.41, *SD* = .47) occurred during the activity with more accuracy than repeated actions (*M* = 1.48, *SD* = .51), and with significantly more accuracy than one action taken from each repeated set

(M =.98, SD = .40). Repeated Actions were also sequenced significantly better than one action from each set. Pairwise comparisons were significant at $p < .001$. No significant interactions were observed.

Results examining children's ability to recall when the actions occurred during the activity demonstrate that overall 7-8 year olds were more accurate than 5-6 year olds and 4 year olds. With respect to response format, children were significantly more accurate at identifying if the actions were before or after the middle anchor and if the actions were a short/long time before or after the middle anchor when using the time-line, with the exception of the before/after task. For this task the 5-6 year olds and 7-8 year olds were slightly better for some action types when using verbal recall. In addition, children were more accurate when determining the location and duration of single actions, then repeated, followed by one from each set.

Time-line vs. verbal recall: 'sequencing' (activity). Three repeated measures ANOVA's with age (3 levels), response format (2 levels: time-line vs. verbal recall), and action type (3 levels: single, repeated, and one repeated action from each set) as independent variables were run to determine children's ability to sequence the sets of actions from the sky at night activity. Three separate scores were used as dependent variables. The first were 'pairs scores' which were created by examining how many pairs of actions out of four (four actions from each single, repeated, and one from each set) the children were able to properly sequence. Higher pairs scores indicates greater ability to sequence and the scores ranged from 0-3. The second dependent variable is 'individual placement scores', which measures the number of actions out of four that were accurately sequenced. Higher individual placement scores represent more accurate sequencing and

scores ranged from 0-4. The third dependent variable is the 'distance score'. The distance score was calculated for each action by subtracting its location in the sequence of four actions, from its correct location. For example, if the child said putting the moon on the picture was the fourth thing they did and it was really the second their distance score would be two. Smaller distance scores represent more accurate sequencing. Scores ranged from 0 - 9.

Sequencing – Pairs. The analysis for pairs scores resulted in a significant 3-way interaction between age, response format, and action type, F (4, 72) = 2.91, p=.027. Means and standard deviations for the interaction can be seen in Table 7 and Figure 2. Follow up analyses were performed separately for each age group. Three repeated measures ANOVAs with response format (2 levels: time-line vs. verbal recall) and action type (3 levels: single, repeated, and one repeated action from each set) as independent variables were performed. The analysis for the 7-8 year olds was the only to produce any significant effects. There was a significant effect for action type, F= (2, 28) =3.70, p=.038. Single actions were sequenced with significantly more accuracy than one action from each set, F (1,14) = 8.73, p = .010. The results demonstrate that 7-8 year olds were able to sequence single items better when using a time-line compared to verbal recall, yet the opposite was found when sequencing repeated items. T-tests were also performed to examine differences for each age group to compare time-line versus verbal recall techniques for single, repeated, and one action from each set. Nine t-tests were completed in total, with alpha lowered to 0.01, and no significant results were found.

In addition to the 3-way interaction, a main effect was found for age, F= (2, 42) =4.98, p=.012, with 4 year olds (M = .19, SD = .45) sequencing significantly less actions

correctly than 7-8 year olds (M = .71, SD = .50) and 5-6 year olds (M = .65, SD = 2.26), p <.018. A main effect was also found for action type F= (2, 72) =7.48, p=.001. Single actions (M = .68, SD = .80) were sequenced significantly better than repeated actions (M = .67, SD = .73) and one action taken from each repeated set (M = .21, SD = .43) p <.01. There was no significant difference between repeated actions and one action taken from each repeated set. Means and standard deviations for the interaction can be seen in Table 12.

Sequencing - Individual Placement. The ANOVA examining individual placement yielded significant effects for age F= (2, 36) = 5.64, p<.001, as well as action type, F= (2, 72) =9.76, p<.001. With regards to age, 4 year olds (M = 1.056, SD = .57) were significantly less accurate than 5-6 year olds (M =1.61, SD = .57) and 7-8 year olds (M =1.78, SD = .57), p< .023. In addition, children were significantly more accurate when sequencing single actions (M = 1.77, SD = 80), and repeated actions (M =1.56, SD = .88), than when sequencing one action from each repeated set (M =1.12, SD = .68), p< .008. No significant interactions were observed. Means and standard deviations can bee seen in Table 13.

Sequencing - Distance scores. The analysis for distance scores resulted in a significant main effect for age F= (2, 42) =9.644, p=.001, as well as for action type F= (2, 72) =12.68, p<.001. With regards to age, there was a significant difference between all three age groups, and 7-8 year olds (M = 2.96, SD = 1.08) were able to sequence the most actions correctly followed by the 5-6 year olds (M = 3.81, SD = 1.08), and than 4 year olds (M = 4.80, SD = 1.08), p <.50.

With regards to action type, there was a significant difference between single actions ($M = 3.12$, $SD = 1.54$) and one action from each repeated set ($M = 4.64$, $SD = 1.28$), as well as between repeated actions ($M = 3.80$, $SD = 1.75$) and one action taken from each repeated set, $p < .010$. Means and standard deviations can be seen in Table 14.

With each type of analysis, 7-8 year olds were more accurate at sequencing than 5-6 year olds and 4 year olds. In addition, children were always able to sequence single actions better than repeated actions and one action from each set.

Discussion

Developmental differences in children's temporal understanding

Hypothesis one stated that there would be developmental increases in children's ability to recall temporal information pertaining to location, duration and sequencing of autobiographical events as well as actions from an activity. Support was found for this hypothesis and developmental changes were evident in all of the tasks in the present study. Consequently, this study has strengthened and clarified previous findings on children's temporal understanding by demonstrating overwhelming support for a clear increase in memory for temporal information with age. With all of our tasks, the 7-8 year olds were the most accurate, then 5-6 year olds, followed by the 4 year olds. In addition, although the 3 year old group was not included in the analyses, they clearly performed the worst, as the three year olds were unable to focus for the entire interview and they were inaccurate on the majority of tasks. Unlike the 4 year olds, the 3 year olds simply would not use the time-line therefore, they were unable to provide any accurate information. One of the goals of the present study was to split up the 3 year olds and the 4 year olds to determine if there were great differences between these groups. While

statistical analysis could not be done to confirm this, there is strong evidence from the differences in their ability to complete the tasks, that the 4 year olds have greater ability to provide temporal recall than 3 year olds.

Location and Duration. For the first memory task (parent provided event), children were asked to provide information pertaining to the location of autobiographical events within the time-frame of a day. Specifically, children were asked to comment on the location of the events within the day with relation to their time before or after lunch. With regards to this task clear increases in ability were seen with age. Seven to eight year olds were always the most accurate on this temporal recall task, and were accurate at least 50 percent of the time when recalling the position of the events within the day, if they were before or after lunch and if they were a short or long time before or after lunch. Five to six year olds were also generally accurate and responded correctly over 50 percent of the time, with the exception of placing the events during the day, without the mention of lunch. It appears that general questions without the mention of an anchor provide more difficulty for 5-6 year olds, than 7-8 year olds. In contrast to 7-8 year olds and 5-6 year olds, 4 year olds were only accurate 40- 50 percent of the time when providing temporal information about the autobiographical events, and performed with significantly less accuracy on all tasks.

For the second memory task (activity), children overall performed with slightly less accuracy than when they were asked to recall the autobiographical events from the past week, but were still able to accurately identify when the actions happened during the activity. As with the parent provided events, 7-8 year olds and 5-6 year olds were more accurate than the 4 year olds on all recall tasks.

Two possible explanations for the small decline in performance are provided. First, the children were probably more interested in events that had occurred during their time at home than the activity they performed in the lab, making the autobiographical events easier to recall than the actions from the activity. Although the activity in the lab was novel, it was structured more like a school task than something exciting the child might have experienced at home, such as going to a hockey game. Second, the children may have found the actions from the activity more difficult to recall because they were asked to recall a piece of a larger activity and they may have viewed the activity more holistically, creating problems when asked to recall a portion. In contrast to the actions from the activity, for the autobiographical events, the children were asked to recall a whole event and not pieces of a larger activity.

Our results pertaining to children's ability to identify the location and duration of events are supported by Friedman (1991). Friedman found that children aged 4-8 were able to judge the relative recency of two events, yet children aged 4 years olds had difficulty when identifying the location of the same events, due to their lack of knowledge surrounding time patterns. In our study we found similar results, in that the 5-8 year olds were able to judge the location of the events in time, yet the 4 year olds had limited success on all recall tasks.

Our results further support location based theories of temporal recall. Location judgments can be difficult for younger children due to their limited knowledge of temporal patterns. Without the knowledge of temporal patterns, children have difficulty reconstructing the time of events. Children as young as four have at times demonstrated some knowledge of temporal patterns as small as a day (Friedman, 1991), which would

account for the occasional accurate performance of the 4 year olds, but their understanding of even short time patterns is not strong enough to allow them to consistently make accurate temporal judgments. In addition, groups of 4 year olds demonstrate a large amount of variation in ability that is not as prominent among older age groups. This variation may have caused some children in our sample to perform far better than others, creating difficulty in classifying children's ability when they are as young as 4. In general, research has demonstrated that young children more readily employ distance based approaches to memory, before they are able to use location based approaches, although both are often used to some degree in unison (Friedman 1992; Friedman 1993; McCormack & Russell, 1997) This makes location judgments difficult for younger children, and we can expect that as children age and develop an understanding of temporal patterns they will begin to use more location based approaches such as the reconstructive model, and be able to provide better temporal recall as our results have demonstrated.

Sequencing. As children aged, their ability to sequence events also increased. In this study children were asked to sequence actions from the sky at night activity and the 7-8 and 5-6 year olds were always significantly more accurate than the 4 year olds at this task. The performance of the 5-6 year olds was often not significantly different than the 7-8 year olds, with the exception of the distance scores. The distance scores were a measure of inaccuracy, and measured the distance that each of the four actions was from its correct location. With regards to the distance scores, the 5-6 year olds were significantly worse than the 7-8 year olds. In this study, the pairs and individual placements scores examined the number of pairs and individual cards that were

sequenced incorrectly. The distance scores on the other hand measured the magnitude of the inaccuracy, in other words, how many places the actions were from their correct location in the sequence of actions. Because there were no significant difference between the 5-6 year olds and 7-8 year olds on the pairs or individual placement scores, but there were for the distance scores, we can conclude that while the 5-6 year olds may not have been inaccurate less than the 7-8 year olds, when they were inaccurate, it was by a larger amount.

Our results, which found developmental increases in the ability to sequence events, further support source monitoring theory. Children are able to sequence events and actions by recalling details about each event that are novel from the next. This ability increases greatly with age, and children as young as 4 years old, often have difficulty monitoring the source of their memories (O'Neil & Gopnik, 1991; Poole & Lindsay 2001). The 4 year olds in the current study were often unable to accurately sequence events, and the 7-8 year olds always performed better than both the 4 year olds and 5-6 year olds.

Children's ability to recall temporal information using a time-line

Partial support was found for the second hypothesis, which stated that children would recall a greater amount of temporal information when using a time-line, rather than verbal recall. We hypothesized that this increase would be seen with location, duration and sequencing types of information. We expected children to benefit from the time-line because it would provide cues to the time frame in question, as well as provide young children with a method of recall that does not require knowledge of temporal words. We had expected this benefit to be greatest with the 5-6 year olds because they already have

partial knowledge of time-frames and we expected the least benefit to be with the 4 year olds because they may not have enough of an understanding of time frames for the time-line to work as scaffolding for their knowledge. In addition, we also expected the 7-8 year olds to demonstrate little variation between verbal and time-line recall because they would already be remembering time information at a level similar to adults.

What we in fact found was, the time-line assisted all of the children and there was no interaction with age. It appears that all children from the ages of 4-8 years old can benefit from using a time-line when providing recall about the duration and location of events. This is an important finding, because this is the first study to directly compare time-line versus verbal recall in the same children. In addition, this is one of the first studies to examine the effectiveness of the time-line as a tool for assisting children with temporal recall.

These results did not support those of Friedman (1991), who had used a time-line with some children when asking them to recall the time of day as well as the season. In Friedman's study, the 4 year olds that used the time-line were more accurate than 4 year olds that did not use a time-line, yet, the 8 year-olds that used the time-line were less accurate than the 8 year olds that did not use the time-line. The present study used a within subjects design as well as specifically designed the questions for the verbal recall and time-line recall so that exact types of information were collected. Currently, more research is needed to clarify children's ability to use a time-line when recalling location information. The present study was the first to make this direct comparison, and while it contradicted previous results, the results in this study would be supported theoretically, while Friedman's are not.

Friedman (1991) found that the 8 year olds' performance decreased with the use of the time-line, while the 4 year olds improved. This is likely attributable to a methodological flaw, considering theory only predicts developmental increases in ability, not decreases. The results found in this research in favour of time-line use support the reconstructive theory of memory. As previously discussed in order for young children to recall temporal information they must have an understanding of temporal patterns. Unfortunately, young children may often have knowledge of time patterns, especially small time patterns, yet they are unable to make the connection between the contextual cues they are using and the time patterns in order to provide temporal recall. The time-line will assist children by making the time pattern salient at the same time as the contextual cues and this may assist young children in making temporal judgments. Time-lines will also be of assistance because they will provide cues to source, which young children tend to confuse. Future research needs to examine the role of contextual cues and the importance of understanding temporal patterns in order to recall temporal information. While theory predicts the importance of both of these factors in recall, little is known about which is more critical to recall, or how these two skills can be increased in children in young children.

Although when providing location and duration information the children always performed better with the time-line, the same results were not found for sequencing. Our third hypothesis predicted that children would sequence actions with more accuracy when using the time-line compared to verbal recall. A three way interaction was found when analyzing pairs scores (which represented the number of pairs sequenced correctly). Further examination of the interaction between age, response format and action type,

revealed that the 5-6 year olds were better on verbal recall than time-line for the single and repeated actions, and the 7-8 year olds were better with verbal recall for repeated actions. It is important to note that while this part of the analysis supported verbal recall over time-line, it is a small portion of all the analysis for sequencing, and the differences were not significant.

Two possible explanations for why the verbal recall technique was more effective for part of the sequencing task is because of the limited practice opportunity provided to children and limited instructions. The practice recall for the time-line only provided children with the opportunity to place one picture on the time-line at once. This did not allow the children to practice sequencing on the time-line. In addition, when children were given instructions on how to use the time-line, they were asked to consider each anchor on the time-line and try to determine when during the activity each action occurred, according to the anchors. While all of the actions were left on the time-line until each set was finished, the children may not have been considering one in relation to another because their attention was not drawn to them. When children were provided with instructions for the time-line recall task, they were only asked to consider the anchors and not the additional actions in each set. In contrast, with the verbal recall the children were specifically asked which action came first, and which one was after that, until the whole set was sequenced. The slight variation in the results, therefore, can be attributed not to the ability to use verbal recall better than the time-line, but potentially to the instructions and limited practice. Future time-line studies need to use instructions that specifically have the children think about sequencing when using a time-line in order to determine the effectiveness of using time-lines for sequencing.

In addition to replicating the results of the time-lines benefit with location, distance and sequencing abilities in children, future research needs to examine the use of different types of time-lines. Based on 4 year-olds' limited knowledge of temporal patterns and insufficient ability to connect contextual cues with temporal patterns, time-lines that are of a small time-frame, such as a day, may be of assistance more than time-frames of larger temporal patterns. In Friedman's (1991) study, even eight year olds were not able to use a time-line of the seasons, and time-lines have not been attempted on other scales. This research is of particular interest, because in the present study a time-line was used for the activity which required children to use abstract thought to infer the time of actions onto the scale. This particular time-frame was one they would not have had prior knowledge of, because it was a time-frame based on an activity completed in the lab. Our results demonstrated that even the 4 year-olds possessed this ability, indicating with the proper training they may be taught to use many other time-lines.

Furthermore, children as young as 4 years old, may have difficulty expressing verbally their understanding of time. A pictorial representation of a time-line will allow children who are unable to use temporal words such as *next*, *yesterday* and *before*, appropriately provide this information to police and social workers.

Sequencing single and repeated actions

Our results for sequencing support our fourth hypothesis and single actions were always sequenced better than repeated actions. In addition, children sequenced repeated actions with more accuracy than one action from each repeated set. Our finding that single actions were the easiest to sequence also supports source monitoring theory. According to source monitoring theory, actions are easier to sequence if each action

contains distinct information. Children are able to retrieve and use distinct information as cues to the order of events more effectively than similar information.

Children also showed a significant increase in their performance when they were sequencing repeated actions than one action from each set. This is a novel finding, in that researchers have previously not examined children's ability to sequence one action from a series of repeated sets, and this is also an interesting finding in that we would expect children to have a more difficult time sequencing repeated actions than one from each repeated set. It would be expected that children would have the greatest difficulty with repeated items because of the lack of discriminating evidence between each item, and when sequencing one item from each set, the items are all different from each other. While source monitoring theory would predict that children would have a more difficult time sequencing one item from each set, our findings support fuzzy trace theory. Children had significantly more difficulty when sequencing one action from each set because they were required to rely more heavily on verbatim details in comparison to gist information. Young children have difficulty retrieving verbatim details about events, and in the case of recalling one action from each set, not only do children have to recall where approximately the action occurred during the activity, but also where it occurred in relation to a set of similar actions. In order to complete both of these processes, children are required to recall a great deal of detail, and there is more room for confusion. For example, when recalling when children gave the researcher a high five with two hands, the children must not only recall when during the activity they gave high fives but where in the sequence of high fives was the high five with two hands.

While our results for sequencing support our fourth hypothesis, which predicted children would sequence single actions with greater accuracy than repeated actions, and they would have the greatest difficulty with one action from each set, we did find that overall children had difficulty with our sequencing tasks. In a previous study, Gosse and Roberts (2005), 7-8 year olds were accurate over 80 percent of the time when sequencing single actions and in the present study they were accurate only 44 percent of the time. The current study had a long interview and took approximately 30 minutes after a 10 minute activity and the sequencing task was the last task the children completed. It is possible that, due to fatigue, children did not perform as well at this task as they could have given less tasks before. Future research should examine children's sequencing abilities in order to confirm the current results and determine if children aged 4-8 are able to sequence single and repeated events with more precision.

Summary

To summarize the current study, children were more accurate in identifying the location and duration of events when they were using a time-line compared to verbal recall. In addition, 7-8 year olds were more accurate than 5-6 year olds, and also more accurate than 4 year olds on all recall tasks. Also, when sequencing actions from an activity, children were more accurate when sequencing single events, followed by repeated and then one from each repeated set. With the exception of using a time-line while sequencing, all of the hypotheses were supported.

This research advances the field of children's memory, by providing a technique that young children can use to assist in temporal recall. Again, future researchers need to focus on the validity of the time-line on different time-scales, as well as for different

types of events. Furthermore, this research contributes to the study of children's memory for single and repeated events. Recalling the time and location of single and repeated events is a large concern for police as it is often a requirement of the courts that children describe accurately the details of at least one event in a series of repeated events. More research needs to be conducted to determine the skills children possess in terms of sequencing, which will lead to more effective, age-appropriate questions.

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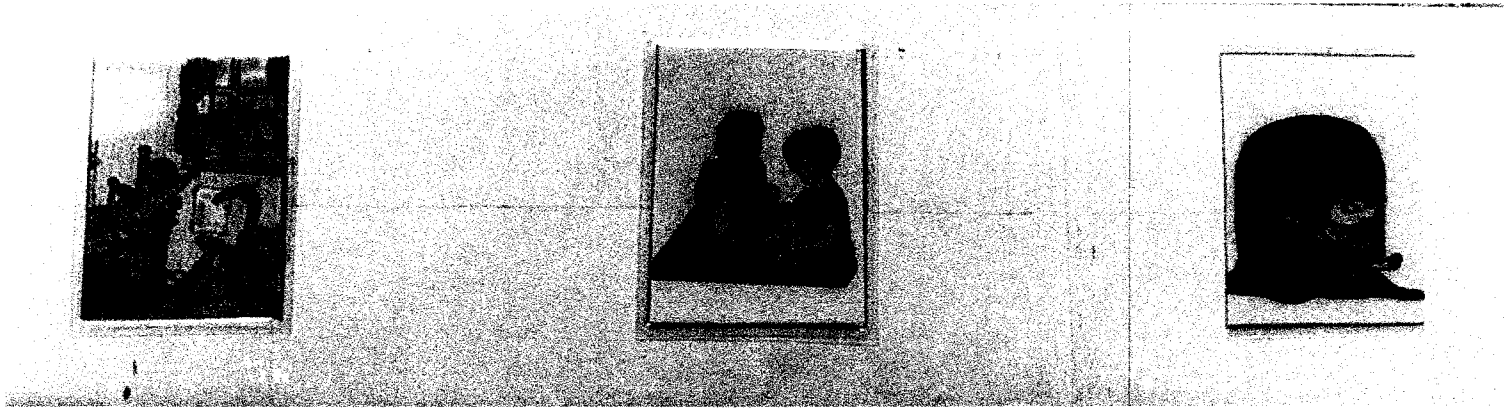
Appendix A

Time-line of a day



Appendix B

Parent Recall Task (time-line instructions in brackets)

I was talking to your ["parent"] earlier and s/he told me about some of the things that you've been doing. I am going to ask you about some things that happened to you and I would like you to tell me [show me] when they happened. Let's see if you can tell [show] me when during the day they happened. Remember, breakfast is at the beginning of the day, lunch is in the middle of the day, and bedtime is at the very end of the day. [To do this we are going to use a time-line of a day. This line shows the whole day. Remember when you are thinking of when these events happened, breakfast is at the beginning of the day, lunch is during the middle of the day and bedtime is at the very end of the day (point to the anchors). When you want to show me when something happened during the day, put this arrow at that time it happened (show arrow).]

I'll do one first, and then you can do one. I remember riding my bike. Now I am going to think when during the day I rode my bike. Let me see. I remember eating my lunch. After I ate my lunch, I helped my mom clean the kitchen, then I put on my bike helmet, and then I went outside to ride my bike. So I rode my bike a short time after I ate my lunch. So what time of day did I ride my bike? Good now let's try to remember one more time. [I remember playing with my friends. Now I am going to think when during the day I played with my friends. Let me see. I remember eating my breakfast. After I ate my breakfast, I brushed my teeth and then I played with my friends. So I played with my friends a short time after I ate breakfast. I am going to place the arrow right here, close to breakfast. So what time of day did I play with my friends, place the arrow at the right time on the time-line?] Provide feedback and explain why child is correct or incorrect.

I remember reading a story. Now I am going to think about what time of day I read a story. Let me see. I remember, before dinner I sat on the couch with my sister and read a story. So I read a story a short time before dinner. So what time of day did I read a story? [Now I am going to think about what time of day I went to the store with my parents. Let me see. I remember after dinner I helped with the dishes and then I went to the store with my parents. So I went to the store a short time after dinner. I am going to place the arrow here a short time after dinner. So what time of day did I go to the store with my parents, place the arrow at that time?] Provide feedback and explain why child is correct or incorrect.

Good job, now it's your turn. I'm going to ask you about some things that happened to you. Let's see if you can remember when in the day they happened. Remember that breakfast is first thing in the morning, lunch is in the middle of the day, and bedtime is right at the end of the day.

Do you remember _____? When did _____ happen? [Show me on the time-line when _____ happened?] (These questions will be asked for each of the six events.)

Followed by: (for each of the verbal recall events)

1. When in the day did _____ happen?
2. Did _____ happen before or after lunch?
3. Was _____ a short time or long after lunch?

Appendix C

Sky at night Activity recall (time-line instructions in brackets)

I am going to show you some things that we used earlier when we made the picture of the sky at night. I'd like you to think about when we used each thing, and tell [show] me when it happened [using this time-line of our picture.]. Remember the very first thing you did was sit on the blue mat, and in the middle of making the picture of the sky at night I had to turn off the alarm clock. Then at the end of making the picture of night you put the blue mat away, that was the very last thing you did. [At this end of the time-line is a picture of the blue mat because the very first thing you did was sit on the blue mat. In the middle is a picture of the alarm clock and it is in the middle because I had to turn the alarm clock off in the middle of making the sky picture. And here at the other end, is a picture of putting blue mat away because the very last you did was put the blue mat away.] Provide feedback and explain why child is correct or incorrect.

Now let's remember one together. Here is a picture of the blue planet we put on the picture. I remember we put it on the picture, a short time after the alarm clock went off and a while before we put the blue mat away. Now tell me when we put the blue planet on the picture? [Here is the picture of the shooting star we put on the picture. I remember when we put it on the picture, I am putting it here because we did this a short time after the alarm clock went off and awhile before I put the mat away. Now show me where the shooting star goes on the time-line.] Good job! Provide feedback and explain why child is correct or incorrect.

Now let's do another one. Here is a picture of the comet we put on the picture. I remember we put it on the picture, after we sat on the blue mat before the alarm clock went off. Now tell me when we put the comet on the picture? (Here is a picture of the red planet we put on the picture. I remember when we put it on the picture, I am putting it here because we did this after we sat on the blue mat before the alarm went off. Now show me where the spaceship goes on the time-line.] Good job! Provide feedback and explain why child is correct or incorrect.

Good job, now it's your turn to tell [show] me when we did some things from the picture of night. I'm going to show you some pictures of things we did and I want you to tell [show me on the time-line] me when we did it.

<u>First set of questions for verbal and time-line recall</u>

<u>Each question will be asked for each instantiation; single, repeated, and one from each repeated set</u>
Do you remember when we_____? (show picture for verbal recall and give the child picture for time-line)
Tell me when we _____. [Show me on the time-line when we_____.]

Second set of instructions for verbal recall only

Each question will be asked for each instantiation; single, repeated, and one from each repeated set

OK, so you remember doing the _____, _____, _____ and _____. Which one did you do first? Was_____ before or after (middle anchor)? Was_____ a short time after or a long time after (middle anchor)?

Which one was next _____, _____, or_____. Was_____ before or after (middle anchor)? Was_____ a short time after or a long time after (middle anchor)?

Which one was next _____ or_____. Was_____ before or after (middle anchor)? Was_____ a short time after or a long time after (middle anchor)?

And last we have _____. Was_____ before or after (middle anchor)? Was_____ a short time after or a long time after (middle anchor)?

Appendix D

INFORMED CONSENT STATEMENT (PARENTS)

WILFRID LAURIER UNIVERSITY
INFORMED CONSENT STATEMENT
Children's Understanding of Time-Lines
Leanne Gosse and Dr. Kim P. Roberts

You and your child are invited to participate in a research study. The purpose of this study is to find out whether children understand various aspects of time, such as the sequence of actions and whether children can use a time-line. Kim Roberts is a professor in the Department of Psychology and Leanne Gosse is a Masters student.

INFORMATION

Children aged 3, 4, 5-6, and 7-8 are invited to participate in a session during which they will complete one activity with Leanne (making a poster of the sky at night). Following the activity, children will complete a series of tasks to see what kinds of time information they remember about the activity, as well as the events provided by their parents (Before the session begins parents will be asked to provide the researcher with eight events from the past week and the time of day they occurred). There are two tasks the children will complete after the activity. First, children will be asked to recall the time of day of the events provided by their parents. Four events will be recalled using a time-line and four events will be recalled verbally. The time-line children will use has a picture depicting morning at one end and a picture depicting evening at the other, with a picture of lunch in the middle. Second, the children will be asked to recall when a series of single and repeated actions occurred from the sky at night picture. Again, half of these actions will be recalled verbally and half using a time-line. The time-line for this task will represent the sky at night activity and a picture of sitting on the blue mat will be at one end and a picture of putting the blue mat away will be at the other end. A picture of an alarm clock will be in the middle, as the clock alarm goes off in the middle of the session. The session will take 40 to 60 minutes, will be video-taped, **[for parents who visit WLU: and you can observe these sessions through a one-way mirror]. Sixty children will take part in the study.**

RISKS

There are no foreseeable risks or discomforts.

BENEFITS

Children and families will learn about the development of time understanding. The results will be used to provide professionals who interact with children (e.g., teachers, police officers, social workers) with appropriate expectations of what children of different ages can be expected to understand. The results will also inform the scientific community of how children remember events.

CONFIDENTIALITY

Children will be assigned a unique ID number that will be used throughout the study. The videotapes are labeled only with the children's ID number and the dates of the study. The tapes will be stored in a locked cabinet in a locked room and can be accessed by Kim, Leanne, and another trained research associate (exact person to be determined). At the end of the study, the videotapes will be copied to DVDs (again labeled only with the children's ID number and date) and the tapes will be wiped clean. The DVDs will be destroyed seven years from now in accordance with the American Psychological Association ethical standards.

Investigator's signature_____ Date _____

Investigator's signature_____ Date _____

Table 1

Summary of Friedman 1991

	Study One	Study Two	Study Three
Method	Children witnessed two target events, one seven weeks before testing and the second one week before. In the interview children were then asked if they remembered the two events and asked which one was a long time ago and which one was a short time ago. Children were then asked about the day of the week, the time of day, the month and the season of one of the events. For each of the four temporal recall questions the children were asked to identify when they thought the event occurred and how did they know which it could be. For example, how did they know it was winter versus summer.	Study two was similar to study one except the two events were reversed in order to determine if the order of the events in the first study had affected results as the events were not counterbalanced. Second only nursery school children were tested. The purpose of this second study was to increase the sample size from study one in order to detect if nursery school children can in fact determine the order of events.	Study three was designed to control for some of the extraneous factors in studies one and two. In addition, children were asked to give estimates of the current time of day, day of week, month and season and children were provided with a pictorial time-line to use to recall the time of day and the season. The day of week and the month was still recalled only verbally. The time-line was used in this study incase the younger children were unable to use verbal skills to identify when the event took place. For example, the younger children may have known the event took part in the earlier part of the day but been unable to call it morning.
Results	<u>Relative recency judgements</u> The First and Third grade children were almost always able to identify the order of the two events. One out of 27	Of the 15 nursery school children in study two, 12 were able to accurately identify which event	<u>Relative recency judgements</u> Children at all three age groups were accurate at judging which of the two events occurred a longer time ago.

children was inaccurate, whereas 10 out of the 14 nursery school children were inaccurate.

Accuracy of Temporal Estimates

The First and third grade children were able to identify the time of the event on three of the four scales (time of day, month, and season but not day of week), on the other hand, the nursery school children were unable to accurately report the time of the event on any of the four scales.

occurred a long time ago or a short time ago. When the children from studies one an two were combined, 22 of the 29 children were accurate at this task.

Nontemporal information

Children at all ages were also accurate on judging nontemporal information. On average children were able to identify the gender of the person who played the game with them, the location of the game and the content of the photographs.

Accuracy of Temporal Estimates

First and third grade children were accurate at a level above chance when identifying the month the event tool place during, while the nursery school children were unable to (a time-line was not used for this task). These results are consistent to the ones in study one.

The first grade and nursery school children were accurate at a level above chance when they identified the time of day of the event (children used a time-line for the time of day recall).These results differed from those found in study one in that the nursery school children were able to identify the time of day and the third grade children were not able to.

For the month (time-line not used) and the season (time-line used) estimates, none of the children were able to identify the correct time.

Table 2

List of memory skills measured in Gosse and Roberts (2005)

Skill being measured	Task Used	Results of Task
Ability to spontaneously recall temporal words	Children were asked to recall everything that happened while making the picture of the sky at night and the fish tank. The children's responses were coded for the number of temporal words.	On average 3-4 year olds made 0.1 temporal references and 7-8 year olds made 5 temporal references.
Ability to recall actions in order	Children were asked to recall everything they did while making the picture of the sky at night and the fish tank in forward order (everything that happened *after* they sat on the blue mat) and in backward order (everything they did *before* they put the blue mat away). Children were always asked to sit on the blue mat at the beginning of the activities and put the blue amt away at the end.	Overall there was a significant difference between the number of statements the 3-4 year olds (M=1.92) and the 7-8 year olds (4.37) were able to recall when asked what happened after, but not when asked what happened before.
Ability to use a time-line	Children were asked to place two events provided by their parents on a time-line of a day. (memory time-line task) Children were read six short stories and asked to place a picture card on the time-line of the day according to where it belonged in the story. (non-memory time-line) For example, in one story Tommy broke an egg for breakfast and the child is asked to place a picture of an egg on the time-line at the time of day that Tommy broke it.	For the parent time-line task children's placements were compared to their parent's placements to create difference scores. Overall the 7-8 year olds performed better and had more accurate placements (a difference score of M=2.31) compared to the 3-4 year olds (a difference score of M= 5.06). When asked to place the story cards on the time-line the 3-4 year olds were correct 43% of the time, whereas the 7-8 year olds were successful 77% of the time.

Ability to sequence actions	Children were asked to sequence three sets of actions from the two activities (sky at night and making the fish tank). The single and repeated set consisted of five items and the set of actions that were taken one from each repeated set consisted of six actions. (memory time-line) Children were asked to sequence sets of cards from the sequencing task in the WISC. (non-memory time-line)	The older children were able to sequence the single and repeated actions better than the younger children. The 3-4 year olds often sequenced less than half of the items correctly, while the 7-8 year olds were able to sequence the single actions correctly almost all the time, and the repeated actions correctly over half of the time. Both the 3-4 year olds and 7-8 year olds had difficulty with the actions taken from each repeated set. When sequencing the picture cards from the WISC all of the children, although the 7-8 year olds performed significantly better (5.85 out of 6 sets) than the 3-4 year olds (4.57 out of 6 sets).
Ability to judge duration	Children were asked which event was the longest; the picture of the sky at night or the fish tank	Overall the 3-4 year olds were correct less than half the time and were only able to recall the picture of the sky at night as the longest event 36.84% of the time, whereas the 7-8 year olds were able to identify the longest event 65% of the time.

Table 3

List of actions children sequenced

Single Actions (One set, six orders of each)		Repeated Actions (Six sets, five orders of each)	One Action Taken from each Repeated set (Five sets, six orders of each)
Beta picture, Pretend fish, Spaceship, Sun, Astronaut, Moon (The children sequenced one of six orders)	Set 1	Stickers: Planet, spaceship, sun, astronaut, star	Wrapper in garbage, shells in red box, low five with two hands, black pen, planet stickers, stretch legs
	Set 2	Stretches: Arm, Leg, Back, Neck, Hands	Tape in garbage, plant in red box, high five with two hands, green sparkly pen, spaceship sticker, stretch neck
	Set 3	Items put in Garbage: Felt, marker, wrapper, extra yellow paper, tape	Yellow paper in garbage, white rocks in red box, low five with one hand, pink sparkly pen, astronaut sticker, stretch hands
	Set 4	Different Coloured Pens: Blue, orange, black, green, pink	Felt in garbage, Background in red box, low five with one hand blue pen, sun sticker, stretch back.
	Set 5	High Fives: Low five with two hands, low five with one hand, high five with two hands, low five with one hand, low five around the back.	Marker in garbage, fish food in box, low five behind the back, orange crayon, star sticker, stretch arms
	Set 6	Extra Items put in the red box: Plant, white rocks, sea shells, background, fish food	

Table 4.

Questions asked during the verbal and time-line recall for the parent recall and activity recall task

Parent provided autobiographical event		Activity Actions	
Verbal (The following questions will be asked for three of the six events)	Time-line (The following questions will be asked for three of the six events)	Verbal (The following questions will be asked for each instantiation in each set.)	Time-line (The following questions will be asked for each instantiation in each set.)
Questions to address memory for activity or event		Questions to address memory for activity or event	
Do you remember _____?	Do you remember _____?	Do you remember _____?	Do you remember _____ ?
Questions to address location		Questions to address location, sequencing and duration	
*When did _____ happen?	Show me on the time-line when_____ happened?	*Do you remember when we_____?	Show me on the time-line when we_____?
When in the day did _____ happen?		When during the picture of the sky at night did _____ happen?	
Did _____ happen before or after lunch? Was _____a short time or long time before/after lunch?		Did we _____before or after (middle anchor)? Ok, so you remember doing _____, _____, _____ and _____. Which one did you do first? Was _____ before or after _____ (middle anchor)? Was _____ a short or long time before/after lunch? Which one was next _____, _____, or _____? Was _____ before or after _____ (middle anchor)? Was _____ a short or long time before/after lunch? (continued until each action in each set is covered) (Repeat questions for all instantiations)	

Notes. * denotes general verbal recall questions; all other verbal recall questions comprise the specific recall task.

Table 5

List of all actions

Single Sets				
1.	Draw a circle for the sun	Place felt on back of moon	Put an astronaut on the picture	Write name on the spaceship
2.	Put extra yellow felt in garbage	Wipe glue off hand with kleenex	Look at different sized comets	Colour earth blue
Repeated Sets				
Red Box	Scissors	Tape	Glue	Extra felt
High Fives	Low five 1 hand	Low five 2 hands	High five 1 hand	High five 2 hands
Stretching	Legs	Arms	Back	Neck
Stickers	Cow	Alligator	Bunny	Bear

Table 6.

Means, standard deviations and sample sizes for the accuracy of recall of autobiographical events

	Age category	Mean	Std. Deviation	N
Time-Line	4 year olds	1.00	0.65	15
	5-6 year olds	1.60	0.91	15
	7-8 year olds	1.93	1.03	15
	Total	1.51	0.94	45
Verbal	4 year olds	1.07	1.16	15
	5-6 year olds	1.20	0.94	15
	7-8 year olds	2.20	0.77	15
	Total	1.49	1.080	45

Note. Scores ranged from 0-3

Table 7.

Means, standard deviations and sample sizes for the accuracy of recall of autobiographical events for before/after lunch.

	Age category	Mean	Std. Deviation	N
Time-line	4 year olds	1.87	0.83	15
	5-6 year olds	2.47	0.64	15
	7-8 year olds	2.53	0.64	15
	Total	2.29	0.76	45
Verbal	4 year olds	1.47	1.13	15
	5-6 year olds	1.93	0.96	15
	7-8 year olds	2.53	0.64	15
	Total	1.98	1.01	45

Note. Scores ranged from 0-3

Table 8.

Means, standard deviations and sample sizes for the accuracy of recall of autobiographical events for short/ long time, before/after lunch.

	Age category	Mean	Std. Deviation	N
Time-line	4 year olds	1.40	0.74	15
	5-6 year olds	2.00	0.76	15
	7-8 year olds	2.00	0.76	15
	Total	1.80	0.79	45
verbal	4 year olds	0.93	0.96	15
	5-6 year olds	1.13	0.83	15
	7-8 year olds	1.73	0.80	15
	Total	1.27	0.91	45

Note. Scores ranged from 0-3

Table 9.

Means, standard deviations and sample sizes for the accuracy of placement of actions within the activity.

	Age category	Mean	Std. Deviation	N
Time-Line				
Single	4 year olds	1.00	0.93	15
	5-6 year olds	1.73	1.10	15
	7-8 year olds	2.40	1.19	15
	Total	1.71	1.20	45
Repeated	4 year olds	1.07	1.10	15
	5-6 year olds	1.53	1.36	15
	7-8 year olds	1.93	0.89	15
	Total	1.51	1.16	45
One from each repeated set	4 year olds	1.00	1.00	15
	5-6 year olds	.93	1.39	15
	7-8 year olds	1.53	1.19	15
	Total	1.16	1.21	45
Verbal				
Single	4 year olds	1.27	1.16	15
	5-6 year olds	2.13	1.25	15
	7-8 year olds	2.27	1.03	15

	Total	1.89	1.21	45
Repeated	4 year olds	1.07	1.10	15
	5-6 year olds	1.53	1.36	15
	7-8 year olds	2.13	0.83	15
	Total	1.58	1.18	45
One from each repeated set	4 year olds	1.07	1.28	15
	5-6 year olds	1.13	0.99	15
	7-8 year olds	2.00	1.41	15
	Total	1.40	1.29	45

Note. Scores ranged from 0-4

Table 10.

Means, standard deviations and sample sizes for the accuracy of before/after placements for actions within the activity

	Age category	Mean	Std. Deviation	N
Time-line				
Single	4 year olds	2.93	1.53	15
	5-6 year olds	2.33	1.18	15
	7-8 year olds	3.93	0.96	15
	Total	3.40	1.29	45
Repeated	4 year olds	1.40	1.12	15
	5-6 year olds	2.47	0.99	15
	7-8 year olds	2.67	1.11	15
	Total	2.18	1.19	45
One from each repeated set	4 year olds	1.47	0.99	15
	5-6 year olds	1.73	1.39	15
	7-8 year olds	2.53	0.99	15
	Total	1.91	1.20	45
Verbal				
Single	4 year olds	1.47	1.24	15
	5-6 year olds	2.27	1.22	15
	7-8 year olds	2.53	0.63	15

	Total	2.09	1.14	45
Repeated	4 year olds	1.47	1.25	15
	5-6 year olds	2.27	1.28	15
	7-8 year olds	2.73	0.96	15
	Total	2.16	1.13	45
One from each set	4 year olds	1.73	0.96	15
	5-6 year olds	1.87	0.99	15
	7-8 year olds	2.33	0.90	15
	Total	1.98	0.97	45

Note. Scores ranged from 0-4

Table 11.

Means, standard deviations and sample sizes for the accuracy of short/long time, before/after placements for actions within the activity

	Age category	Mean	Std. Deviation	N
Time-line				
Single	4 year olds	0.93	0.96	15
	5-6 year olds	1.80	1.08	15
	7-8 year olds	2.60	1.24	15
	Total	1.78	1.28	45
Repeated	4 year olds	1.13	0.99	15
	5-6 year olds	1.60	1.40	15
	7-8 year olds	2.00	0.75	15
	Total	1.58	1.18	45
One from each repeated set	4 year olds	0.87	0.83	15
	5-6 year olds	1.00	1.37	15
	7-8 year olds	1.27	0.96	15
	Total	1.04	1.07	45
Verbal				
Single	4 year olds	0.87	0.83	15
	5-6 year olds	1.00	1.36	15
	7-8 year olds	1.27	0.96	15

	Total	1.04	1.07	45
Repeated	4 year olds	0.60	0.63	15
	5-6 year olds	1.60	1.55	15
	7-8 year olds	1.93	1.33	15
	Total	1.38	1.33	45
One from each set	4 year olds	0.80	0.77	15
	5-6 year olds	0.67	0.90	15
	7-8 year olds	1.27	0.89	15
	Total	0.91	0.87	45

Note. Scores ranged from 0-4

Table 12.

Means, standard deviations and sample sizes for pairs sequencing scores

	Age category	Mean	Std. Deviation	N
Time-Line				
Single Actions	4 year olds	0.33	0.89	12
	5-6 year olds	0.17	0.39	12
	7-8 year olds	1.27	1.49	15
	Total	0.64	1.19	39
Repeated Actions	4 year olds	0.42	0.90	12
	5-6 year olds	0.75	1.19	12
	7-8 year olds	0.33	0.49	15
	Total	0.49	0.85	39
One Action from each repeated set	4 year olds	0.00	0.00	12
	5-6 year olds	0.58	1.16	12
	7-8 year olds	0.40	0.83	15
	Total	0.33	0.84	39
Verbal				
Single Actions	4 year olds	0.17	0.39	12
	5-6 year olds	1.33	1.50	12
	7-8 year olds	0.80	1.21	15
	Total	0.77	1.20	39

Repeated Actions	4 year olds	0.25	0.45	12
	5-6 year olds	1.00	1.48	12
	7-8 year olds	1.27	1.49	15
	Total	0.87	1.30	39
One Action from each repeated set	4 year olds	0.00	0.00	12
	5-6 year olds	0.08	0.29	12
	7-8 year olds	0.20	0.41	15
	Total	0.10	0.31	39

Note. Scores ranged from 0-3

Table 13.

Means, standard deviations and sample sizes for individual placement sequencing scores

	Age category	Mean	Std. Deviation	N
Time-Line				
Single Actions	4 year olds	1.00	1.21	12
	5-6 year olds	1.47	0.79	12
	7-8 year olds	2.40	1.50	15
	Total	1.67	1.34	39
Repeated Actions	4 year olds	1.00	0.95	12
	5-6 year olds	1.75	1.22	12
	7-8 year olds	1.53	0.83	15
	Total	1.44	1.02	39
One Action from each repeated set	4 year olds	1.00	0.85	12
	5-6 year olds	1.17	1.53	12
	7-8 year olds	1.67	0.98	15
	Total	1.31	1.15	39
Verbal				
Single Actions	4 year olds	1.25	0.87	12
	5-6 year olds	2.50	1.44	12
	7-8 year olds	2.01	1.10	15
	Total	1.95	1.23	39

Repeated Actions	4 year olds	1.17	0.83	12
	5-6 year olds	1.75	1.82	12
	7-8 year olds	2.13	1.64	15
	Total	1.72	1.52	39
One Action from each repeated set	4 year olds	0.92	0.79	12
	5-6 year olds	1.08	0.67	12
	7-8 year olds	0.87	0.83	15
	Total	0.95	0.76	39

Note. Scores ranged from 0-4

Table 14.

Means, standard deviations and sample sizes for distance sequencing scores

	Age category	Mean	Std. Deviation	N
Time-line				
Single	4 year olds	4.33	2.23	12
	5-6 year olds	3.50	1.73	12
	7-8 year olds	2.00	2.00	15
	Total	3.18	2.19	39
Repeated	4 year olds	5.33	2.31	12
	5-6 year olds	3.67	2.39	12
	7-8 year olds	3.20	1.86	15
	Total	4.00	2.31	39
One from each repeated set	4 year olds	5.17	2.33	12
	5-6 year olds	5.00	2.89	12
	7-8 year olds	3.20	1.66	15
	Total	4.36	2.42	39
Verbal				
Single	4 year olds	4.25	1.60	12
	5-6 year olds	2.17	2.62	12
	7-8 year olds	2.47	1.81	15
	Total	2.92	2.18	39
Repeated	4 year olds	4.58	2.27	12

	5-6 year olds	3.33	2.99	12
	7-8 year olds	2.67	2.58	15
	Total	3.46	2.68	39
One from each repeated set	4 year olds	5.08	1.08	12
	5-6 year olds	5.17	1.34	12
	7-8 year olds	4.20	1.93	15
	Total	4.77	1.56	39

Note. Scores ranged from 0-9

Figure Captions

Figure 1. Interaction between response format by action type for before/after scores (activity).

Figure 2. Interaction between response format, action type and age for pairs sequencing scores.

Figure 1.

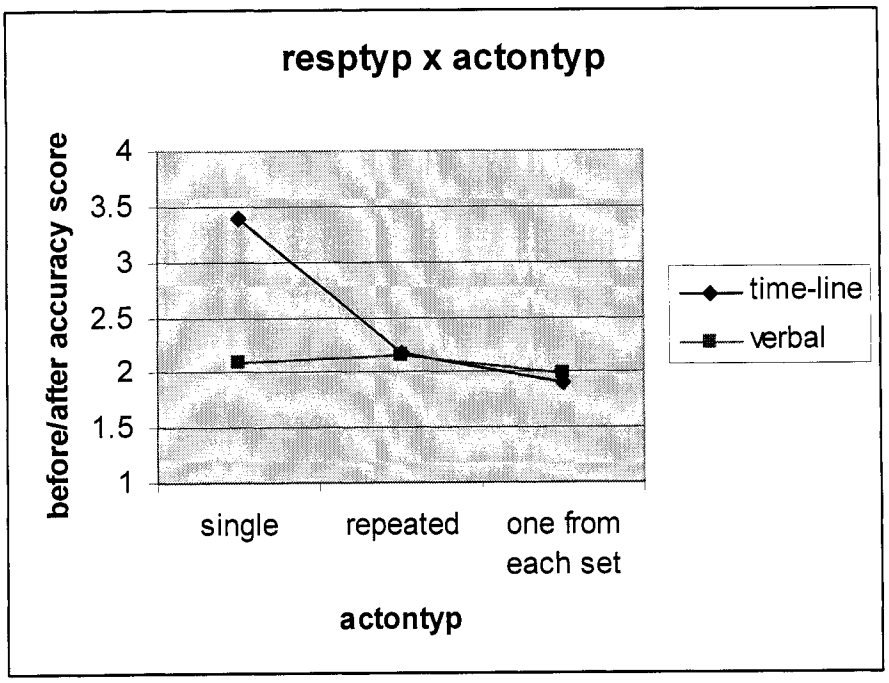
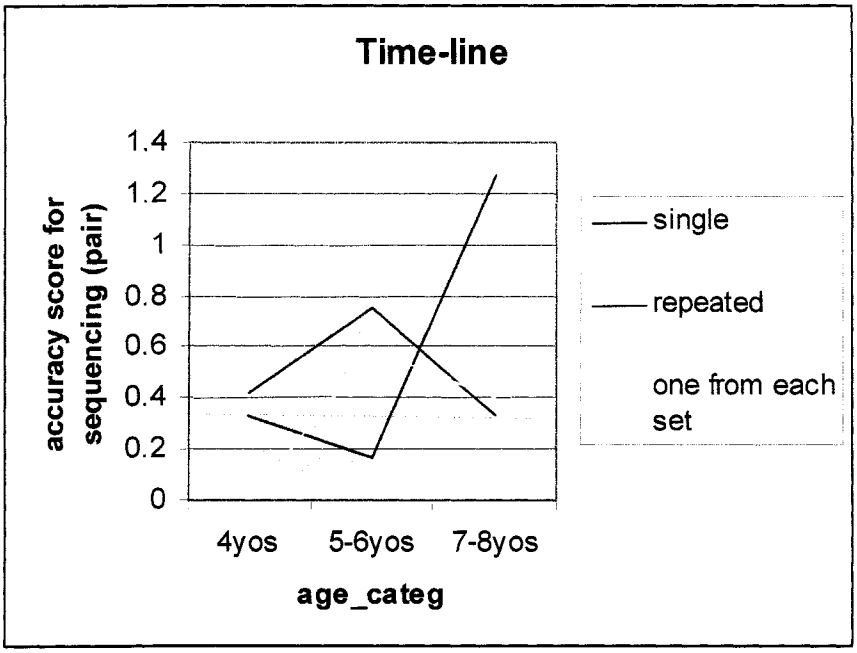
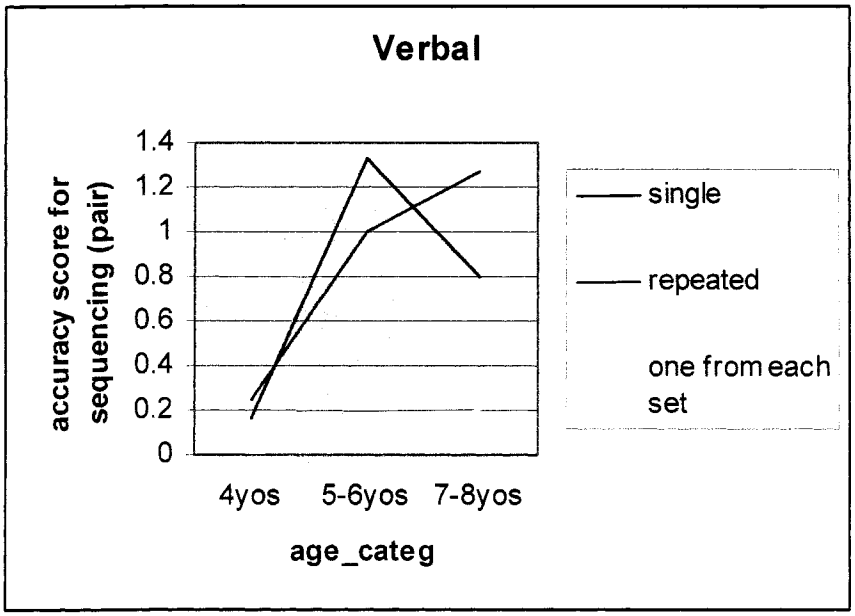

resptyp x actontyp
before/after accuracy score
4
3.5
3
2.5
2
1.5
1
single
repeated
one from each set
actontyp
time-line
verbal

Figure 2.


Time-line
accuracy score for sequencing (pair)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
4yos
5-6yos
7-8yos
age_categ
single
repeated
one from each set


Verbal
accuracy score for sequencing (pair)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
4yos
5-6yos
7-8yos
age_categ
single
repeated
one from each set